THE

PATHOLOGICAL ANATOMY

OF

THE HUMAN BODY.

BY JULIUS VOGEL, M.D.

PROFESSOR OF CLINICAL MEDICINE AT THE UNIVERSITY OF GIESSEN.

TRANSLATED FROM THE GERMAN WITH ADDITIONS,

BY GEORGE E. DAY, M.A. & L.M. CANTAB.

MEMBER OF THE ROYAL COLLEGE OF PHYSICIANS; PHYSICIAN TO THE WESTERN GENERAL DISPENSARY; LECTURER ON HISTOLOGY AND ANIMAL CHEMISTRY AT THE MIDDLESEX HOSPITAL MEDICAL SCHOOL; MEMBER OF THE PATHOLOGICAL SOCIETY OF LONDON, AND FORMERLY SENIOR PRESIDENT OF THE ROYAL MEDICAL SOCIETY OF EDINBURGH.

ILLUSTRATED BY UPWARDS OF ONE HUNDRED PLAIN AND COLOURED ENGRAVINGS.

LONDON:

H. BAILLIERE, PUBLISHER,

FOREIGN BOOKSELLER TO THE ROYAL COLLEGE OF SURGEONS AND THE ROYAL-MEDICO CHIRURGICAL SOCIETY.

PARIS: J. B. BAILLIERE, LIBRAIRE DE L'ACADEMIE ROYALE DE MEDECINE, RUE DE L'ECOLE DE MEDECINE.

1847.

LONDON:
Printed by Schulze & Co., 13, Poland Street.

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THE TREASURER

OF

THE PATHOLOGICAL SOCIETY OF LONDON,

WHOSE LABOURS IN MORBID ANATOMY AND PATHOLOGY
HAVE ACQUIRED FOR THEM UNDYING NAMES IN
THE RECORDS OF MEDICAL SCIENCE,
THIS VOLUME IS DEDICATED
WITH EVERY FEELING OF RESPECT

BY THE EDITOR.

TO THE READER.

THE entire absence of any English work on Morbid Anatomy, embracing the recent discoveries effected by Chemistry and the Microscope, affords a sufficient reason for the appearance, in the present form, of Vogel's PATHOLOGICAL ANATOMY OF THE HUMAN BODY.

This volume forms in itself a complete Treatise on general Morbid Anatomy. It will very shortly be followed by a second, devoted to the consideration of Pathological changes affecting special organs.

The additions that I have made to this volume are trivial and unimportant, with the exception of the Plates and their explanations. These are almost entirely selected from the Author's "Icones Histologiæ Pathologicæ," and will, I trust, be found valuable aids to the clear understanding of the subjects they are intended to illustrate.

I gladly avail myself of this opportunity of expressing my obligations to Dr. Vogel, who has not only promised me a considerable amount of additional matter bearing on general Morbid Anatomy (which will appear in an

Appendix on the completion of the Work), but has carefully examined a considerable portion of this volume, and expressed his satisfaction at the manner in which I have executed my task. I am likewise much indebted to my brother, Mr. E. Welby Day, for important assistance in preparing this volume for the press.

GEORGE E. DAY.

3, SOUTHWICK STREET,
HYDE PARK.

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INTRODUCTION.

The great object of works on the Anatomy of the Human Body in a state of health, is the description of the elementary tissues and their properties, and of the manner in which these tissues are arranged and distributed so as to form the different organs; further, to explain their mode of formation, and the manner in which the whole body is developed from them. The whole of these elementary textures, tissues, and organs are in each individual body essentially the same, although occasional differences present themselves, which if very striking, are described as varieties.

The case, however, is different when a body, or a portion of it, which has suffered from disease is submitted to anatomical examination. Here deviations from the appearances presented by the healthy body are frequently observed. These deviations are very numerous in character; sometimes the elementary textures are changed; sometimes new formations foreign to the normal condition are introduced; in some cases the position or form of some of the organs is changed; whilst in others the deviation has reference merely to particular portions or elements of one or more organs.

The knowledge and description of these changes, and the investigation of their origin and development constitute *Pathological Anatomy*, which, therefore, depends upon healthy anatomy as its natural basis; the former embraces as its peculiar study precisely that which the latter rejects. From the nature of the boundary between these two departments of anatomy, the question often arises—to which of the two certain cases belong. Each draws its materials from the examination of the dead body and its various organs; one investigates healthy, the other diseased conditions. But the ideas of health and disease are very relative, and since no human organ presents the ideal of health in absolute perfection, it frequently becomes questionable whether certain appearances ought to be regarded as appertaining to pathological or to healthy anatomy. When these dubious changes influence whole organs, or large parts of them, a precise decision is possible, but the farther the investigation is carried out in all minute details, so much the more difficult becomes the decision; and it must be granted that there is a neutral ground, the indisputable property of neither department.

The influence of our science on pathology is frequently misunderstood, being sometimes too lowly, sometimes too highly estimated; it consists essentially in the information which it communicates respecting the material changes in the different parts of the body which accompany or produce morbid symptoms. In showing how these morbid products are formed and gradually perfected, it assists pathology; and in elucidating the processes by which the affected part returns to its normal condition, it is subservient to therapeutics. To both of these departments of medicine, it yields an important part of the materials absolutely requisite for their firm establishment. They may be incomplete, and consequently susceptible of augmentation; but if based on correct observations, and free from hasty and incorrect conclusions, they will remain permanently valid. They have continued and will always continue the same, independently of the confirmation or subversion of any medical theory.

Having thus shown the intimate connexion between pathological anatomy and the medical sciences in general, we will now notice its bearings in relation to the individual branches.

Medicine has a double signification; it is at once a science and an art. Medicine, as an art, has a practical value in relation to life, and is therefore regarded by the mass of its disciples as of the highest importance. But it is an error, and an indication of little intelligence to regard the practical as the only important part of medicine, and the scientific as a mere superfluous decoration, as a brilliant but useless ornament. There are crafts in which the manual dexterity acquired by long practice seems to suffice for practical purposes independently of all scientific inquiry; yet even in these cases, the immeasurable strides with which these arts have recently progressed, afford the most convincing proof that the application of scientific principles to even the simplest operations, which were supposed to be incapable of improvement, has been productive of the happiest results. In medicine such narrow views must be rejected, for they would tend to produce the blind self-esteem which regards ancient formulæ and mechanically learned processes as sufficient to heal all diseases; or else they would excite doubts regarding the whole science of medicine and deny its power *in toto*, because there are difficulties and obscurities which exceed its power of solution. Each of these views regarding the healing art is equally erroneous; the directions for medical treatment given to us by the various schools are yet far from sufficient, and every conscientious physician will confess that those unworthy disciples of Esculapius, who, with self-sufficient confidence, publish their own methods of cure as alone true and infallible, are richly deserving of the scorn and contempt which satire from the earliest ages has heaped upon them. Equally mischievous and deplorable is medical scepticism. It is true that the science is yet far from being in a condition to answer all the intricate questions which the varied character of disease may suggest; that time is still far distant, indeed it may never arise; yet the science still remains, and confidence in its results is the sole prop on which the practice of the physician can rest. The consciousness that he has scrupulously followed its indications, and so discharged his duty, is his only comfort, when in sadness he is constrained to confess the inutility of all his efforts. Above all, we must not be led away by such phrases as "practical views" and "medical experience"—terms of common use, and too often conveying an erroneous impression. The practical views of the physician are the result of a series of accurate observations elucidating the treatment of disease. The true physician may be distinguished from the empiric by this, that the latter is more or less unconscious of the grounds on which he acts; and if the experience of the empiric seems in some few cases to be more successful than science, it can only be referred to a fortunate chance directing to the right point, and probably not based on the conscious experience of a single case. But science itself consists of the accumulated experience of individuals; and in proportion as that experience is limited (and especially when it is confined to a single individual) it follows from the very nature of the case that it cannot rest on a sufficiently broad scientific basis. In proportion as the science advances, and its cultivation is zealously carried on, so much the more will practical views and experience become the common property of all physicians who combine theory and practice; and that which was formerly regarded as the exclusive property of the medical pioneer will be open to all—will be almost the common stock of all who strive to obtain it.

It has been shown by long experience that scepticism in medicine leads, as it does in religion, to bigotry and superstition. It often leads its votaries to become the converts of one-sided unscientific systems, which having some semblance of truth, have at different periods been brought forward and supported, such as Humoralism, Solidism, Brunonianism, Iatrochemistry, Homœopathy, Hydropathy, and the like, which after a short meteoric brilliancy have utterly disappeared; or, in better cases, after withdrawing their vaunting pretensions, have contributed the germs of truth which they contained to the great stock of medical knowledge. Confidence in true science is the best defence against this medical bigotry. He who takes a calm survey of the whole science is not likely to take up a one-sided system; he who feels the incompleteness of the science will be in little danger of glorying in the perfection of his knowledge, or of proclaiming the infallibility of his practice.

The above observations apply equally to every part of medical science. The relation in which pathological anatomy stands to the sister science is still more striking.

The human organism is wonderfully constructed, being infinitely more complicated and delicate than the most perfect mechanism ever designed by the human intellect. It consists of an infinite number of parts, fluid as well as solid, connected with each other in a wondrous manner. The branches of medicine elucidating this structure are histology, anatomy, and animal chemistry. The various parts of the human organism are in a state of continuous activity, and stand in various relations both to each other and to the external world. Hence are developed those mysterious vital phenomena which physiology has in vain attempted to unravel. But these vital phenomena are by no means uniform in their character; they present the most striking contrasts in different individuals, and even in the same individual at different periods, and the relative proportions of the various parts and systems of the organism are, even in the normal condition, for ever fluctuating.

The idea of normal life is, therefore, extremely indefinite, and it is only by a forced abstraction that the normal can be separated from the abnormal.

Hence also the idea of disease is very indefinite; it cannot be separated by any well-defined boundary from the idea of normal life, and the two conditions are connected by a species of debateable border land. It is not a mere deviation from the normal condition which constitutes disease, for that condition is of itself variable; but it must be productive of injury to the organism before it can be ranked as disease. The extent and degree of this injury is again most variable. From those grave injuries which rapidly terminate in death, down to the slightest form of disturbance, hardly worthy of the term *disease*, how infinitely multiplied are the varieties. Hence, in this point of view, disease is not strictly distinguishable from the normal state.

The idea of disease must also be considered in a different point of view. A disease is not, as many believe, a self-existing entity; it consists rather in a change in the vital phenomena of an organism; it is no more an independant organism, or even pseudo-organism, than are the separate states or vital indications of an organism, such as walking, sleeping, eating, or speaking. Diseases may in different cases present the greatest varieties; each vital indication of an organism, every process connected with life may, in various ways, either alone or in combination with other processes, assume a morbid condition. Hence diseases will not admit of the same species of classification as if they were peculiar organisms, such as animals or plants: organisms, like diseases, are generally complex in their character, but in every animal and vegetable species all the individuals are, with very trifling deviations, composed of the same parts, while there are hardly two cases of disease in which the symptoms are precisely identical. And when, for convenience in teaching, such a classification is adopted, we must bear in mind that it is, and ever must be, an imperfect and arbitrary one, and not based on any natural system.

As the normal condition of the vital processes is dependant on the normal condition of the individual parts of the body, and on the proper discharge of their various functions, so disease arises when portions of the body deviate from their normal character, and either cease to discharge their functions at all, or discharge them in an abnormal manner. These morbid changes, affecting the functions of the body, are very frequently dependant on material changes, perceptible to the eye, and recognized by the feelings. These material changes (in the widest sense of the term) form the domain of pathological anatomy.

It is not, however, in all diseases that we can, at least in the present state of our knowledge, recognise such material changes. Hence there are diseases to which pathological anatomy seem to have no application. There are many transitory morbid changes in the vital phenomena, dependant on the nervous system, which appear and vanish without leaving a material change capable of detection by the most zealous investigator. Certain changes probably have occurred, but were unsuspected at the time, and hence, in a scientific point of view, yielded no result. In other cases, diseases seem to produce appreciable changes, not on the solid organized parts, but on the fluids, impressing upon them certain chemical changes either of a qualitative or quantitative character: whether these are to be regarded as appertaining to pathological anatomy, must be a matter of opinion. As anatomy is usually considered to embrace the theory of the constituent parts of the human body in relation to form and composition, so pathological anatomy ought to include deviations in chemical composition: there seems, however, to have been a tendency lately to regard this class of changes as belonging to a separate science to which the term *Pathological Chemistry* has been given.

In addition to observing the material changes accompanying various diseases, it is likewise the object of pathological anatomy to investigate the causes which give rise to them, their development and gradual formation, and their consequences; but this can only be done as far as is consistent with certainty. This condition, therefore, is especially important in all that concerns pathological anatomy. Pathology, from its very nature, must often frame hypotheses, and must frequently be content with probabilities when certain truth is unattainable; for the physician cannot suspend his practice in cases where he does not distinctly see his way.

But it is otherwise with pathological anatomy, in which the immediate object in view is not the same as in practical medicine; it must, therefore, restrict itself to positive knowledge, and must be always conscious of the degree of certainty which its conclusions warrant. And then, let the systems of medicine change as they may, the doctrines of pathological anatomy will stand unaffected.

Almost every disease is made up of various disturbances, which often, to the detriment of science, as well as of the patient, are referred to a single morbid origin, and receive one common name. Pathological anatomy must not adopt this course; its object must be, on the contrary, to separate each material change from all the rest; to isolate it, follow it in its minutest details, and trace its causes and effects. It is not till this is accomplished that the relation of these changes to others is to be considered. By these means, and by these alone, can pathological anatomy arrive at certain truth, and gradually attain a position to assist in the construction of the medical sciences on a broad and sure foundation. Pathological anatomy is, therefore, a useful section of pathology, contributing to practical medicine, as it were, the solid materials from which to construct a basement, without having the power to erect a perfect edifice. And here is the point in which it differs from pathology—a point respecting which there are two common errors. Some have overstretched the true limits of pathological anatomy, and have included within them disturbances in the functions of the nervous system, and other morbid symptoms altogether foreign to its jurisdiction, and have endeavoured to elevate it to pathology. Others, on the contrary, have attempted to reduce pathology to pathological anatomy, and to explain all morbid phenomena by recognized material changes, debasing the science of medicine into one-sided pathological solidism.

The importance of pathological anatomy to the different branches of pathology varies considerably. It has always been of the greatest importance to surgery, principally in reference to visible changes in the position, size, and connexion of the different organs: hence the origin of the surgical department of pathological anatomy. The changes accompanying internal disease are less obvious to the eye. They require the finest dissection and microscopic observation, and then often evade detection; their causes and consequences are likewise very obscure. Hence the influence of pathological anatomy on this department of pathology is of, comparatively speaking, recent origin. We may here again repeat what has been already mentioned, that the pathology of the solids is that which will receive the greatest benefit from pathological anatomy, whilst in diseases of the nervous system, and in disordered conditions of the fluids, it will be of less service.

Although at first sight it might appear that our subject was of small importance in relation to therapeutics, this is not in reality the case. Scientific treatment necessarily demands an extensive knowledge of the material changes which lie at the foundation of the various morbid symptoms. Hence pathological anatomy necessarily forms a portion of the positive basis of therapeutics; and, farther than this, it points out the processes by which the different altered parts may be gradually restored to their normal condition. It not merely points out what requires healing, but in many cases, also, the course that must be adopted in order to aid the curative tendency of nature. It serves likewise as a check on therapeutics, exposing, in a most conclusive manner, the absurdity of many pretended methods of cure. It points out, for example, that in a certain stage of inflammation of the lungs, a fibrinous fluid separates from the blood, and by its coagulation renders a portion of the parenchyma of the lungs impermeable to air; and further, that it requires several days for this coagulated matter to reassume the fluid condition, and be removed. Now, if any one should assert that, in this stage of the disease, he could apply a remedy which would cure the patient in a few hours, a very superficial knowledge of pathological anatomy would show the folly of such an assertion.

Let us now turn to the means by which a knowledge of pathological anatomy may be attained.

The study of those morbid changes to which the various parts of the body are liable, depends on a thorough previous knowledge of their normal relations; hence pathological anatomy requires a perfect knowledge of the structure of the healthy body, and of a special department of physiology (*de usu partium*) in order to be able to estimate the influence which any morbid alteration of an organ impresses on its function. Our science must not merely study the coarser changes, such as are visible to the unaided eye; but also those finer modifications affecting elementary tissues, visible only by the microscope; hence the necessity for an accurate knowledge of general anatomy or histology. Histology and descriptive anatomy are most intimately connected with pathological anatomy; they unite to form the necessary data for its successful cultivation; and further, there exists a boundary in common to all three, which they simultaneously occupy and cultivate. Thus, for example, certain varieties in the form and position of different parts of the body, as of the vessels, may be ranged under either normal or pathological anatomy; moreover, the theory of the development of most of the tissues is the same in pathological as in normal histology. In order to understand those deviations from the normal type which occur in the fœtal condition, pathological anatomy demands an accurate previous knowledge of the law of development; indeed there are many points in which these two sciences closely approach each other.

In the establishment of its own observations, pathological anatomy requires not merely the theoretical knowledge already alluded to, but also the same manual dexterity which is needed in the practical exercise of normal anatomy, namely, skill in dissection, which can be much more readily acquired by practice than by any verbal, or written instructions. The absence of any regularly adopted system of investigation—of that *savoir faire* which diminishes and shortens every difficulty—is not so indispensable, but that by application and careful investigation it may be retrieved; and this very *savoir faire*, without such qualities, would only lead to charlatanism, dazzling the eyes of ignorant spectators, but evolving no results useful to science. In the investigation of delicate points connected with pathological histology, the microscope is indispensable, and the application of chemical re-agents must be observed under it. Chemical analysis is, indeed, of the greatest importance to pathological anatomy, being the only means by which we can on several points obtain the desired information. At present, much to the detriment of the science, chemical investigation is little pursued in conjunction with pathological anatomy; but assuredly the time will soon arrive, when chemical analysis will be deemed just as indispensable to the prosecution of pathologico-anatomical investigations as the microscope is at present, and when every follower of this science will consider chemical analysis so essentially requisite, that if his own time and opportunities prevent him from carrying it out, he will employ a chemist, under his immediate guidance and direction, to undertake it for him.

Pathological anatomy derives the materials of its knowledge from two separate sources. First, from *observation*, which includes the examination of portions of the living body altered by disease, and removed either by the knife of the surgeon, or thrown off as excreta (in the widest sense of the word) together with the examination of the dead body, which is often sufficient of itself alone to explain to the practised observer the whole course of the disease.

In most cases, it is, however, of importance that the examination of the dead body should be supported and perfected by observations made during the progress of the disease. It is also essentially important to therapeutics, that pathological anatomy should be pursued by scientific, unbiassed pathologists, rather than by mere anatomists; but we must be very careful in tracing the connexion which subsists between the symptoms observed during life, and the changes noticed after death. Hypotheses, which can be as little avoided in pathological anatomy as in medicine generally, must be most carefully checked, and their actual value borne in mind; they must not be ranked with ascertained facts and theories, if we wish to see our science preserve its positive character and its objective position high above the troubled flood of medical systems; and if we would protect it from the contempt with which certain physicians are inclined to regard it.

The other mode by which pathological anatomy gains new facts is by *experiment.* Experiments instituted on animals, and, in certain cases, on man, with the view of artificially producing a morbid condition, and then carefully studying it, afford most valuable aid; for here the quality and quantity of the causes in action are much more under control than in ordinary cases of disease.

By these means, the actual causes and consequences of individual pathological changes can be much better studied than in cases when they arise of themselves, and where their causes are frequently either entirely concealed, or can only be followed in doubt and obscurity through a multitude of influences, whose origin cannot be traced with certainty, or even probability.

We sometimes hear it objected, that from pathological changes observed in the lower animals, no certain conclusions can be drawn as applicable to man. This objection has, however, long been refuted by experience, which shows that, bearing in mind the differences necessarily consequent on variety of structure, such conclusions are not only admissible, but that comparative pathology and pathological anatomy afford as much assistance in the prosecution of this science in relation to man, as comparative anatomy does for the thorough comprehension of human anatomy and physiology.

It is, therefore, much to be desired that experiments producing morbid changes in animals should be more frequently instituted; for it is only from a large number of similar experiments, not from isolated cases, that conclusions can be safely drawn. The adoption of the experimental method in pathological anatomy promises farther advantages; for, by its application, the fruitful labours of that science will cease to remain the exclusive property of the practical physician, who, from his usual occupations, or possibly from his ignorance of the means of carrying out microscopic and chemical investigation, frequently fails to draw from the cases that come under his eye such useful observations as might have profited himself and his science.

The materials thus gained by observation and experiment must be used with the greatest care, if science is in reality to be advanced by them. This care must, in the first place, extend to description; the object of which is to give to others a correct and intuitive conception of the changes that have been observed; hence definite terms must be used, whose interpretation can admit of no mistake. Care must also be taken to describe in like manner all the relations which admit of an exact notice, as number, size, and weight. This must only be omitted in cases where it is obviously unnecessary, and general information will suffice. What these cases are, must be left to the judgment of the describer, who must, therefore, always clearly understand, in every case that he examines and describes, what are the essential points requiring an exact description, and what, on the contrary, do not require, or even admit of particular notice.*

In the next place, it is the object of pathological anatomy to examine the various changes occurring in the different parts of

* On these points the reader may consult with advantage the recent Treatise by Engel; Propädeutik der pathologischen Anatomie. Wien. 1845.

the body; to follow each individually through its minutest details; and to set forth, as clearly as possible, its causes, gradual development, and consequences. It is only by strictly pursuing this course of complete separation and isolation that useful results can be obtained, and confusion—that bane of all science—be avoided. A comparative examination of the various changes shows that there is much in common between many of them, and that the same, or similar processes frequently occur in very different parts of the body.

Thus it becomes another department of our science to examine into the community of the various changes, and to regard them from one general point of view. Hence pathological anatomy is naturally separated into a special and a general part. Of these the latter, although of the later origin in the development of the science, must yet, for the sake of a scientific arrangement, be first considered.

In order to obtain general results in pathological anatomy, two different methods may be pursued, similar to those already mentioned, in relation to obtaining material for our science; namely, the method of observation and the method of experiment.

Observations instituted on the dead body, teach us what are the changes that most commonly occur together; and from the frequency or rarity of their simultaneous occurrence, enable us to draw conclusions respecting the relative connexion of these changes. Experiment seeks to investigate the actions induced by artificial causes; and, consequently, to discover the causes and consequences of certain pathological conditions in the most direct manner.

If we wish to attach a scientific value to observations grounded on experiment respecting the simultaneous occurrence of certain changes in the human body, and the relation in which they stand to each other, such observations must be made with the greatest care. Cases imperfectly recorded, respecting the frequency or rarity of simultaneous phenomena, must be rigidly excluded, as unfit to form the basis for any sound conclusions. The comparison must be made on an exact mathematical basis; and conclusions must only be deduced in accordance with the rules of probabilities and the laws of high numbers. The numerical or statistical method must be carried out as fully as possible.*

In applying this method to pathological anatomy, we must clearly understand what it is actually capable of effecting, and neither employ false data, nor overrate the results yielded by it. The certainty of its results is dependant on two conditions; Firstly, on the number of the observations; and, secondly, on the accuracy with which each observation is described.

The more closely these conditions are fulfilled, so much the more sure and accurate will be the results yielded. A few illustrations will elucidate our meaning. Let us assume that, from the Creation to the present time, at least one billion of men have lived, and, after a longer or shorter life, have died. Of this whole number none have lived beyond a certain age; for instance, no one is now alive who was born in the fourteenth century. Hence, the probability that any man now alive will die, is to the probability that he will not die, as a billion to one. The number is here so large, that no rational being can doubt that death must earlier or later ensue. In this case, the number of observations is the greatest that can possibly occur, and the conditions respecting the nature of the observation are clearly defined. Hence, the probability is so very great, that it may be deemed an absolute certainty.

There are likewise other questions respecting which, if the numerical method cannot reply with the same degree of certainty, it may yet yield an answer for the correctness of which there will be the highest degree of probability. For example, suppose it be asked what per centage of mankind die before their thirtieth year? Here the object of the question—the

* Consult Gavarret: Principes Généraux de Statistique Médicale. Paris, 1840.

occurrence of death before or after the thirtieth year—may be determined with tolerable certainty. In a well ordered country, there are few cases in which the age at death is not recorded. The official registration of births and deaths places a large number of observations at our command; and from these data the question may be answered, not only with very considerable accuracy, but we can even approximate to the greatest error that can possibly occur in the calculation.

In pathological anatomy the case is, however, different; for the number of observations is much smaller, while the objects to be observed are frequently of a very indefinite nature. Suppose it were determined to prove, by statistical records, that scirrhus and tuberculosis exclude each other. In the first place, the meaning of the terms scirrhus and tuberculosis must be accurately determined; for although physicians are not likely to dispute whether or not a man is really dead, there are few points on which there is more difference of opinion than whether a tumour is to be regarded as of a scirrhous nature or not. But, even if this difficulty were overcome, and it were agreed that a number of observations on the presence of scirrhus in undoubted cases were actually made, still the number must be comparatively small. Suppose thirty cases of scirrhus have occurred without the presence of tubercle in any of them; then the probability that the next (thirty-first) case of scirrhus will not be associated with tuberculosis will be as thirty to one.

But in addition to these cases of scirrhus in which there have been found to be no indication of tuberculosis, probably 300,000 other cases have occurred, yielding no evidence for or against its co-existence. Now, if from these thirty observed cases, we were to conclude that scirrhus always excludes tuberculosis, that is to say, that amongst the 300,000 cases there had not been a single one in which tubercles were present, such a conclusion would, according to the laws of probability, be very uncertain, and such an application of the calculations, founded on that law, would be misplaced.

It would be a still more dubious matter to attempt to establish, on statistical grounds, not merely the simultaneous occurrence, or non-occurrence of certain morbid changes, but likewise the mutual relations, and the connexion of cause and effect existing between them. Suppose it were attempted to be proved by statistical records from the dead-house, that hydrocephalus in children is the cause of tuberculosis; or, *vice versâ*, that hydrocephalus arises from tuberculosis. Our first object would be to obtain statistical information respecting the simultaneous occurrence of these two diseases, or of the invariable disappearance of the one before the appearance of the other; and the conclusions would be very doubtful unless drawn from a large number of cases. It would further have to be proved that other morbid changes frequently occurring with hydrocephalus, but independent altogether of tuberculosis, were not the actual cause; or, to penetrate still deeper, that other changes, invisible in the dead body, may not have produced the hydrocephalus. For such reasons as these, the statistical information we at present possess, in relation to pathological anatomy, must be used with the greatest caution. I do not, however, desire to underrate the importance of the application of the statistical method to our science; on the contrary, I hold it of essential importance that in all serious forms of disease, statistical information respecting the morbid changes found in the dead body should be carefully drawn up and laid publicly before the profession. But these examinations must be made with the greatest care; the nature of the changes must always be communicated in the most definite and special manner; and, above all, the observer must avoid drawing general conclusions from too small a number of cases, or from cases badly observed and badly described. In our science, we must follow the examples set us by the astronomers, magnetists, and meteorologists, who continue for years to carry on the most careful general observations, and to make them public property, in the hope that the general laws which they fail to establish will be developed by their successors.

The other method by which pathological anatomy can and will extend its limits, seeks to penetrate directly into the connection of symptoms; far from excluding the statistical method, it is rather an essential completion of it, whilst its results, when sure, act as a test for those obtained by the numerical method. A few examples will serve to illustrate my meaning.

Common observation teaches us that venous hyperæmia is frequently accompanied by a collection of dropsical fluid in the surrounding parts. Our knowledge of the functions of the blood-vessels renders it probable that the dropsical fluid, in these cases, proceeds from the veins, and that their hyperæmia is the cause of its collection. Carefully instituted experiments, which by ligature, or in some other way, have caused venous hyperæmia, and thus actually produced dropsical effusion, confirm this opinion; and it becomes more sure in proportion to the number of experiments, and the different conditions under which they were performed, with the view of removing every possible source of error.

The following may serve as another illustration: Experience shows us that certain changes in the substance of the kidneys are accompanied by the secretion of albuminous urine. A close examination of the diseased kidney shows that blood-plasma has escaped from the vessels into the substance of that organ, and that the fibrin has coagulated there. Physiological theory leads us to assume that the fluid portion of the blood-plasma becomes mixed with the urine, and that the albumen is at least in part obtained from that source.

In order to fulfil its office, and efficiently to serve general and special pathology and therapeutics, pathological anatomy must adopt and scrupulously carry out both these methods.

If pathological anatomy lays claim to the rank of a science, it must arrange the results which it has obtained, and exhibit them connected in one comprehensive scheme. This can, at present, only be effected in a very imperfect manner. One of the most difficult tasks in the science of pathology, is to classify the different diseases, and to arrange them in accordance with a scientific system. The great cause of the difficulty consists, as we have already mentioned, in their being neither organisms nor pseudo-organisms, but merely deviations from the normal condition. In pathological anatomy, the difficulty is still greater; for, from its very nature, it must investigate isolated facts; and its general department, if we retain that which is positive, and do not adopt too many hypotheses, is at present in a very aphoristic condition. Hence, I regard a systematic arrangement in pathological anatomy—at least at the present time—as of small importance, and I shall only add a few words regarding the system I have adopted, not so much with the view of justifying it, as to assist the reader in the perusal of the following pages.

The special department treats of the pathological changes in different parts of the body. The arrangement is entirely arbitrary, and I have adopted it simply with the view of avoiding repetition.

The general part, which proceeds as it were from the special, embraces the changes of a more general nature, which may occur in different tissues and organs in the same, or in a very similar manner, noticing also their general relations, causes, and consequences, so far as they are at present known. The following sketch of the order in which the different morbid changes follow each other, will serve as a summary of the contents. We commence with abnormal collections of fluids in the body—of the gaseous (pneumatoses), of the aqueous (dropsies). The latter are divided in a manner that seems natural and practically important, although not hitherto adopted: namely, into serous, fibrinous, and false dropsies. Then comes a sketch of the morbid changes of the blood as far as they are at present understood. This is succeeded by a chapter on pathological epigeneses,* which from their nature occupy

* Neubildungen; literally, new formations.

a very considerable space, and by a brief sketch of the changes which the tissues undergo in their physical properties, together with some remarks on the manner in which morbid changes in the elementary tissues are connected with each other. The next chapter treats of the independent organisms which occur in the human body, as causes or consequences of morbid changes (parasites). Then there is a chapter devoted to congenital pathological changes (malformations), and we conclude with a notice of the changes occurring in the body after death.

PATHOLOGICAL ANATOMY.

CHAPTER I.

ABNORMAL DEVELOPMENT OF GASEOUS MATTERS.—PNEUMATOSES.

ABNORMAL collections of gaseous matter are by no means rare, either in the living or the dead body. They are included in the general term pneumatoses,* and occur in the tissue of organs (constituting emphysema), between the fibres of cellular tissue, as in the parenchyma of the lungs or liver; and in the natural cavities of the body, as in the intestinal canal, the peritoneum (constituting tympanites), the pleura (constituting pneumothorax), the pericardium, between the membranes of the brain, or in the cerebral ventricles; in the urinary bladder, the uterus, the heart, and blood-vessels.† They are most common in the intestinal canal, and comparatively rare in the other cavities.

As we shall have occasion to notice most of these pneumatoses in relation to the special organs in which they occur,

* J. P. Frank, De Cur. Hom. Morb. lib. VI. § 701—730; Andral, Path. Anat. vol. I. p. 394; Lobstein, Path. Anat. vol. I. p. 134; Canstatt, Spec. Path. u. Ther. vol. I. p. 178.

† Otto, Path. Anat. vol. I. p. 42.

we shall here merely offer a few general remarks on their causes and mode of origin. These accumulations of gas may be dependant on very different causes.

1. *They may arise from the external pressure of the atmospheric air.* The mechanism of this form of origin is most strikingly seen in those cases of general emphysema which arise from an injury to the lungs, dependant on a penetrating wound of the thorax. If the intercostal opening of the wound be not parallel with that in the external skin, emphysema almost invariably results, since the air is forced through the wound at every expiration; and instead of escaping externally, is propelled into the cellular tissue beneath the skin. If, on the other hand, the external opening of the wound is parallel with the internal, and the course of the wound is thus kept open, no emphysema results, since there is no impedimemt to the progress of the air outwards. The air admitted into the cellular tissue of the thorax gradually works its way over the body, and the emphysema thus becomes more or less general. The orbits become closed up; the eyes and mouth remain shut, in consequence of the swollen condition of the eye-lids and lips; the nose is hidden between the tumid cheeks; the skin of the neck is so monstrously distended that all distinction between the head and the trunk disappears. The skin is most distended at those points where it is connected with the sternum and the spinous process of the vertebral column. The scrotum swells to such a size as to conceal the penis. The limbs enlarge and assume a cylindrical form; the palms of the hands and the soles of the feet (in consequence of their firm connexion with the subjacent tissues) being the only parts not affected. The swollen parts feel tense, crepitate when pressed by the fingers, and on removing the pressure no pitting is visible. In unfavourable cases, the patient dies from impeded respiration and apoplexy, in consequence of the compression exercised on the air-tubes and jugular veins by the

swelling. Larrey* has described two cases of this nature, and has given a representation of one of them. Some very similar instances are mentioned by P. Frank, after penetrating wounds of the larynx or trachæa, and in cases of fractured ribs; and, indeed, without any external lesion in severe cases of pertussis and in phthisis; in raising heavy weights, and during the pains of labour.† In all these cases there was, doubtless, an internal laceration through which the air penetrated from the respiratory organs into the cellular tissue. The case is precisely the same in local, or circumscribed emphysema; thus, according to Dr. Frank,‡ persons in the habit of playing on wind-instruments, frequently suffer from a painful inflation of the cheeks, arising from the air entering the cellular tissue of these parts, through laceration of the buccal mucous membrane. It likewise happens that in applying the air-douche, with a view to open and enlarge the Eustachian tube in cases of deafness, local emphysema is sometimes produced in a similar manner. In this way the various forms of pulmonary emphysema are produced, of which we shall here only explain briefly the mode of origin; since they will be fully discussed when we treat of the pathological conditions of the lungs.

When a portion of lung is so clogged up with fluid or solid depositions that no air can enter it, or when it is bound down by unyielding false membranes, it is impossible that it can follow and correspond with the movements of the thorax at each inspiration, as in the normal state. A vacuum is formed between the lungs and the parieties of the thorax, which the air, entering through the trachæa, endeavours by the ordinary laws of mechanics to fill; consequently, the expansive portions of the lungs are enlarged to a greater degree than in the normal state, and the result is vesicular emphysema, in which the pulmonary cells of the expansible

* Larrey, Clinique chirurgicale, tome II. p. 188, planche 4.

† J. P. Frank, Epitome, cap. VI. § 707.

‡ Op. cit.

portion of lung become distended, and contain a larger amount of air than in a state of health. If, however, in consequence of the pressure of the air, or the delicacy in the cell-walls, any laceration occurs, the air enters the parenchyma of the lung, and interlobular emphysema is the consequence.

Air may likewise enter the cavities of the body in this mechanical way, either from the respiratory organs or directly from the atmosphere. When vomicæ in the lungs, communicating with the bronchi, perforate the cavity of the pleura, air is forced inwards and pneumothorax is the consequence.

After wounds of the large superficial veins, especially in the vicinity of the heart, where the diastole of the right auricle and the enlargement of the thorax during inspiration, exert a certain suction-force on the blood, the external air may enter the vein and thus be conveyed with the blood to the heart.

Finally, it appears that many accumulations of gas take place mechanically in the course of the intestinal canal (especially in the stomach) by the entrance of atmospheric air. Pneumatoses of the œsophagus and of the stomach are by no means rare, and most commonly occur in hysterical and hypochondriacal persons, especially when the stomach has been long empty, as two or three hours after meal-time. In some of these cases, there is an excess of acid developed in the stomach; in others, on the contrary, there is a deficiency. Their most frequent cause is a mental one.* The stomach becomes swollen, and forms an elevated, elastic tumour beneath the sternum, yielding a clear sound on percussion. Various nervous symptoms, palpitations, dyspnœa, angina, pain in the gastric region, &c. accompany the phenomenon, which usually disappears with eructations.† Many authors (P. Frank, Lobstein, &c.) are of opinion that in these cases the gas is secreted by the walls of the stomach. Budge‡ has,

* Sir Francis Smith, Dublin Med. Journal. Jan. 1841, p. 454.

† P. Frank, op. cit. § 714.

‡ Die Lehre vom Erbrechen, 1st Part.

however, shown that in the eructations which precede vomiting, and, therefore, probably also in many other cases, atmospheric air enters the stomach through the œsophagus. I confess, however, that to me the mechanism by which the air is driven into the stomach is not perfectly clear. According to Budge, the stomach enlarges its cavity by an active tension, and then the air is driven in by the ordinary laws of physics. How the stomach can, by a contraction of its muscular fibres, dilate itself, and thus produce a vacuum, I do not understand. If the fact is placed beyond doubt, some further explanation is at least requisite.

It is possible that some of the cases in which gas is discharged from the generative organs of the male, from the uterus, and the urinary bladder,* may be explained in this way: namely, by a mechanical pressure of the air into these parts in consequence of a peculiar antiperistaltic motion, or dilatation of the organs. In the same manner, in all probability, the air passes from the stomach into the other parts of the intestinal canal; however, most of these collections of gas in the intestinal canal admit of another explanation, as we shall immediately see.

On making a chemical analysis of these gases, it is found that in their composition they are identical with common air; but that in consequence, probably, of their prolonged contact with the blood and other organised fluids, they undergo changes similar to those which occur in the lungs in the act of respiration: viz., the oxygen is, in part, replaced by carbonic acid, and is saturated with hydrogen.

2. *Gases are developed in the body in consequence of decomposition, fermentation, and putrefaction.*

It is well known that most organic matters undergo decomposition at the temperature of the human body and in the presence of water, even when air is excluded. This decomposition occurs under the forms of fermentation and putrefaction;

* P. Frank, op. cit. p. 724—726.

and, in many cases, is accompanied with the development of gaseous products. That such decompositions, accompanied with the development of gas, also occur to the human body, and that some pneumatoses are produced in this way cannot be doubted by any one who is in the slightest degree acquainted with the recent progress of zoo-chemistry. But if these general facts are established, our special knowledge of the subject is very imperfect; and it is at present impossible to explain theoretically, in any given case, the nature of the decomposition, and the properties of the developed gases. The following attempt to determine this point with a greater degree of certainty must only be regarded as provisional.

The decompositions of organic matters, which have been hitherto studied, have received different names in consequence of their different natures. We distinguish: firstly, alcoholic fermentation, in which sugar is converted into alcohol and free carbonic acid gas. Secondly, acetic fermentation, in which alcohol absorbs oxygen, and is converted into acetic acid and water, or sugar is converted into lactic acid; in this case no gaseous products are formed. Thirdly, putrefactive fermentation, which, according to the nature of the putrifying body, presents very different modifications, but in which gaseous products are usually evolved. The alcoholic fermentation is of very rare occurrence in the human body, unless when fermenting drinks, unfermented beer, &c. have been taken in large quantities. It appears that in such cases this fermentation may occur in the stomach, and give rise to the development of an accumulation of carbonic acid. Acetic fermentation cannot give origin to any pneumatosis, since no gaseous products are developed. Hence, there is only left the putrefactive fermentation to be carefully studied. As a general rule, it occurs very rapidly when portions of vegetable or animal organisms are exposed in the presence of water to a temperature corresponding with that of the human body. The gases that are developed vary in accordance with the putrefying substances that give origin to them. Nonnitrogenous substances yield carbonic acid, carburetted hydrogen, and hydrogen; nitrogenous matters yield ammonia in addition to carbonic acid: if sulphur and phosphorus are present, sulphuretted and phosphoretted hydrogen, and hydrosulphate of ammonia are also developed.*

Gas may be developed in this manner in the human body, partly from food in the act of decomposition in the intestinal canal, and partly from the decomposition of the constituents of the body itself.

A. *Development of gas from the decomposition of food in the intestinal canal.*—Accumulations of gas in the intestinal canal, at least in its lower portion, and the discharge of wind by the anus, are of such common occurrence, that they can hardly be regarded as pathological indications. Indeed, they occur in perfectly healthy persons.

That the gas arises from the decomposition of food is much more probable than that it is secreted by the mucous membrane of the intestines, as the older writers (P. Frank and Lobstein) believed. For: firstly, food moistened with water, and exposed to a temperature of 95°—104° for a space of twenty-four or thirty-six hours actually becomes putrid. Secondly, human fæces present all the signs of putrifying matter; they have a putrid odour, and infusoria are developed in them. And, thirdly, the gases in the intestinal canal are identical with those which are formed out of the human organism during the putrefaction of animal or vegetable bodies; they consist of carbonic acid, hydrogen, carburetted hydrogen, sulphuretted hydrogen, hydrosulphate of ammonia, and nitrogen.† The nitrogen probably arises from the air that is swallowed, the corresponding oxygen being contained in the carbonic acid. In support of the view that

* Compare Weinlich, Lehrbuch der theoret. Chemie, p. 344; Hünefeld, Chemie und Medicin. vol. I. p. 258; Liebig, die organische Chemie in ihrer Anw. auf Agrikultur, 1st Edition, p. 200.

† Compare Berzelius, Thierchemie, 4th Edition, p. 338.

these gases originate from the food, it may be urged that certain species of food give rise to an abundance of gas in the intestinal canal, and that sulphur taken medicinally gives rise to a copious development of sulphuretted hydrogen.*

In a state of health, these accumulations of gas in the intestinal canal are, however, very trifling, or may be altogether absent, whilst in certain pathological conditions they are very abundant, and may even produce fatal effects. The cæcum, or colon, will occasionally swell to the thickness of the arm or of the thigh, and may even burst.† The explanation of these cases is pretty clear on taking a close view of the chemical relations of the process of digestion. During healthy digestion, as soon as the food has entered the stomach a secretion of acid gastric juice is excited, which checks any decomposition and evolution of gas. The food, after its conversion into chyme, retains its acidity, which is not at once neutralized by the addition of the bile, but gradually disappears towards the extremity of the small intestine. Consequently, in a normal condition, there can be no evolution of gas in the small intestine. But nature has further afforded means of restraining the decomposition of food in the cæcum and colon; for when, after having advanced so far, it still contains undecomposed sugar, this constituent becomes changed into lactic acid, and consequently it happens, according to Blondlot,‡ that the chyme which has gradually become neutral towards the extremity of the small intestine, not unfrequently again becomes acid in the cæcum. Hence, in the normal state, the decomposition of food, accompanied with the development of gas, is restricted to the lower extremity of the intestinal canal. But when, in a diseased condition of the digestive organs, the secretion of gastric juice is either entirely absent or not sufficiently abundant, the decomposition of the

* Berzelius, op. cit.

† P. Frank, op. cit. p. 715—720.

‡ Blondlot, Traité Anal. de la Digestion, § 103.

food takes places sooner, and a considerable volume of gas may be generated. Blondlot has shown, by experiments on animals, that the absence, or accumulation of gas is in some degree dependant on the nature of the food. When ruminating animals take turnips, beans, or peas, which being rich in sugar, readily yield lactic acid, there is no development of gas in the first stomach. Gas is, however, formed when they have eaten hay or clover, which yield no lactic acid, and are, therefore, prone to decomposition.*

The occurrence of these gases is, as a general rule, restricted to the intestinal canal, and gives origin to the conditions known as meteorism and flatulence. They may, however, find their way from the intestinal canal into the cavity of the peritoneum, either by an actual lesion, (as in cases of perforation), or by permeating the unwounded intestinal walls. That this may happen, is obvious from the slate-grey colour of the surface of the spleen and liver frequently observed in *post-mortem* examinations, and due to the action of sulphuretted hydrogen or hydrosulphate of ammonia, which must have permeated the walls of the intestinal canal before it could reach those organs.

Further particulars on this subject will be found in our observations on Melanosis.

B. *Development of gas from the decomposition of the constituents of the body.*—Gas may likewise be developed by the putrefaction of the constituents of the animal body, either during life or after death. Its occurrence during life is not very rare; it takes place in putrid fevers, in typhus, and gangrene. Gas is most commonly evolved from the animal fluids, especially from the blood, when, before undergoing any chemical decomposition, it is arrested in different parts of the body, and its purification by respiration and secretion is thus impeded, when certain secretions, as the biliary and urinary, are checked, and their constituents remain in the blood. Gaseous

* Blondlot, op. cit. p. 95.

products are then developed, which collect in the parenchyma of organs, and in the cellular tissue, constituting emphysema, and find their way into the cavities, or finally are discharged externally. These gases are usually accompanied by a volatile odorous matter, and consequently evolve a penetrating putrid odour.* Morbid fluids effused into the cavities of the body may likewise undergo decomposition and evolve gases. Thus, pneumothorax may arise from the decomposition of fluid effused into the cavity of the pleura, and air may collect in the cavity of the peritoneum after gangrenous peritonitis. Likewise excretions, as urine or fæces, may develop gas when they escape through wounds, lacerations, fistulæ, &c., into the parts adjacent to their natural passages, and there undergo decomposition.

Many of the accumulations of air arising from putrefaction, which are found in the body after death, are formed after the cessation of vitality.† This putrefaction after death takes place, however, the more rapidly under similar external conditions (temperature of the surrounding medium, and the greater or less facility with which the dead body gives off its warmth to surrounding objects; the period that has elapsed between death and the examination, &c.), in proportion as the constituents of the body—at least its fluids—were predisposed towards putrefaction during the final period of life. There may, consequently, be an abundant secretion of gas in the dead body, when, from external conditions, it would not have been expected, if during life there has been a tendency towards decomposition. Hence, in individual cases, it is not always easy to determine whether gas found in the body existed there during life, or has been developed after death.

Many cases of pneumatosis in which authors have stated that no signs of putrefaction were presented by the body,‡ belong

* For further particulars, see *Gangrene*.

† See the chapter on the changes of the body after death.

‡ Otto, op. cit. p. 42.

probably to the latter category. Thus the vesicles of air in the vessels of the arachnoid, if they actually existed during life, and whilst the circulation was still proceeding, would, in accordance with the ordinary laws of physics, be conveyed with the blood to the heart.

We have thus shown, that very many of the accumulations of air that have been described as occurring in the body, may be explained on physical and chemical grounds. There remain, however, other cases that do not admit of explanation on these grounds, and we are almost led to add, that

3. *Gases may be actually secreted by different parts of the body.*

Thus, Magendie and Girardin assert that, on confining a portion of the intestine of a live dog between two ligatures, in the course of some hours the included portion was found full of air, which escaped with a hissing sound on making an incision.* In the intestinal canal of swine we sometimes meet with considerable accumulations of gas between the layers forming the walls of the bowels. Sir Francis Smith† has described an interesting case of the development of gas in man, which deserves a full notice. He states—"On the 12th of May, 1840, I was consulted by a gentleman, who told me that he often suffered from an enormous development of gas in the stomach, which he discharged by eructation: that he likewise, occasionally, experienced a development of gas from the bladder, and that his skin acted in a similar manner, as he had observed in the bath. On the morning of the 15th, I found my patient in a bath at 79° F. His breast, shoulders, abdomen, and hands, were literally covered with minute bubbles of gas. On being questioned, the attendant at the bath stated that he had never previously witnessed any

* Magendie et Girardin, Recherches physiolog. sur les gaz intestin. Paris, 1824, p. 24.; Lobstein, Path. Anat. vol. I. p. 138.

† Dublin Med. Journal, January, 1841, p. 454.

thing of the kind. On removing the hands and arms from the water, the air-bubbles disappeared, but gradually returned on again immersing those organs. The bubbles were of the size of a pin's head. On wiping them off, they disappeared, but gradually formed again."

In opposition to the above observations of Magendie and Girardin, it may be urged that the gas which was developed might probably have arisen from the decomposition of remnants of food in the inclosed portion of intestine, or that the portion of gut becoming distended by peristaltic motion, had imbibed air from the peritoneal cavity, or from the adjacent portions of the intestinal canal; and, similarly, the escape of air from the stomach and urinary bladder, in Smith's case, admits of the same mechanical explanation as has been given in a previous page. Not so, however, the escape of air from the skin: the fact that all bodies, when immersed in water, give off a little entangled air, affords no explanation of the continuous evolution of gas from the skin: neither does the accumulation of air occasionally noticed in the intestinal canal of swine seem to admit either of a mechanical or chemical solution. If we are asked for the particular causes of these developments of gas, I confess I can give no satisfactory reply. No secretion of gases occurs in the human body in a normal condition; for the development of gas in respiration is a purely physico-chemical proceeding, and is in exact accordance with the laws of displacement and diffusion of gases, as has been recently proved by Valentin and Brunner;* and, probably, the same law holds good for the development of gas through the skin. We can only refer to the analogical proceeding in fishes, where we find an actual secretion of gas in the swimming-bladder, and must, for the present, defer all further questions respecting their causes or pathological indications.

* Valentin, Lehrb. d. Physiolog. d. Menschen, vol. I, p. 559.

CHAPTER II.

ABNORMAL COLLECTION OF AQUEOUS FLUIDS.—DROPSIES.

MORBID collections of aqueous fluids in the body are designated by the general terms, hydrops, or dropsy. Dropsies are of very frequent occurrence, and in an anatomico-pathological point of view, present many varieties dependant on the region of the body in which the fluid has collected, on its action on the adjacent parts, and, finally, on the chemical properties and mode of origin of the fluid.

1. *The dropsical fluid may be situated in one of the serous cavities of the body, and in such cases it often amounts to a very considerable quantity.*—This class of dropsies has been further divided into dropsy of the pleura (hydrothorax), dropsy of the pericardium (hydrops pericardii), dropsy of the peritoneal sac (hydrops ascites), dropsy of the tunica vaginalis testis (hydrocele), dropsy in the cavity of the cranium (hydrocephalus), dropsy of the spinal canal (hydrorhachis), and of the eye (hydrophthalmus).

In these cases the fluid usually occurs free, and, in accordance with the laws of gravity, settles in the most dependant part of the serous sac. It is, however, occasionally enclosed in recently formed membranous sacs. It is then termed encysted dropsy (hydrops saccatus).

2. *The fluid may be effused within the parenchyma of certain organs.*

This condition is known as œdema; its ordinary position is the cellular tissue beneath the skin, between the muscles,

&c. The disease is then known as dropsy of the cellular tissue (anasarca, hydrops telae cellularis). It is, however, by no means rare to find the parenchyma of internal organs affected in this manner, as in œdema of the lungs. Moreover, certain forms of dropsy of the cellular tissue have received special names, as œdema of the cellular tissue of the upper part of the larynx (œdema glottidis), and œdema of the scrotum.

Some writers* have denied that œdema occurs in internal organs of dense texture, as for instance, the liver, spleen, kidneys and brain. They are undoubtedly wrong, for collections of dropsical fluids occur in these structures, as will be shown when we come to speak of the organs specially; but this condition may be easily overlooked, or ascribed to other causes.

Moreover, dropsical fluids are sometimes found enclosed in recently formed membranous sacs, both in the cellular tissue and in the parenchyma of organs. These sacs, with their contents, are termed hydatids. They are closely connected, in part, with encysted dropsy, and in part with other formations that will be subsequently noticed.

On examining the properties and chemical characters of dropsical fluids, we may divide them into:

1. Serous dropsy, in which the fluid is identical in its qualitative chemical composition with the serum of the blood.

2. Fibrinous dropsy, in which the fluid contains dissolved fibrin, and in its chemical composition resembles the plasma of the blood.

3. False dropsy (hydrops spurius), in which the fluid differs essentially in its chemical composition from either of the preceding forms.

These three forms of dropsy differ, not merely in the physical and chemical characters of their fluids, but likewise very essentially in their causes.

* Lobstein, op. cit. vol. I. p. 156.

Dropsical fluids are not always pure; they frequently contain extraneous substances, as, blood, pus, ichor, &c.

We shall not in this place enter fully into the various points connected with these fluids. The various forms of dropsy occurring in different parts of the body, will be fully discussed in the chapters on the individual organs. Here we shall merely treat of their general relations, and the causes of their formation; in this point of view, the chemical arrangement is the most suitable. The above chemical differences in dropsical fluids have only very recently been accurately determined.

I. SEROUS DROPSY.

Dropsy in which the effused fluid corresponds with the serum of the blood is by far the most common, and constitutes true dropsy in the restricted sense of the word. Most cases of ascites, hydrothorax, hydrocele, anasarca, and œdema, belong to this category, as likewise do the fluids of pemphigus, blisters, &c.

Properties and chemical composition of the fluids occurring in serous dropsy.—It is only the dropsical fluids effused in serous cavities, or enclosed in cysts, that can be collected in large quantity and in a state of purity, and be submitted to analysis; although the fluid of œdema does not admit of being collected in so large a quantity, or in the same degree of purity, it cannot be doubted that in its chemical and physical properties it is perfectly similar.

A pure dropsical fluid is generally nearly clear, limpid, or colourless; or, it may be, of a yellowish green tint, more or less turbid, opalescent, and whey-like.

Its reaction is most commonly alkaline, rarely neutral, and still more rarely acid. Sometimes it is as fluid as water, but is frequently thick, viscid and tenacious.

Under the microscope it appears as a pure fluid; it frequently, however, contains a small amount of corpuscles which, on standing, form a more or less abundant sediment. This sediment may possess various properties, and be dependant on very different modes of origin. It may contain fragments of epithelium from the serous surface, accidentally mixed with the fluid, pus-corpuscles from secondary suppuration, blood-corpuscles accidentally present, or finally, but rarely, an actual deposition of inorganic matter. The fluid of hydrocele frequently contains a crystalline deposit of cholesterin.

The many differences observed in the physical properties of dropsical fluids are dependant, for the most part, on the presence of extraneous matter. In a perfectly pure condition, the fluid of dropsy is either colourless, or of a yellow or yellowish green tint from the presence of bile-pigment. On the addition of nitric acid, it then yields the series of colours indicative of bile-pigment; that is to say, a little nitric acid renders it green; on the addition of more acid, it becomes blue, then violet-coloured, a hyacynthine tint, and finally of a pale yellowish red colour. A red colour is dependant on hæmatin; a milk-white turbidity, on the admixture of fat or epithelium scales, or of albumen, if the fluid is very aqueous.* The consistence varies with the chemical composition; the more water is present, the thinner it is. A large quantity of albumen renders it viscid; a very large quantity (above 12%) renders it thick, tenacious, and capable of being drawn out in threads, like albumen itself. Its alkaline reaction appears to be due, like that of the blood, to alkaline carbonates (?) or basic phosphates. An acid reaction is rare, but sometimes occurs in dropsy after miliary fever and acute rheumatism: the acid on which the reaction is dependant is probably lactic acid. I have on several occasions attempted to isolate it, but always without success, in consequence of the small quantity present.

The chemical constituents of the dropsical fluid are identical with those of the serum of the blood; water, organic substances, especially dissolved albumen, fat, and extractive matters, (sometimes, also, small quantities of urea, bile-pigment, and hæmatin) and various salts, (chiefly alkaline and earthy carbonates, (?) and phosphates, and chlorides.) The amount of these constituents is somewhat variable; sometimes the dropsical fluid is identical in its quantitative composition with the serum of the blood; but, most commonly, there is more water and

* Scherer, Untersuch. p. 113; or Simon's Animal Chemistry, London, 1846, vol. II. p. 491.

less organic matter to the same amount of salts. It is only very rarely that we find it more concentrated, and richer in organic constituents than the serum.

Dropsical fluids, especially those that have collected in large quantity in the serous cavities, have been often submitted to analysis. Of these analyses, I will only quote so many as are essential to the clear understanding of their chemical relations,* and for their better comparison with the normal serum of the blood.

	1 Serum of the blood.	2 Hydrocele.	3 Hydrocele.	4 Ascites.	5 Ascites.	6 Ascites.	7 Ascites.
Water	905.0	920.0	927	946	956	988.0	704
Albumen	78.0	71.5 (Albumen and Extractive matter)	48	33	29	0.9	290
Extractive matter	4.2		10	13 (Extractive matter and Fat)	9		2
Fat	3.8		9		7	10.0 (Fat and Salts)	—
Salts	9.0	8.5	6	8	8		4
	1000.0	999.0	1000	1000	1009	998.9	1000

1. Healthy serum of the blood, the mean of two analyses by Lecanu, (Etud. Chim. sur le Sang, p. 57).

2. By Marcet, (Leop. Gmelin, vol. II. 2nd Part, p. 1392.

3. By v. Bibra, (Chem. Untersuch. versch. Eiterarten, p. 160.)

4. Analysed by myself.

5. By v. Bibra, (op. cit. p. 170.)

6. Analysed by myself; the fluid was turbid and of a milky appearance.

7. By Dublanc (Leop. Gmelin, vol. II. 2nd Part, p. 1391.)

These analyses, conducted in different ways, and therefore not admitting of close comparison, clearly show the great similarity between the serum of the blood and these dropsical fluids. In analysis 2, the dropsical fluid is almost identical quantitatively with the serum; in the

* The most important chemical analyses of dropsical fluids may be found in the following works and Memoirs :—Berzelius' Thierchemie, 4th Edit. p. 198; Leop. Gmelin's Chemie, vol. II. 2nd Part, p. 1388, &c.; D. Wagner, mediz. Jahrbüch d. österr. Staates, 1833, vol. V. p. 2; Marchand and Bouchardat, in Valentin's Repert. vol. II. p. 198; Babington and Becker, in Valentin's Repert. vol. V. p. 359; Marquart in Albers' Atlas d. path. Anat. 14th Part; Valentin's Repert. vol. VI. p. 300; v. Bibra, chem. Untersuch. verschied. Eiterarten, Berlin, 1842, p. 155, &c.; Scherer, chem. u. mikrosk. Unters. z. Pathologie, p. 112, 119, 125; Simon's Animal Chemistry, vol. II. p. 490, &c.

following analyses, the amount of water increases, and of albumen diminishes, till in analysis 6, the latter has reached its minimum. The amount of salts, on the other hand, remains very nearly the same. The fat and extractive matters are extremely variable, and we cannot very well compare them in the two fluids. Analysis 7 shows that dropsical fluids may be more concentrated than the serum of the blood; and it would not be difficult to refer to other cases illustrative of the same point; for instance, several are given by Scherer;* they are, however, comparatively rare, and only occur when the effusion is of some standing, and a portion of the water has been gradually removed by absorption. In most of these cases, where the fluid is very thick and pultaceous, peculiar terms are applied, as, for instance, cysts, hygromata, &c. The causes of these varieties are, for the most part, enveloped in mystery; we shall, however, notice them in our observations on the causes of dropsy generally.

If, in its general characters, the dropsical fluid resembles pure or diluted serum, there still may exist in many cases chemical differences between them, which can only be detected by a careful analysis. The essential organic constituent of the serum, as likewise of dropsical fluids, is dissolved albumen, which, in the majority of cases, has all the properties of pure albumen or of albuminate of soda: it either coagulates immediately on the application of heat, or in the latter case, after the albuminate of soda, has been decomposed by an acid. On submitting this albumen to ultimate analysis, it is found to be identical with the ordinary protein-compounds (Scherer).† Sometimes the fluid does not coagulate thoroughly on boiling, even after the previous addition of an acid, although a large quantity of albuminous matter is present: the albumen appears, therefore, to be modified; it separates on evaporation in the form of a membrane, and in that respect, although not in its behaviour towards reagents, it resembles casein; this was observed in some of the cases analysed by myself. Scherer found a substance of this nature, similar in many respects to mucus, in the fluid of ovarian dropsy, which likewise contained albumen and albuminate of soda. Elementary analysis proved that in its composition, it differed from protein ($2Pr+NH_3-O_4$).‡ Moreover, Collard de Martigny found, in the contents of a long standing cystic tumor between the uterus and rectum an albuminoid matter, differing however from actual albumen;§ but it appears to be questionable whether the case should be

* Chem. und mikr. Unters. p. 125, 130.

† v. Bibra, op. cit. p. 217.

‡ Scherer, op. cit. p. 129; or Simon's Animal Chemistry, vol. II. p. 487.

§ L. Gmelin, op. cit. vol. II. 2nd Part, p. 1393; or Simon's Animal Chemistry, vol. II. p. 485.

regarded as one of dropsy. In many cases a portion of the protein-compounds is thrown down by the mere addition of water, but on adding a neutral salt, the precipitate dissolves, as is frequently observed in the albumen of the egg. From these observations, it follows that the protein-compounds occurring in dropsical fluids, present various chemical modifications—modifications which, in the present deficient state of our knowledge regarding the protein-compounds, it is impossible clearly to elucidate. Urea has been frequently noticed in dropsical fluids; thus in three cases, Marchand found 4.2, 6.8 and 5 in 1000 parts of fluid.* In other cases, again, this substance is either entirely absent, or is present in so very small an amount as to render its quantitative determination impossible (Scherer's† and my own observations). The salts in dropsical fluids are in general the same as occur in the serum of the blood. Chloride of sodium is usually the predominating ingredient; the other salts—phosphate and carbonate (?) of soda, sulphate of potash, phosphates of lime and magnesia, and lactates—occur in smaller and very variable quantities‡.

Under the term dropsical fluids, we include some which, from their pathology, are distinguished by special names; but which in respect to their chemical composition, as likewise to their mode of origin, are identical with the fluids we have been considering. These are the fluids of the bullous exanthemata (erysipelas bullosum, pemphigus, pompholyx), the vesicles resulting from burns, or from the application of cantharides, and those occurring in gangrene. The formation of bullæ differs in this respect alone from true dropsy, that the fluid is not enclosed within a shut sac, or effused in the tissue of an organ, but is confined beneath the cuticle, which is thus elevated, so as to constitute a blister. Some of these fluids form, as it were, the transition from serous to fibrinous dropsy. Moreover, dropsical fluids may be mixed with the secretions; for instance, with the urine, which, in such cases, is albuminous; with the sputa in œdema of the lungs, &c.

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* Valentin's Repert. vol. II. p. 198, and vol. III. p. 212.

† Op. cit. p. 116; or Simon's Animal Chemistry, vol. II. p. 491.

‡ Compare v. Bibra, op. cit. p. 159, &c; Scherer, op. cit. p. 121, 124; or Simon, op. cit. vol. II. p. 490, &c.

Some of these fluids have not yet been fully analysed. The fluid in blisters produced by burns, or the ordinary vesicants, (independently of minute flocculi, consisting of coagulated fibrin, pus-corpuscles, and epithelium-cells,) is clear, and sometimes of a yellowish-green colour, communicates a blue tint to reddened litmus paper, and in addition to its principal constituent albumen, contains a little fat, extractive matters, and the ordinary salts of the serum of the blood. In the fluid from a blister raised by cantharides, which on heating coagulated into a solid mass, Bostock found: water 928.6; albumen 60; extractive matters 1.4; salts 10.* The fluid of the vesicles that are found on the body, in cases of gangrene, is red (from dissolved hæmatin), but clear, resembling port wine diluted with water, and contains so large an amount of albumen, that on boiling it coagulates into a firm mass. The fluid of sudamina, containing no albumen, is not included in this category.

Causes and mode of origin of serous dropsy.—The close coincidence between the chemical composition of the fluid of dropsy, and the serum of the blood, seems to suggest that the former takes its source from the latter. Pathologico-anatomical observations and experiments on animals confirm this view; showing that any impediment to the venous circulation, in whatever part of the body it may occur, is accompanied by an effusion of dropsical fluid from the veins affected into the adjacent parts. Here we are induced to believe that serous dropsy always proceeds from the venous system, and that it takes place as soon as there is a want of balance between the porosity of the venous walls and the specific gravity of the blood contained therein; that is to say, when the venous walls become more porous, or the blood lighter and more aqueous than in the normal condition. In either case there is an increased transudation of serum through the walls of the vessels.† This is the manner in which local dropsy invariably occurs where individual veins are compressed, or, either for a time or permanently obstructed, as in cases of pressure from a tumour, or of complete obliteration. In this manner, the pressure of the impregnated uterus causes œdema of the feet; and pressure on the

* Leop. Gmelin, op. cit. vol. II. 2nd. Part, p. 1394.

† Compare Henle in Hufeland's Journal, May, 1840, p. 13.

vena portæ and *vena cava ascendens*, arising from degeneration of the liver, or some other tumour, produce ascites and œdema of the lower part of the body.

Instances of this nature are so numerous, and occur so frequently to every observant physician, that it is unnecessary to refer to special examples. In all these cases, if there are no anastomoses to carry off the venous blood, the hydrostatic pressure of the blood in the affected veins increases, and their walls become distended and attenuated. An increased flow of arterial blood to a particular part produces a similar result. If the aorta of an animal is compressed or tied below the spot at which the renal arteries are given off, dropsical effusion takes place from the renal veins; for the veins, as the most yielding part of the vascular system, become first distended by the increased quantity of blood.*

From these experiments we are led to the belief that the blood, under the influence of strong pressure, causes and gives origin to the formation of dropsical fluids, by permeating the attenuated vein-walls, so that the whole proceeding might at first sight be regarded as purely mechanical. This, however, is not the case, and the phenomena still present much that is obscure. In the first place, it is remarkable why the fibrin dissolved in the plasma does not enter into the dropsical fluid; and secondly, why, as a general rule, dropsical fluids should contain as large an amount of salts, and more water, but less albumen than the serum of the blood. This shows that the process is more complicated than at first sight it appears to be. A more accurate acquaintance with the relations of endosmosis than we at present possess is required to explain these points in a satisfactory manner.

As a local action on individual veins gives rise to local dropsy, so general dropsy is produced by causes acting on the venous system collectively; such as organic diseases of the heart and lungs, which hinder the return of the venous blood to the right side of the heart, and consequently give rise to an increased hydrostatic pressure throughout the whole venous system.

We shall enter at length into this subject, when treating of the pathological anatomy of the lungs and heart.

Dilatation of the veins, and subsequent dropsy may be

* Compare the investigations of Meyer in Roser und Wunderlich's Archiv. für Physiolog. Heilk. 1844, Part 1, p. 119; and those of G. Robinson in the Medico-Chirurg. Trans. 1843, p. 51—79.

dependant not merely on external causes acting mechanically on those vessels, but may arise from dynamic causes, such as nervous influence alone. In this way, dropsy occurs in paralysed limbs in very debilitated constitutions.* Under this head we may also place (what is termed) inflammatory dropsy, which is either a complication of dropsy with inflammatory exudation, or mere dropsy caused by an esoteric dilatation of the veins dependant on the nervous system, and accompanied by symptoms of irritation, (Fuchs's hydrochysis).

Dropsies of this sort are very frequent, but the phenomena accompanying them are generally complicated, and consequently their causes are not so immediately obvious as when the dropsy is dependant on mere mechanical conditions. To this class belong the blisters arising from burns or ordinary vesicants, erysipelas bullosum, anasarca after scarlatina and acute rheumatism, inflammatory hydrothorax, and acute hydrocephalus. These subjects, however, fall under the head of the pathology of the nerves, rather than of pathological anatomy. The difference between dropsy and inflammation will be found in our next section—on fibrinous dropsy. Serous dropsy, in my opinion, appertains to the venous system; and fibrinous dropsy to the capillary vessels.

The forms of dropsy already considered, take their origin in an attenuation (and increased porosity) of the venous walls; another cause of dropsy is probably to be sought for in an attenuation of the blood. Even at a very early period, the causes of most dropsies were referred to a modified condition of the blood, including those which we now know to arise from distention of the venous walls. Recent experiments have, at least, in isolated cases, confirmed this view; thus, Magendie found that dropsical effusions occurred after defibrination of the blood, and the same has been observed by Valentin, myself, and others, after the injection of a large quantity of water into the vessels. (In rabbits dropsy was easily induced; in dogs with more difficulty). Moreover, dropsy occurs when the blood has been rendered

* Compare Henle in Hufeland's Journal.

very aqueous by repeated venesection. Moreover, it is probable that the retention of the aqueous secretions, (as in cases of suppression of the cutaneous perspiration and urine,) may give rise to an excess of water in the blood, and thus cause dropsy.*

Our knowledge on these points is, however, still very imperfect. A large number of quantitative analyses of the blood in cases of dropsy may serve to fill up some of these deficiencies. It is not every temporary overloading of the blood with water that causes dropsy, otherwise the abundant use of water, if not at once carried off by the kidneys, would always produce it; hence other relations, at present unknown to us, are in action.

Henle's explanation of the causes of dropsy have obtained for him a deservedly high reputation. The laws which he has laid down appear to me only in so far to require limitation, that instead of referring the source of dropsical fluids to the vascular system generally, it should be limited, as we have already stated, to the venous system alone.

Further progress of the dropsical fluid after its effusion. A dropsical fluid may be either resorbed or remain unchanged. As only the aqueous portion admits of resorption, the fluid may become thickened. It admits of no organization, and cannot act as a cytoblastema for organic formations.

Whether, and to what degree dropsical fluids become resorbed depends on various causes. The veins resorb the aqueous portion by endosmosis, with a facility proportionate to the tenuity and dilution of the fluid. Hence it is clear that venous resorption cannot occur when dropsy is dependant on a mechanical impediment to the venous circulation. It takes place, however, when dropsy arises from a dynamic dilatation of the veins, as soon as there is a remission of the noxious agency. In addition to the veins, the lymphatics, also, exert a power of resorption; and if for any reason, the functions of both classes of vessels are destroyed, there can obviously be no resorption. On the other hand, resorption by the lymphatics may proceed with such activity that the effused fluid is at once removed; and, therefore, cannot collect in any quantity. In this point of view, the old opinion, that dropsy was dependant on increased exhalation and diminished resorption, has a certain degree of truth. Resorption is, however, dependant on local

* Henle, op. cit. p. 16.

relations and circumstances. Œdema, in portions of the body abundantly supplied with lymphatics, disappears much more readily than dropsy in cavities where the only absorbents are situated on the surface. By the absorption of the water and salts, in accordance with the laws of endosmosis, the fluid becomes thicker, and ultimately forms a viscid mass, containing comparatively little water, but much albumen (see p. 37, anal. 7). That the dropsical fluid never forms a cytoblastema in which pus-corpuscles or other cells can be developed, I have convinced myself by numerous experiments. When pus-corpuscles and other organic forms occur in dropsical fluids, they always arise from other plastic processes accidentally combined with the dropsy. But by chemical influences some of its own constituents may be separated, as, for instance, cholesterin, or albumen, on diluting the fluid with water (see page 39).

Diagnosis of the dropsical fluid, and its anatomical relations.—Dropsical fluids may be recognised by the physical and chemical characters already described. They are distinguishable from the spurious dropsical fluids (subsequently to be described), by their containing fluid albumen, which coagulates on the application of heat, or the addition of nitric acid. A precipitate is caused by the addition of nitric acid, when (as we have already mentioned), the albumen is modified, and no longer coagulates on boiling. It is only in those cases in which the dropsical fluid contains so little albumen that no coagulation occurs, either on boiling, or on the addition of nitric acid, that the diagnosis becomes difficult or doubtful; then, however, a quantitative analysis usually gives the required information. It is distinguished by negative characters from other morbid fluids, as fibrinous dropsy, pus, &c.; it does not coagulate spontaneously, and contains no essential corpuscles, such as occur in blood and pus. By means of a quantitative analysis we can sometimes, but not generally, ascertain whether these substances are mingled with the dropsical fluids.

On this subject, see the remarks on the following fluids.

If the dropsical fluid is contained in a serous cavity, the sac becomes distended, and compresses the adjacent organs.

The serous membranes enclosing the fluid are usually (and always when the disease is of any duration) loosened (*aufgelockert*), pale, dull, and opaque. In cavities with yielding walls, fluctuation may be detected by percussion.

In infiltration of the tissues, there is a soft, pasty, shining tumidity, which pits on pressure of the finger. On making a puncture or incision, the fluid escapes either by drops, or in a stream, in proportion to the quantity present. The fluid occurs in the first place in the interstices between the elementary parts of the tissues, which imbibe it and assume a less compact and more flaccid appearance than in the normal condition In recent cases, that is to say, when the venous dilatation that has caused the dropsy has only occurred shortly before death, the dropsical organs appear to be reddened (as is frequently noticed in pulmonary œdema); usually, however, they are pale, and only the larger veins appear to contain much blood.

More on this subject will be found in the second part when speaking of the separate organs.

2. FIBRINOUS DROPSY.

This species of dropsy, distinguished by the circumstance of the effusion containing dissolved fibrin, is not rare, being of more frequent occurrence than the preceding, although hitherto it has seldom been described,* and its signification has not been properly interpreted. It has never hitherto been correctly distinguished from serous dropsy, and has consequently never had a special name assigned to it. Like serous dropsy, it may occur either in serous cavities (as in the pleura,

* Cases in which this form is described are given by: Schwann and Magnus, in Müller's Archiv. 1838, p. 95, &c.; Delaharpe, in Archives génér. de Med. Juin, 1842; Scherer, Unters. z. Patholog. p. 106—110; or Simon, op. cit. v. II. p. 491, &c.; Gluge, Anat. mik. Unters. 1838, p. 74; Quevenne, Journal de Pharmacie, Nov. 1837. I have myself observed a very large number.

arachnoid, peritoneum, or pericardium), or may collect in the parenchyma of organs, either by infiltration, or by filling recently formed cavities in them, as, for instance, in the substance of the brain. Hitherto, this occurrence has received the general name of dropsy; effused into the peritoneum, it is known as ascites; into the pleura, as hydrothorax or empyema; into the parenchyma of organs, as œdema. This morbid process is, however, distinguishable by the circumstance, that the fluid does not, like that of serous dropsy, present any constancy in its behaviour towards different reagents, but under varying circumstances occurs in varying forms, as will be fully shown in its proper place.

Properties and chemical composition of this fluid.—The fluid is essentially the same, whether obtained from the parenchyma of an organ, or from a serous cavity. In the latter case, however, it may be obtained in larger quantity, and purer, and consequently its different properties are more obvious.

Examined immediately on its discharge, the fluid resembles in all points that of serous dropsy. It is either perfectly clear and colourless, or else more or less turbid, opalescent, and of a greenish yellow colour; and, examined microscopically in its recent condition, exhibits either no solid particles, or only such as may be accidentally present, as occasionally minute amorphous coagula of fibrin, pus-corpuscles, &c. Some time after its discharge, the whole fluid generally coagulates in consequence of holding fibrin in solution, and forms a homogeneous, tremulous jelly, which, after standing for some time, separates into a partially consistent, colourless, or yellowish-red clot of coagulated fibrin, and a clear, yellow fluid analogous to the serum of the blood. On washing the clot with water, and pressing it between folds of fine linen, we obtain a small quantity of tolerably firm, stringy fibrin, precisely similar to that which may be obtained from fresh blood by stirring and thoroughly washing.

The coagulation of the fibrin sometimes takes place in the body during life, as we shall presently show. The coagulation out of the body, to which we have already referred, varies considerably in the time of its occurrence; sometimes taking place in an hour, in other cases, not until the lapse of twelve, or even twenty-four hours. Moreover, Delaharpe (op. cit.) has occasionally observed the fibrinous clot re-dissolve in the fluid. The coagulated fibrin appears under the microscope as a perfectly amorphous mass, and devoid of any traces of cellular structure.

In its chemical composition, this fluid is identical with the plasma of the blood; that is to say, with the blood independently of its corpuscles; it is serum, or the fluid of serous dropsy, with dissolved fibrin. By chemical analysis, we find that it contains: water, dissolved fibrin and albumen, fat, extractive matters, and salts (chloride of sodium, carbonate (?) and phosphate of soda, sulphate of potash, phosphates of lime and magnesia, carbonate (?) of lime, and lactates). The similarity of the fluid to the plasma of the blood occasionally extends even to their quantitative composition; usually, however, the dropsical fluid is the richer in water, and contains a less amount of organic constituents—albumen and fibrin. It is very seldom that this rule is reversed. In this point, therefore, there is the same relation as between the fluid of serous dropsy and the serum of the blood.

In order to give a clear view of these relations, I shall communicate a few analyses, preceded by a formula representing the mean composition of the plasma of the blood.

1000 parts of fluid contain:

	1 Plasma of the blood.	2 Empyema.	3 Empyema.			4 Empyema.		5 Ascites.
			A.	B.	C.	A.	B.	
Water	906	903,5	945,6	953	941	935,5	936	881
Fibrin	3,4	1,7	1,09	0,91	—	0,62	0,60	83
Albumen	77	77,5	47,3	32	42,2	49,8	52,8	27
Extractive matters	3					3,4	1,6	
Fats	3	17	6	6	7,2	2,1	1,4	
Salts	8			8	8,1	8	7,4	9
	1000,4	999,7	1000,0	1000	998,5	999,4	999,8	1000

1. The mean composition of the plasma of the blood, according to Lecanu.

2. The fluid of empyema removed by paracentesis, analysed by Quevenne.*

3. The fluid of empyema consequent on pleuritis, analysed after paracentesis by Dr. Merklein and myself.

A. Discharged at the first operation, on the 18th of January, 1841.

B. Discharged at the second operation, on the 25th of January. On both these occasions the fluid coagulated after some hours.

C. Discharged at the third operation, on the 27th of January, shortly before the patient's death. It did not coagulate, and contained no fibrin; that constituent seemed to be supplanted by pus-corpuscles, which formed a white, creamy sediment at the bottom of the fluid.

4. Fluid of empyema, analysed by Scherer.†

A. The fluid yielded at the first operation.

B. The fluid yielded at the second operation, eight days subsequently.

5. Fluid of ascites, analysed by Schwann.‡ The form of the analysis is slightly modified, in order that it may admit of comparison with those that precede it. The amount of fibrin is so large, that a doubt arises whether the amount stated was actual fibrin.

These analyses are sufficient to show the close similarity, in a quantitative point of view, that exists between the fibrinous form of dropsy and the plasma of the blood. The differences are slighter than between serous dropsy and the serum of the blood. Analyses 3. and 4. are especially interesting, as showing that there may be very considerable differences in the secretion of the same organ of the same individual under similar circumstances. It seems impossible to make analysis 5. (by Schwann) harmonize with the others; probably the amount of fibrin is much overstated. It is very possible that Schwann neglected to wash the clot before drying it, and that it contained pus-corpuscles, &c. At any rate, this seems to be the case when we consider that the amount of fibrin in the dropsical fluid (according to this analysis), exceeds by twenty-four times the amount in the normal plasma. With respect to the other constituents of fibrinous dropsy, the same observations apply as to serous dropsy. The albumen occurs either as pure albumen, or albuminate of soda. Of the fixed salts, Scherer§ found chloride of sodium 7.5, carbonate of soda 0.8, phosphate of soda 0.4, sulphate of potash 0.9, phosphate of lime 0.3, carbonate of lime 0.3; total 10.2 in 1000 parts of fluid.

* Journal de Pharmacie, Nov. 1837.

† Op. cit. p. 106.

‡ Müller's Archiv., 1838, p. 95.

§ Op. cit., p. 111.

In analysis 3 B instituted by Dr. Merklein and myself, the salts in 1000 parts of fluid amounted to 8, of which 0.4 was phosphate of lime; there was also much carbonic and a little sulphuric acid, chlorine, and a trace of phosphoric acid; of bases there was much soda, and traces of potash, magnesia and lime. In 3 A there was much chlorine, a little phosphoric acid, much carbonic and no sulphuric acid.

The fluid of fibrinous dropsy may be effused on the surface of the body in vesicles and pustules, in the same manner as the fluid of serous dropsy: it always occurs in the pustules of variola and varicella, at least in the early stages; frequently in the blisters from the ordinary vesicants, and burns before they have proceeded to suppuration, and in many other similar cases. It may also be mixed with the secretions, in which case they possess the property of spontaneous coagulation; this has sometimes been observed in the urine.*

I may mention, as a case of this sort, a secretion containing dissolved fibrin, from the udder of a goat: it is interesting as showing that the same process takes place in animals. In the summer of 1842, I received from a veterinary surgeon a glass with the following note. "It contains a fluid from the udder of a goat suffering from inflammation of that organ, it is originally of a pale green colour, and issues only from one teat, the others yielding normal milk." The fluid amounted to about an ounce, was of a greenish yellow colour, and rather turbid. There was floating on it a coagulum somewhat larger than a walnut, which did not make its appearance till after it had been despatched to me. It was larger than the orifice of the glass, so that there was some trouble in removing it. The fluid appeared homogeneous; but when examined under the microscope was seen to contain innumerable normal pus-corpuscles about the 400th of a line in diameter, which gave rise to its turbidity. The clot was composed of coagulated fibrin, which, when examined under the microscope, appeared to be amorphous; it enclosed numerous pus-corpuscles, and a section exhibited a radiating appearance. Not a trace of milk-globules could be seen either in the fluid or in the coagulum.

Causes, mode of origin, and further development of fibrinous dropsy.—If there are good reasons for believing

* Compare H. Nasse, Unters. z. Physiolog. und Pathol. 2nd Part, p. 209.

that the fluid of serous dropsy is derived from the blood, the reasons in favour of the fibrinous fluid arising from the same source are even stronger; for it so very closely resembles the plasma of the blood, that in many cases no difference whatever can be detected, and, indeed, we can imitate the fibrinous fluid by quickly filtering frog's blood through fine tissue paper. Hence, we are led to the view that, in this case, even more decidedly than in the serous form, there is a purely mechanical permeation of the plasma through the walls of the vessels. We must not, however, forget that the fluid sometimes appears more dilute, and, as a general rule, contains rather less fibrin and albumen than the plasma of the blood. Hence, in such cases, as we have already seen, endosmotic action is called into play, only to a less degree than in serous dropsy. Since the serous, and also the fibrinous fluids, take their origin from the blood, and are produced by the permeation of its fluid constituents through the walls of the vessels, how is it that in some cases we have one, and in others, the other form of effusion? In the present state of our knowledge, this question cannot be satisfactorily answered; there is, however, every probability that it admits of this solution: namely, that serous dropsy, as we have already stated, owes its origin to a permeation of the fluid of the blood through the walls of the veins, while fibrinous dropsy arises from a similar permeation through the walls of the capillary system.

In favour of this view may be urged: firstly, the different properties of the walls of these two divisions of the vascular system. The veins have thick walls, consisting of several layers of cells and fibres, while the walls of the capillaries are very thin and delicate. It is true, that we cannot accurately estimate the differences in their endosmotic properties, but from analogy (from all the experiments that have been made in this department), we may conclude that the product of endosmosis, in the former case, is more dilute and poorer in solid constituents; and that in the latter, it is more concentrated and abundant in them. Secondly, as we have already shown that serous dropsy is associated with dilatation of the veins and attenuation of their walls, so we learn from microscopic examination of the capillary system, that a dilatation of those vessels and an attenuated condition of their walls, precedes, and is associated with the occurrence of the fibrinous fluid, either in the parenchyma of an organ, or in a cavity. The simultaneous occurrence of the effusion, and the modified condition of the vessels is, however, so constant, that we may conclude with all the certainty possible in such cases, that the dilatation of the capillaries is the cause of the effusion. It naturally follows, that in the gradual transition of the capillaries into veins, there is no rigid limit between fibrinous and serous dropsy, and that one may easily merge into the other. Further, many causes producing a dilatation of the capillaries can likewise act in a similar manner on the veins; hence the two processes are very frequently associated together; and thus, in the fluid of serous dropsy, we very often meet with small quantities of fibrin.

In serous dropsy, the causes of venous dilatation are frequently mechanical, and are, consequently, included in the department of pathological anatomy. Not so with fibrinous dropsy. Here the dilatation is dependant on dynamic causes, whose investigation would, of necessity, lead us far into the department of nervous pathology. We should, moreover, be led to the consideration of many other phenomena, as, for instance, the stoppage of the blood in the dilated capillaries, which will be considered in another place. I restrict myself, therefore, at present, to the mere statement that fibrinous dropsy is essentially dependant on the capillary system; that it is associated with, and for the most part arises from a dilatation of those vessels, and a tension and attenuation of their walls.

The consequence of this process, in relation to the pathology, as well as to the physiology of nutrition is so great that, in point of importance, there is scarcely any other that can be compared with it. All nutrition depends on an effusion of fibrinous fluid into the parenchyma of organs, and the transition from the normal state into a morbid condition is so imperceptible, as to render any line of rigid demarcation an impossibility. And, as the process admits of being associated with many others, it has received a variety of appellations. Many portions of the process of inflammation, may be referred to it. The so termed exudation, and the effusion of plastic lymph are nothing more than the result of this same process, and the general nutritive fluid which we term, "exudation, or plastic lymph," is nothing more than the fibrinous fluid now under consideration. I have made this brief statement with the view of avoiding unnecessary repetition; I shall subsequently have occasion in many places to take up the thread, which I for the present drop, and pursue it further.

The subsequent fate of the fibrinous fluid may be much varied; and the course it may take is of high pathological significance. It is mainly dependant on two principal conditions: firstly, the fibrinous fluid being coagulable, coagulation may occur while the fluid is still in the body; and, secondly, as it admits of plasticity, and it may act as a cytoblastema for organic formations. Both these points require a full consideration.

The fibrinous fluid may remain unchanged in the body for days, or even weeks; and then coagulate on its discharge and behave in the manner already mentioned. In other cases, however, the fibrin coagulates in the body itself. It then forms a coagulum of more or less firmness; which, under the microscope, appears either perfectly amorphous, or exhibits a confused fibrous, or radiating appearance; and is sometimes covered with a finely granular, or pulverulent matter.* If the fluid is effused in the parenchyma of an organ, these coagula fill all the interstices between the elementary parts of the

* See pl. II. figs. 2 and 3; and pl. III. fig. 5.

tissue surrounding them, just as solidified mortar does the stones of a wall, and forming with them a compact, apparently homogeneous mass, in which the original elements of the tissue can only be rendered visible by the action of acetic acid or ammonia, which dissolve the coagulated fibrin. In the cavities, on the other hand, these coagula occur as flocculent, or filamentous masses, either attached to the walls of the cavity, or, occasionally, swimming unattached in the fluid; or the fibrin may be deposited in layers on the walls of the cavity, forming membranous patches. These membranes occasionally form a perfectly closed sac within the cavity; indeed, there may be several such sacs of coagulated fibrin lying one within the other. This is the origin of encysted dropsy, and of many forms of hydatids. When all the fibrin dissolved in the fluid has assumed the coagulated condition, and has become perfectly isolated, then the remaining fluid in every respect corresponds with that of serous dropsy, and, consequently, the older observers regarded all these as cases of "hydrops serosus."

The question, why the fibrin in many cases remains for a long time fluid, whilst in others it rapidly coagulates, and on what its coagulation in the latter cases is dependant, cannot at present be satisfactorily answered, any more than we can state with certainty, why the blood coagulates after its removal from the body. The most satisfactory reason is doubtless a chemical one, although at the same time certain influences of the organism seem also to be in play. Just as difficult is the explanation how and why fibrin in its coagulation assumes such very different forms.* On allowing a fibrinous fluid to remain in a state of repose, the whole mass at first assumes the consistence of a tremulous jelly; the fibrin then collects together and forms a species of clot, whereby a portion of the fluid contained in it is mechanically pressed out, and separates as serum. If, on the other hand, the fibrinous fluid during its coagulation is stirred with a rod, or is shaken with solid bodies, as fragments of glass, &c. in a stoppered bottle, the fibrin then assumes a filamentous, or membranous form on the solid bodies.

* A very instructive account of the various relations influencing the coagulation of fibrin, is given in Henle's Report: Zeitschr. für rationelle Medic. vol. II. p. 168, &c.

From these acknowledged facts, and with the aid of experiments on the dead body, we may draw many conclusions respecting the mode in which fibrin coagulates in the living body. A perfect coagulation of the fibrin (such for instance as to form a jelly), never or very rarely occurs within the body. The comparatively frequent cases where an apparently gelatinous exudation occurs, as for instance, on the surface of the pleura, do not fall under this head: they consist merely of serum, with which the fibres of the serous membrane are infiltrated. Experience teaches us that the coagulation of the fibrin takes place more slowly within than without the body, and hence it is probable that the organic parts exert a certain attractive power on the fibrin, such as the glass rod seems to do during the process of stirring. Further, the organs of the body are seldom in a state of absolute repose, but in a manner imitating the action of stirring, which we adopt in the artificial separation of the fibrin. Thus, in the cavities we find stratified depositions of coagulated fibrin. As coagulation within the body takes place very slowly, these layers are extremely thin; a layer, a line in thickness, of coagulated fibrin may be divided into twenty or more separate and distinct strata. From the regularity and similar thickness of these layers, it cannot be doubted that they have been successively deposited by the fluid, so that the outer layer (that namely in apposition with the serous membrane) is the oldest. As a further argument in favour of this view, it may be added that the external layer is the first that becomes organized.

If, moreover, we bear in mind that in many cases the separation of the fibrinous fluid from the capillaries is very gradual, and further, that it does not occur equally at all points of a serous membrane, (as for instance, the pleura or peritoneum) we can easily understand why some parts of these membranes are covered with layers of coagulated fibrin, while others are not. In such cases, the fibrin coagulates at the points at which it exuded, depositing itself on the serous membrane, and forming slight elevations on it. The subsequent exudation seems to be chiefly deposited on these elevations, which, like foreign bodies, act as points of attraction, and in this way there are formed tufts, flocculi, &c. This affords us an easy explanation of the formation of the *cor villosum*, and other singular forms of coagulated fibrinous exudations, without any necessity for having recourse to electricity, &c., as has been done by Eisenmann, who fancies that in these forms he can detect electric figures.*

As long as the fibrinous fluid is not coagulated, it may, like the serous fluid, be resorbed, and either entirely or in part disappear, or become more concentrated; and the resorption

* Häser's Archiv. vol. I. Part III. p. 373.

proceeds with a greater facility than in the former case, there being commonly no hindrance to the activity of the venous system.

But if the fibrin has once coagulated, then the resorption can only extend to the serum; hence, in consequence of their loosing a portion of the fluid enclosed in them, the fibrinous coagula become tougher and firmer. The coagulated fibrin can only disappear by undergoing an organic change, as will be shown in the following section. Whether it cannot be rendered fluid, and then gradually resorbed by chemical means, as, for instance, by the use of iodine, and other similar remedies, must, for the present, remain unanswered questions.

The dropsical fluid, enclosed in a sac of coagulated fibrin, is in a manner cut off from the resorbent vessels—the veins and lymphatics; and its resorption is a more difficult and tedious process than if it were not thus enclosed. This explains the unyielding character of encysted dropsy.

The fibrinous fluid is capable of organization, which is always effected at the expence of the fibrin contained in it. It constitutes the peculiar cytoblastema; hence there is no developmental capacity in the fluid of serous dropsy in consequence of the absence of fibrin. As far as development is concerned, it is indifferent whether the fibrin is in a fluid or coagulated state, as in either case it acts equally well as a cytoblastema, and its capacity is unlimited, that is to say, there may be evolved from the fibrin the most different forms of tissue, either normal, as cellular tissue, simple muscular fibre, cartilage, bone, vessel, nervous fibre; or pathological, as, pus, granular cells, cancer, tubercle, concretions, &c. The process of development invariably follows general laws, whose bearings I have attempted to investigate in the following section on pathological epigeneses. Through this capacity for organisation, fibrinous dropsy becomes the common source of a great variety of morbid growths, as will be shown in the subsequent chapters.

The first indication of the developmental process in the coagulated fibrin, is the formation of cells: till then it is amorphous. Sometimes the fibrinous coagula attached to the serous membranes contain cells of an earlier formation; these, however, are not developed from the fibrin, but appertain to the epithelium of the serous membrane, and having been thrown off during the process of exudation, have thus become entangled in the coagulating fibrin. This is especially frequent in recent exudations into the pericardium, and in all probability the case described and illustrated in pl. II. fig. 4, belongs to this class.

The fibrin appears to undergo no essential change in its elementary composition by the act of coagulation; subsequently,* however, certain chemical changes do occur in it. I postpone their consideration to one of the following sections.

Diagnosis of fibrinous dropsy, and anatomical relations of the surrounding parts.—The fluid is sufficiently characterised by its containing dissolved fibrin, and by its spontaneous coagulation after removal from the body. The diagnosis can only be doubtful when a serous fluid contains a considerable quantity of blood, as sometimes happens from the operation of paracentesis; for a serous fluid, mixed with one third or one fourth its quantity of blood, after a time likewise gelatinizes. If, however, the amount of blood is not so considerable (and this may be decided by the colour and the quantity of the blood-corpuscles), then the coagulation of the fluid is a certain sign that the dropsical effusion contained dissolved fibrin. If the fibrin has coagulated within the body, the diagnosis is rendered certain by the following tests: by the appearance of the coagulum under the microscope; by its becoming transparent on the addition of acetic acid or ammonia; by its dissolving in caustic potash, and by the liquid in which it floats resembling that of serous dropsy.

The surrounding parts are usually reddened, and when

* Von Fellenberg, (Fragments de recherches comparées sur la nature constit. de differ. sortes de fibrine du cheval. Berne, 1841), believes, however, that he has proved by his ultimate analyses, that it loses the elements of hydrogen, or of oxygen and hydrogen in the proportion to form water; a view which being opposed to the experiments of Scherer and others, at all events requires further confirmation.

examined under the microscope, their capillaries appear to be distended and filled with blood.*

When the parenchyma becomes infiltrated by the fluid, there is at first a soft, doughy swelling, such as occurs in serous dropsy; when, however, the fibrin coagulates, the tumour becomes hard, and, on making a section through it, appears firm and lardaceous. Since, however, in inflammatory affections of the external organs, the fibrinous fluid is usually poured forth very gradually from the capillaries, the first portion coagulates before the second is effused; hence, the tumour is commonly firm and resistent from the time it is first observed.

When effusion takes place in a serous cavity, it gives rise to distention of the enclosing membrane; and, hence, to compression of the surrounding parts.

The fibrinous effusion is of most common occurrence after pleuritis, or pericarditis; it is more rare after peritonitis succeeding paracentesis. In the dead body it is usually found in a coagulated state.

3. FALSE DROPSY.

In the early systems of pathology, many cases were regarded as dropsies, in which fluids collected in the secreting organs, or in their discharging passages, in consequence of some impediment to their exit. Thus, we read of dropsy of the kidneys (hydrops renum), of the uterus (hydrometra), of the fallopian tubes, of the gall-bladder, of the appendix vermiformis of the cæcum, and of the lachrymal sac. These dropsies belong neither to serous nor to fibrinous dropsy. They arise from the duct of the secreting organ being, in some part of its course, either temporarily or permanently closed. In consequence of this impediment, the fluid accumulates in the secreting organ, and in its discharging duct as far as the obstruction, distending those parts. The fluid in this form of dropsy, is, therefore, originally identical with

* See pl. II. fig. 1.

the secretion which has thus given rise to the tumour; in the kidneys it is urine; in the intestines, uterus, and fallopian tubes, it is a product of the secretion of the mucous membrane, &c. If the obstacle continues for any length of time, the secretion undergoes certain changes, becoming modified by the endosmotic action that is set up between it and the surrounding fluids. Hence, for instance, the fluid of dropsy of the kidneys (hydrops renum) is not always identical with normal urine.

The particulars respecting the different forms of these false dropsies may be found in the special part of our treatise, under the individual organs.

CHAPTER III.

PATHOLOGICAL RELATIONS OF THE BLOOD.

The blood of the human body may in various ways deviate from its normal condition. The following may be regarded as the most important deviations:

1. Its physical and chemical characters may undergo alteration. It may be either thinner or thicker than usual, and its colour may be affected. The blood-corpuscles may appear changed. The proportion of its constituents to each other may be altered, and it may contain matter not normally existing in it, as sugar, free lactic acid, &c.

2. Its quantity may be increased (hyperæmia or polyhæmia) or diminished (anæmia or hypæmia). This increase or diminution may either be general, extending to the whole organism, or local, and restricted to particular parts of the body.

3. It may be effused in consequence of laceration of the blood-vessels, into the interstices of the parenchyma of certain organs, or into some of the cavities of the body, constituting extravasation.

4. The hæmatin may, by a process of decomposition, become dissolved, and then be imbibed by the tissues.

1. PHYSICAL AND CHEMICAL CHANGES OF THE BLOOD.

Deviations in the physical and chemical characters of the blood are of very frequent occurrence. We find them in the body after death, just as they are observed during life when blood has been taken by venesection or other means; and yet, until recently, the statements of most authors respecting these changes are extremely indefinite and unsatisfactory, rendering it alike difficult to attach any certain meaning to their facts, or to discover their causes or signification. Moreover, there is hardly another department in the whole range of medical science which has been so frequently used as a foundation for false hypotheses and theories relating to pathology and therapeutics—hardly another on which the majority of the profession entertain such obscure views and vague ideas as on the pathological changes of the blood. Hence, on this subject, the necessity for thoroughly determining the rigid and exact truth is doubly necessary.

The above changes may be arranged under two divisions, in accordance with the means requisite for their detection; firstly, such as are directly obvious to the senses, and are especially noticed in pathologico-anatomical researches on the dead body. These are principally modifications in its physical characters, as in the colour, consistence, or nature of the coagulation. Secondly, such as for their detection require certain processes, often of a complicated nature—as most of the deviations of a chemical character.

In accordance with the plan stated in my Introduction, I shall say nothing of the physiological or vital phenomena of the blood. But the changes in the blood which are recognizable by the senses, belong strictly to pathological anatomy, and with respect to the chemical changes, I certainly think that the most important, if they are sufficiently confirmed, should not be excluded, even if they appertain less to pathological anatomy than to chemistry. But it is the task, and fortunately also the tendency of the present day, to unite these two sciences.

DEVIATIONS IN THE PHYSICAL CHARACTERS OF THE BLOOD.

Change in colour. — Arterial blood in a normal state is, as is well known, of a bright red, while venous blood is of a dark red colour, with a shade of blackish brown. Any attempt at an accurate estimation of these shades of colour, and of the associated pathological conditions, by mere description, must of necessity be vague and unsatisfactory. To obtain accurate results of this sort, we should draw up certain colour-tables, such as are used in the cyanometer for the purpose of estimating the blue tint of the sky. Hence, the statements hitherto made respecting the changes of colour noticed in the blood are very unsatisfactory. The following are the most important of these changes. Variations in the colour of arterial blood have been seldom noticed, and little is known regarding them, in consequence of the few opportunities that present themselves of examining that form of blood. In cases of cyanosis, where the venous and arterial currents become partially mixed, in consequence of a portion of the former not passing through the lungs, but going through the patent *ductus botalli*, *foramen ovale*, or a perforation of the wall separating the ventricles, it is commonly darker than in the normal condition. A similar condition is probably established in those pulmonary diseases in which, although the passage of the blood through the lungs is not impeded, the free contact of the blood and atmospheric air is disturbed, as in *œdema pulmonum.* Here the cause is sufficiently obvious. It consists of a limitation of those shades of colour which the venous blood naturally acquires in its passage through the lungs. It is seldom clearer, but often of a darker colour than in the normal state. Venous blood is sometimes observed with a bright red tint in cases of scurvy;* this is probably dependant on an increased amount of saline matter, which as is known, communicates

* Lobstein, path. Anat. vol. II. p. 537.

that tint to the blood. I have sometimes noticed venous blood of a bright red colour, with a shade of blue, much the tint that is developed on treating uric acid with nitric acid and ammonia: thus, in the dissection of an arthritic subject, the blood of the renal veins presented this tint. In other cases, the venous blood appears dark, of a brownish red or almost black colour, sometimes even resembling tar or ink. These variations in colour are often associated with other physical changes, as an abnormal increase or diminution of density, &c. They are, however, never so constant as to permit of our always finding the same tint in the same disease, nor can we recognise their causes with any degree of certainty. In fact, the causes of the tints proper to healthy arterial and venous blood are not altogether established. Hence, no great importance should be attached to any peculiar colour presented by the blood, and still less should any conclusions be drawn from them, at least, until we are in a better condition than we now are to recognize with certainty the cause of such a change in each individual case.

With respect to the causes of the difference in the colour of arterial and venous blood, see H. Nasse's Article in Wagner's Handwörterbuch der Physiologie, vol. I. p. 181, &c., where all that we at present know on the subject is clearly described and criticised. The colour of the blood is modified by the action of many different substances, and we possess a great amount of information respecting these artificial changes;* but even the very circumstance that so many causes produce a similar colour, renders the determination of the cause in an individual case, a matter of much greater difficulty.

The colour possessed by fresh blood remains after coagulation and the separation of the coagulated blood into the clot and expressed serum. The former retains the original colour, but, after a time, the surface usually assumes a brighter tint from the action of the oxygen of the atmos-

* Compare Berzelius, Thierchemie, 4th Edit. p. 72, &c.; Simon's Animal Chemistry, vol. I. p. 112; and especially Hünefeld, der Chemismus in der thier. Organisation, p. 117.

phere. In the normal state, the serum is colourless, but it frequently exhibits a brownish green, or yellow tint. This yellow, yellowish green, or brown colour of the serum, may depend on two distinct causes.

1. *On bile-pigment.*—In this case on treating the serum with nitric acid, the well-known changes of colour are produced: a little acid renders the serum green; a larger quantity, blue, purple, violet, and lastly of a dull red or yellow colour. This reaction is, however, usually somewhat modified by the presence of the albumen of the serum, which is precipitated by the acid, and subsequently assumes a yellow tint, which conceals or modifies that of the altered bile-pigment. A large amount of this pigment is always present in cases of jaundice, when not merely the blood, but also the other fluids and secretions, and even the parenchyma of the different organs become of a yellow tint. This may, however, occur without jaundice in persons apparently healthy. I have seen a large amount of bile-pigment in the serum of an old man, who was not jaundiced, in whose case venesection was ordered in consequence of apoplectic symptoms, and a smaller, but still very considerable quantity in the serum of a man with arachnitis.

2. The yellowish green or brown tint of the serum may be dependant on the brown colouring matter of healthy blood, which was first described by Simon, and received the name of *hæmaphæin* from that chemist.* Nitric acid will serve to prevent its being mistaken for bile-pigment.

The, serum which in a normal state ought to be clear, is sometimes opaque and of a milk-white appearance. This may depend on various causes. Firstly, on a large number of microscopic fat-vesicles. Secondly, on the presence of a considerable quantity of minute granules of coagulated fibrin,

* For a description of hæmaphæin, see Simon's Animal Chemistry, vol. I. p. 42.

as has been observed by Scherer and Simon.* Thirdly, probably also on the formation of a free acid in the blood, whereby a portion of the albuminate of soda becomes decomposed, and albumen, in a finely granular form, becomes separated. The turbidity dependant on the presence of fat is sometimes observed in perfectly healthy persons, shortly after partaking of an abundant meal, when the blood is receiving a large quantity of chyle. Turbidity, arising from coagulated fibrin, was observed by Scherer in a pregnant woman with *bronchitis tuberculosa,* in a leuco-phlegmatic person suffering from attacks of vertigo, and in a spirit-drinker with cerebral congestion; Simon noticed it in a man with Bright's disease. It would appear as if this separation of the fibrin in a granular form, were owing to some peculiarity in its mode of coagulating. The causes of the turbidity in these cases may be readily detected by the microscope; the fibrin-granules dissolve in acetic acid and in a solution of nitrate of potash; the fat-vesicles which may be recognised by their peculiar form, are not soluble in these fluids but dissolve in ether. The serum sometimes appears reddened in consequence of blood-corpuscles being suspended in it; this is chiefly noticed when the coagulation is imperfect; it occasionally, but more rarely, is dependant on a solution of the hæmatin, of which we shall speak presently.

The *changes in the consistence* of the blood are likewise very imperfectly understood, and the statements on this subject are as indefinite as they are uncertain, since we have no proper means of determining with accuracy the degree of consistence of this fluid. Our information is limited to this, that we sometimes find the blood thinner than in the normal condition, sometimes thicker and more viscid; a change of consistence is usually associated with a modification in the

* Untersuch. p. 85 and 87. Simon, Beiträge z. physiolog. und patholog. Chemie, p. 287; Zimmermann zur Analysis u. Synthesis der pseudo-plastischen Processe, p. 100, &c.

colour of the blood. According to Lobstein,* the blood is thinner than usual in scurvy, in morbus maculosus Werlhofii, in typhus, in petechial fever, in malignant pustule, in scarlatina, and in measles. It was likewise noticed by Scherer† in puerperal metritis. It appears thicker than usual in cholera, in consequence of the amount of water in the blood being much diminished. Generally speaking, our information respecting the variations in the consistence of the blood are of little value, because their determination has not been based on accurate principles; and they are even more unserviceable and deceptive when they refer, not to fluid blood escaping from the living body, but to the entirely or partially coagulated blood found on dissection, since the original degree of consistence existing during life is already modified.

This leads to the consideration of *deviations in the coagulation* of the blood. The blood coagulates out of the body in the same manner as in the body after death. In each case the process is essentially the same, although, in the latter there are so many modifying circumstances that it is better that we should consider each phenomenon separately. Blood obtained from the living body, either by opening a vein, or by any other means, may present the following peculiarities in its coagulation.

1. The blood may coagulate very rapidly, or, on the other hand, not for some time after its discharge: in some cases it occurs in one and a half minutes; in other cases it only commences after the lapse of fifteen or twenty minutes. This acceleration and retardation of the coagulation cannot be well accounted for; and the causes influencing the rapidity being apparently very complicated, no practical conclusions can as yet be drawn from these phenomena. It appears that it is hastened, and, indeed, principally caused by the action of the

* Path. Anat. vol. II. pp. 539. † Op. cit. p. 160 and 163.

atmospheric oxygen;* on the other hand, it is well known that the artificial addition of many salts to fresh blood retards the coagulation. Hence we must conclude that a slow coagulation is frequently dependant on an increase of the salts. According to H. Nasse, the blood of the common hen and the goose, which is very slow in coagulating, contains from one third to one half more salts than human blood.† In every case the cause of the difference appears to be chemical, and not vital.

2. Many deviations occur in the consistence and other properties of the clot, as well as in the proportion of its volume to that of the serum. The clot is sometimes very tough and firm, difficult to break up, and offering a resistance to the knife; in other cases, it is very soft and loose, forming a slightly consistent gelatinous mass, like currant jelly, breaking up on the slightest touch; in some cases it even happens that no true clot is formed, the blood remaining fluid, and, after standing for some time, merely forming a few soft, flocculent coagula. These are the two extremes, between which there may be many intermediate degrees. These differences are dependant on the condition of the fibrin, and in part, also, on its quantity. In proportion to the coagulating tendency possessed by the fibrin, and to its quantity, so much the firmer and more solid is the clot, which, in this way furnishes us with an approximation to the amount of fibrin present. These modifications of the fibrin may depend on various causes, all, however, of a chemical nature. The most frequent cause is the same that retards the coagulation, namely, an increase of the salts; in extreme cases, when, for instance, no coagulation takes place, it depends on an increase of the alkaline carbonates. The salts, when artificially added, lessen the tendency to coagulation, and the latter

* See Nasse's Article in Wagner's Handwörterbuch, &c., vol. I. p. 112.

† Op. cit. p. 114.

(the alkaline salts) altogether destroy it. Thus, in a case of putrid typhoid fever, Scherer* found carbonate of ammonia in the blood, which was black and pitchy, and did not coagulate into a solid clot, but merely formed a diffluent saline mass.

The presence of the carbonate of ammonia was shown by the development of a white vapour on holding a glass rod moistened with non-fuming hydrochloric acid over the blood; and further by the circumstance, that the blood distilled on the water-bath yielded a fluid which had an alkaline reaction, and frothed on the addition of an acid.

The volume of the clot to that of the serum differs extremely in different cases; sometimes the clot is small, while above it there is a very considerable quantity of serum; sometimes it is large, occupying nearly the whole volume of the blood, while only a very small quantity of serum is separated. These proportions, like those we have just considered, are also dependant on the coagulability of the fibrin, which stands in a direct ratio to the compactness of the clot, and to the amount of serum expressed from its interstices. Hençe the presence of a large amount of serum must not lead us to infer that the blood contained an excess of water; neither is a large clot to be regarded as a certain indication of the presence of an excess of fibrin.

The coagulated fibrin of the blood likewise exhibits differences in its chemical relations. Such differences occur in health between the fibrin of arterial and venous blood; thus, venous fibrin gradually dissolves in an aqueous solution of nitrate of potash, while arterial fibrin is insoluble in that menstruum. In inflammatory affections, however, the coagulated fibrin of venous blood is frequently insoluble in that solution. This a point worthy of consideration.

3. Coagulated blood sometimes exhibits on its surface

* Untersuch. p. 68.

what is termed the *buffy coat* (crusta phlogistica seu pleuritica). We may explain its formation in this way, that in this case the blood-corpuscles began to sink before the occurrence of coagulation, so that the upper surface of the clot, enclosing no blood corpuscles, appears colourless, and consists of mere fibrin. Several causes may tend to produce this deposition of the blood-corpuscles previous to coagulation; thus, sometimes, they sink more rapidly than usual from their arranging themselves in columns resembling rolls of coin, and thus overcoming the resistance of the plasma, on the same principle that large bodies sink through a fluid more rapidly than small ones; sometimes the blood appears to coagulate more slowly than usual; and not unfrequently both causes are in operation. We frequently observe an increased quantity of fibrin in blood with the buffy coat; but the increase of that constituent is not the cause of the buff, and the opinion that the formation of a buffy coat is always a sign of inflammation, and that, consequently, further venesection is necessary, is utterly false, and has led to very disastrous practical consequences.*

The variations occurring in the coagulation of the blood in the body after death cannot be easily explained, and the observations that have been recorded on this point are of little or no value, in consequence of the causes of their variation not being at the same time indicated. Generally speaking, on examining the body after death, we find the blood in the capillaries fluid; while in the heart and veins, it is coagulated, the arteries being frequently empty. The fluidity of the blood in the capillaries is not dependant on a deficiency of fibrin, for blood taken from the capillaries after death, frequently coagulates in the course of twenty-four hours, or even later. It is very possible, as has been suggested by Nasse,† that the exclusion of the atmospheric air

* Compare Nasse, das Blut. p. 36 and p. 204, &c.

† Handwörterbuch der Physiolog. vol. I. p. 113.

tends to retain the fibrin in a state of fluidity. Although the coagulated blood in the heart and large vessels of different bodies presents different properties, it has been found impossible to deduce any general laws on the subject. Coagulation within the vessels is never so perfect, nor the clot so firm as when the coagulation takes place out of the body. The condition of the blood, or at least of the fibrin, previous to death, obviously exerts a great influence on the condition of the subsequently formed coagulum. The heart not unfrequently contains white or yellow coagula of fibrin, with few or no enclosed blood-corpuscles. These coagula sometimes extend from the heart into the large arteries; more rarely into the large venous trunks. It is not very easily seen, how so perfect a separation of the plasma from the blood-corpuscles can take place after death, that the fibrin for the most part shall coagulate alone, without including blood-corpuscles; and hence it is most probable that when the fibrin has a tendency to coagulate, these white coagula are ready formed during life in the death-struggle. The contractions of the heart, and the pulsation of the arteries exert in these cases an influence on the blood, similar to that artificially produced by stirring with a glass rod, and thus the fibrin is separated and forms white coagula. I am confirmed in this opinion, from having repeatedly found tough white coagula in the heart, in cases where some days before death, syncope with disturbed cardiac action has supervened.* The blood in the heart and large vessels is either fluid or very imperfectly coagulated in cases of death from lightning, from various sorts of poison, in scurvy, in many cases of typhus, and in putrid fevers. Although this condition is obviously dependant, (like the analogous relations of the blood out of the body), either on a diminution of the fibrin, or on that constituent having lost its power of coagu-

* See the description of fig. 3 in pl. II

lating, we are not at present in a condition to state with any degree of certainty the chemical causes of these changes. Consequently we are not yet in a condition to draw any valuable inferences from the changes undergone by the blood in the dead body.

Changes in the odour and taste of the blood have been noticed by different observers; thus the taste of the blood of syphilitic women has been observed to be saline; of jaundiced persons, bitter; and in cases of rachitis, acid;* in scurvy and putrid fever, it has a putrid odour; and Barruel even asserts, that from the odour developed on the addition of sulphuric acid, he can distinguish the blood of man from that of woman, and recognise the blood of different animals. Experiments of this nature in respect to the taste and odour of the blood are generally of trifling importance, although the former might be serviceable in the detection of odorous matters, not easily recognised by tests, in the blood: as for instance, alcohol, phosphorus, hydrocyanic acid, &c.

Changes in the blood-corpuscles.—It is well known that the blood-corpuscles undergo numerous changes, when brought in contact with various reagents, as well as during the decomposition and putrefaction of the blood.† Numerous as these changes are, the causes producing them may be referred to two distinct types. Firstly, they may be of a merely physical character, and dependant on endosmosis or exosmosis, as when the blood is diluted with water, or mixed with a concentrated saline solution. In the former case, the blood-corpuscles become tumid, and the central depression disappearing, they cease to be biconcave and become spherical. In the latter case, they become contracted, irregular and indented at the edges, or present the appearance

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* Lobstein, Path. Anat. vol. II. p. 540.

† For the most perfect account of these changes, see Hünefeld, der Chemismus in der thier. Organisation, p. 43, &c.

of being surrounded with a festoon of minute granules. Secondly, the changes may be of a chemical nature, since many substances enter into combination with, or dissolve certain constituents of the blood-corpuscles. Thus water dissolves their colouring matter, causing them to become transparent, and ultimately to disappear; nothing but the nuclei (when these are present) remaining. Moreover, acetic acid, ammonia, and the other alkalies dissolve the corpuscles. Changes of this nature rarely occur in the living body, but frequently after death.

The most common change noticed in fresh blood, just drawn from a vein, is this, that some of the corpuscles appear tumid and spherical, or else contracted, irregular or studded with granules. This appearance as we have already observed may be explained on the principles of endosmosis and exosmosis.* Even this change is of rare occurrence.

In the dead body these changes are of more common occurrence. Thus Scherer† found that the corpuscles of the blood, contained in the heart of a woman who died from puerperal metritis, were swollen and indented at the edges; the blood contained free lactic acid, and chemical decomposition had therefore already commenced. In gangrenous parts, I have frequently observed that the greater number of the corpuscles were entirely dissolved, not a trace of them being left. In all these cases we may conclude that the modification of the blood-corpuscles is dependant on the influence of a chemical change in the blood; the nature of this change must be determined by chemical analysis, since very different reagents produce similar changes in the corpuscles. Sometimes these chemical changes and the consequent alteration in the form of the corpuscles, do not commence till after death. Thus in typhus, the change in the

* According to Andral, the raspberry-like appearance of the corpuscles is dependant on the adhesion of fibrinous granules to them.

† Untersuch. p. 160—163.

blood-corpuscles frequently takes place in ten or twelve hours, in consequence of the rapidity with which putrefaction commences in this disease, as has been frequently observed by myself, and confirmed by Gluge.* Dubois† found that the blood-corpuscles of scrofulous persons were devoid of the proper colour, some having lost it at their edges, others entirely; moreover some were more flattened than usual, while others presented a tumid and spherical appearance.

Changes in the blood-corpuscles may easily be induced by diluting the blood with water, or thin syrup, or by the evaporation of the liquid portion of the serum during the experiment; hence, the necessity for great care in such observations.

In microscopic examinations of the corpuscles of defibrinated blood, we sometimes, but not always, observe that they indicate a tendency to arrange themselves with their surfaces in contact, in forms resembling rolls of coin. This tendency is interesting, since it very probably plays a part in many pathological phenomena; thus it favours the formation of the buffy coat‡ since the corpuscles, arranged in this form, sink more rapidly than in ordinary cases. Henle§ remarks that this arrangement is closely connected with the occurrence of inflammation, being the cause of the stagnation of the blood in the capillary vessels. Hence it would be of much importance to ascertain the cause of their tendency to adhere to each other. Henle believes that it arises from an excess of albumen, and at the same time a deficiency of salts in the serum of the blood. I have instituted several series of experiments with the view of elucidating this important question; they did not, however, yield any definite results. I was

* See the chapter on the changes occurring after death.

† L'Expérience, 1839, No. 87.

‡ See p. 68.

§ Henle und Pfeufer's Zeitschr. vol. II. p. 120, &c.

unable to establish this tendency by the addition of an albuminous solution, devoid of salts; while on the other hand, by the addition of a concentrated saline mixture to blood already exhibiting it, this tendency was sometimes, but not invariably increased. The point is one of sufficient importance to render a further investigation well worthy of being undertaken.

CHANGES IN THE CHEMICAL CONSTITUTION OF THE BLOOD.

With a few exceptions, all our knowledge respecting the chemical changes of the blood has been acquired during the last few years, and although it seems to explain several important points, it is still far from being in a complete and satisfactory state. In the following observations I shall therefore merely bring forward the most important points.*

The blood in its chemical composition is a very intricate fluid, containing a large number of different substances. As each of these substances entering into the composition of the blood may undergo either a qualitative or quantitative change; and as, moreover, in certain pathological conditions, substances not occurring in normal blood may be present, it is manifest that the deviations in its composition must be very numerous. To make the subject clearer, we shall divide them into certain groups.

1. Any one constituent may be either relatively increased or decreased.

A. *The fibrin may be increased.*—In 1000 parts of nor-

* The following are the most important works on this subject:

Denis, Essai sur l'application de la Chimie à l'Etude physiolog. du Sang de l'Homme, Paris, 1838.

Lecanu, Etudes chimiques sur le Sang humain, Paris, 1837.

Andral et Gavarret, Recherches sur les Modific. de Proportions de quelques principes du Sang dans les Maladies, Paris, 1840.

Scherer's Untersuchungen z. Pathologie, 1843.

Andral's Hematologie.

Simon's Animal Chemistry; to which may be added the Translator's Reports on the Progress of Animal Chemistry, in Ranking's half-yearly Abstract of the Medical Sciences.

mal blood, there are from one to three parts of dried fibrin; but in certain pathological conditions, it may rise to 5·7, or even 10 parts, being more than treble the normal quantity. This is the case in most inflammatory affections, and especially in most of the cases that give rise to fibrinous dropsy, in pneumonia, pleuritis, bronchitis, peritonitis, acute rheumatism, severe erysipelas, and in many cases of pulmonary tuberculosis; at the same time we frequently find that the qualities of the fibrin are also altered. After coagulation it is insoluble in a solution of nitrate of potash, differing in this respect from normal venous fibrin, and resembling that of arterial blood.

The fact that the fibrin is thus increased is established beyond all doubt, but respecting the causes of this augmentation, and in part respecting its signification, there is still much to be explained. Simon, relying on the observation that the quantity of blood-corpuscles is simultaneously diminished, conjectures that this increase takes place at their expense, and that the fibrin is formed from the hæmatoglobulin. On equal grounds it might be asserted that the fibrin is produced from the albumen of the plasma, since we possess no certain knowledge respecting the conditions under which one protein-compound is converted into another, and respecting the production of the fibrin in normal blood. Henle* has offered another explanation. He believes that the increase of the fibrin in all these cases is dependant on an exudation from the vessels (our fibrinous dropsy) containing less fibrin than the plasma, which thus after the exudation contains a relatively larger amount of fibrin than before. But this hypothesis fails to account for the great augmentation of the fibrin in inflammation, and for its relative increase in proportion to the quantity of blood-corpuscles.

A diminution in the amount of fibrin (when for instance it falls below 1 in 1000 parts of blood) may either actually

* Zeitschrift für rationelle Medicin v. Henle und Pfeufer, vol. I. No. I. p. 119.

occur, or may be only apparent in consequence of its coagulation and separation being prevented by an excess of salts, or by the occurrence of carbonate of ammonia.

The amount of fibrin is determined by collecting the fresh blood in a weighed vessel, and stirring it with a glass rod of known weight, till all the fibrin has coagulated, and either separated in floccules or attached itself in the form of membranous shreds to the rod. By weighing the whole, we know the weight of the blood. The blood is then strained through a cloth which retains the fibrin that has separated in flocculi. To this we must add the portion adherent to the rod, and wash the whole (retaining it in the cloth) till it becomes colourless. It must then be dried on the water-bath, its fat removed by boiling in ether, and finally weighed.

B. *The quantity of blood-corpuscles may be increased or diminished.*—Although we have not the means of determining the amount of the blood-corpuscles with the same accuracy as that of the fibrin, we have yet sufficient evidence to show that, like the other constituents of the blood, they admit of considerable variation. While every 1000 parts of normal blood, contain on an average 127 of dried corpuscles, in cases of fever the number may rise to 136, 160, or even to 185, while on the other hand, in cachectic conditions, and especially in chlorosis, it may fall to 100, 80 or even 38.* This diminution is associated with morbid processes which impede nutrition, but we do not at present possess any insight into those processes which cause this diminution, those cases being excepted in which it is obviously dependant on hæmorrhage, copious blood-letting, or, in short, any other direct removal of them from the system. In a therapeutic point of view, it is an interesting circumstance that the internal use of iron, not merely gradually removes the bad consequences of this condition of the organism, but also effects a gradual augmentation in the amount of the corpuscles. Whether the augmentation of the corpuscles in cases of fever

* Andral and Gavarret.

is, as Andral and Gavarret believe, essentially connected with the disease, or whether it is merely the result of an imperfect system of analysis, must be decided by future investigations.

The quantitative determination of the blood-corpuscles requires a much more complicated process than that of the fibrin, and is much less accurate. It may be undertaken in different ways. Andral and Gavarret adopt the following method: A portion of blood is allowed to coagulate, and the serum and clot are then separated as completely as possible. Both are weighed, dried on the water-bath and again weighed. By subtracting the latter from the former weight, we obtain the amount of water in the serum, and in the clot. The rest of the proceeding is merely numerical, being founded on the undemonstrated assumption that all the fluid contained in the clot was serum, and therefore contained as large an amount of solid constituents as actual serum. Hence we first calculate the amount of solid constituents of serum corresponding with the quantity of water separated from the clot, and subtract this and the fibrin (which is supposed to have been already determined) from the clot; the difference is the weight of the dried corpuscles. The following illustration may serve to elucidate the somewhat complicated calculations requisite in this process. An old man was bled in consequence of strangulated inguinal hernia, and a portion of the blood collected in a basin of known weight. The blood weighed 280 grains. In the course of twelve hours, the separation into clot and serum was perfect. A small quantity of serum was carefully taken up with a small pipette, so as to include no corpuscles, and was placed in an evaporating basin of known weight. By deducting this weight from the given weight of the serum and the basin, the serum was found to weigh 95 grains. On drying it on the water-bath till it ceased to lose weight, the residue weighed 8 grains, consequently 87 grains of water had been expelled. The clot with the rest of the serum weighed 185 grains and after the most careful drying weighed 48 grains; hence 137 grains of water were lost. This water is, according to the above assumption, regarded as serum, and is consequently associated with a corresponding amount of solid constituents, which must be deducted from the clot. It follows from the above data, that 87 (the quantity of water in the serum) : 8 (the quantity of solid residue in ditto) : : 137 (the quantity of water in the clot) : x = 12.6. Subtracting thus from the dried clot, there remains, 48 — 12.6 = 33.4 grains as the weight of the dried corpuscles, or reducing to the scale 1000 parts (280 : 33.4 : : 1000 : x), the dried globules amount to 119.3.

This method of estimating the quantity of the blood-corpuscles is simple and easily performed, but does not yield very accurate results. It is uncertain, on account of the undemonstrated assumption, that all the water in the blood is associated with the same amount of solid constituents as the water of the serum—an assumption opposed to the idea that a portion of the water may be combined in some other form with the hæmatoglobulin of the blood-corpuscles, in which case the above calculations would no longer hold good. But besides this, it has disadvantages which influence the accuracy of the results. For it is difficult to remove the whole of the water from the portion of clot, which according to this process must always be tolerably large. The retained water increases the apparent weight of the blood-corpuscles in two ways, namely by its own weight, and further, by its amount of solid constituents regarding it as serum, which in this way escapes deduction from the clot. Hence in proportion to the abundance of corpuscles in the blood, is the uncertainty of this method of analysis, in consequence of the increased difficulty of drying the clot.

Another method has been proposed by Simon. He attempts a direct estimation of the hæmatoglobulin, which cannot be accomplished with any degree of accuracy except by an expert chemist. I, therefore, merely refer the reader to the description of Simon's method.*

Instead of determining the blood-corpuscles collectively, we may estimate their individual constituents—the globulin, hæmatin, and iron—and the ratio of each to the other. This, however, is laborious, difficult, and with our present resources yields only approximate results.

Another method of determining the amount of blood-corpuscles in a direct manner has recently been proposed by Figuier.† It is founded on the circumstance, that on adding sulphate of soda to defibrinated blood, the corpuscles can be collected by filtration. He directs that three or four ounces of defibrinated blood be mixed with about double its volume of a saturated solution of sulphate of soda, and that it be projected on a previously weighed filter, moistened with the same saline solution. The serum and the saline solution pass through, while the blood-corpuscles remain behind. They must then be washed with the saline mixture, which must be removed by dipping the filter with the corpuscles in boiling water, which coagulates the hæmatoglobulin while it extracts the sulphate of soda. From repeated trials I can confirm this statement in all its essential points: I did not, however, always

* Animal Chemistry, vol. I. p. 175.

† Comptes Rendus, vol. II. p. 101; or Simon's Animal Chemistry, vol. I. p. 190.

succeed in obtaining the corpuscles entirely colourless; a proof that the hæmatin is not entirely insoluble in a solution of sulphate of soda.

An accurate trial of these different methods of analysis instituted simultaneously with the same blood, and a comparison of the results yielded by them would be highly important. For until we are better informed respecting the degree of accuracy that can be attained by each method, any application of their results to pathology must be open to various objections.

C. *The amount of water in the blood may be increased or diminished.*—The amount of water in the blood is liable to considerable variations, even in healthy persons, and Lecanu has endeavoured from numerous experiments, to deduce general laws on the subject. He found it less in men, more abundant in women; less in vigorous persons in the bloom of life, larger in children and in aged and debilitated persons; less in the sanguineous, larger in the lymphatic temperament. In 1000 parts of blood the mean quantity is 790; it is, however, considerably augmented in anæmia, chlorosis and similar conditions, in which it has been observed at 870, if not lower; in cholera, on the other hand, the amount of water in the blood is diminished, in consequence of the copious liquid evacuations from the bowels.

The estimation of the quantity of water is simple. A weighed quantity of blood must be reduced to a state of dryness on the water bath; the loss is equivalent to the amount of water. As the accuracy of the result depends on the completeness of the drying, it is advisable to use a smaller quantity of blood than is recommended by Andral and Gavarret.

D. *The amount of albumen in the serum of the blood may vary.*—It appears to be diminished in Bright's disease, and probably in other cases in which there is a considerable secretion of serous fluid from the blood (serous and fibrinous dropsy). In 1000 parts of healthy serum, there are 70—80 of dry albumen; but in Bright's disease the amount falls, according to Andral and Gavarret, as low as 61—57.

The amount of albumen may be determined in the following manner. A weighed quantity of serum is neutralised with a little acetic acid, in order to decompose any albuminate of soda that may be present, and then diluted with water and boiled till the albumen coagulates into flocculi. These are collected on a filter of known weight, washed with water, and dried on the water-bath. The accuracy of the determination may be increased by boiling the dried albumen in ether, which takes up any fat that may be present.

E. *The salts of the blood may be either increased or diminished.*—Variations in the amount of the fixed salts (those, namely, left after incineration of the blood) are not only of common occurrence, but of considerable pathological importance. The salts are increased in scurvy, and it is very probable that this change influences the condition of the fibrin, hindering its coagulability, and perhaps checking its formation; that it affects the blood-corpuscles by withdrawing their water, rendering them granular, and collecting them in heaps; and that it thus plays an essential part in the disease itself. On the other hand a diminution of the salts is of considerable importance; it causes a tumidity of the corpuscles, favours their adherence to each other, and, according to Henle, tends to produce the retardation in the capillaries in inflammatory affections, of which we shall say more presently. Moreover, the relative proportions of the different salts may change. If these observations entitle us to conjecture that we may expect important developments in this department of pathology, we are not yet in a condition to deduce general laws respecting these augmentations or diminutions.

The mean amount of fixed salts in 1000 parts of normal blood has been variously estimated by different observers, some assigning it at 8—9, others 12—13 parts. The amount is estimated by incinerating the blood in a platinum crucible; an operation requiring considerable time, but facilitated by frequently moistening the ashes with distilled water; it must be continued till the residue forms a white or faintly coloured saline mass.

F. *The amount of urea may be increased.*—In healthy blood it occurs in such minute quantity as scarcely to admit of detection. In cases where its separation by the kidneys is prevented or impeded, as after extirpation of those organs, or in Bright's disease, it increases to such an extent as to admit of quantitative determination.

2. Substances may occur in the blood which do not exist there in a state of health.

A. *Free lactic acid.*—If the blood has an acid reaction, it reddens litmus paper. The occurrence of free acid in the blood is a sign that the fluid is undergoing decomposition, and occurs in diseased conditions in which a tendency to decomposition in the fluids is suspected—in miliary fever, in acute rheumatism, and in puerperal fever: it is, therefore, of considerable pathological signification, although we are still not in a condition to see how the free acid acts on the blood, and, consequently, on the whole organism.

Scherer found that the blood had an acid reaction in the bodies of persons dying from puerperal fever and phlebitis,* and declared that it contained free lactic acid. I have on several occasions noticed this acid reaction in miliary fever and in rheumatism, but only in the dead body; never in blood taken by venesection. If the quantity of the acid is only small, the blood loses its alkaline reaction and becomes neutral; this was observed by Scherer in the blood obtained by venesection, in a case of metritis.† In a practical point of view the acid reaction of the blood is a sufficient indication of the presence of the acid; the separation of the lactic acid requires a difficult and complicated process.

B. *Carbonate of ammonia.*—The occurrence of this substance in the blood is also an indication of decomposition; it hinders the coagulation of the fibrin, and renders the blood unfit to discharge its ordinary functions. This change is sometimes observed in well-marked cases of typhus.

* Untersuch. p. 160, 163, 174, 230.
† Op. cit. p. 149.

Scherer* found carbonate of ammonia in blood taken from the arm of a typhus patient. The means of detecting this substance are given in p. 67.

c. The blood may contain a substance precipitable by acetic acid, resembling pyin. Scherer† found a substance of this nature, together with free lactic acid, in the blood of a woman who had died from metroperitonitis. This observation is important, because a similar, if not the identical matter, is of common occurrence in exudations, in pus, in scirrhous tumors, &c., as we shall presently see.

To recognize this substance, the serum must be boiled in order to separate the albumen, and then treated with acetic acid, which throws down a precipitate insoluble in an excess of the reagent.

D. The blood may contain sugar in cases of diabetes mellitus. As the process for the recognition of this substance is intricate and difficult, I shall not attempt to describe it.

E. The blood may contain bile-pigment which may be detected by the rules given in p. 63.

In addition to these abnormal conditions, indicated by the art of the chemist, there are others which can only be detected by microscopic observations; of these the most important are pus-corpuscles and entozoa.

In morbid conditions of the system, pus-corpuscles in the blood are not of very rare occurrence. They are in some cases produced within the vessels, in others they enter the vessels from without.

Respecting the means of detecting them, their signification, and their mode of development, we shall have various occasions to speak.

Entozoa have also been discovered in the blood, especially

* Op. cit. p. 69.

† Op. cit. p. 160.

in the lower animals. This subject will be fully discussed in the chapter on parasites.

We are indebted to J. Engel* for a meritorious essay which has been lately published on the theory of the changes which the blood undergoes generally, as far as they can be revealed by the different pathological conditions observable after death.

The following are the most important of his conclusions:

In suppurative fermentation (*Eitergährung*) the blood loses its tendency to coagulate; it is of a dirty dark red colour, does not become brighter on exposure to the atmosphere, and is very fluid. The corpse appears swollen, and presents a dirty appearance, being marked with numerous death-spots, partly hypostases and partly sugillations.

After inflammatory affections and tuberculosis, numerous fibrinous coagula are found in the blood, the clot is large and hard, and the blood more consistent than in the normal state. The sugillations are fewer and not so diffused, and their colour is less deep.

In typhus and miliary tuberculosis the blood has a dark violet tint, is viscid, and exhibits no tendency to form a consistent clot. It is slow in reddening when exposed to the air, has no peculiar hypostatic tendency, but communicates to the organs, a dark violet, or reddish brown tint, by the firm adhesion of its colouring matter.

In the cancerous dyscrasia, the blood is of a dark colour, very slight consistence, does not readily coagulate, reddens imperfectly or not at all on exposure to the air, and exhibits a hypostatic tendency. The colour of the dead body is of no diagnostic importance, in consequence of the slight viscidity of the blood, and the consequently slight adhesive power of the colouring matter.

In dropsy, the blood is not deeply coloured, and is very

* Roser und Wunderlich's Archiv. vol. I. p. 535, &c.

fluid, but yet exhibits a tendency to the formation of small clots. The hypostatic appearances on the dead body are trifling.

In marasmus (senilis vel præcox) the blood is black and fluid, deficient in quantity, and forms no clot. It soon reddens on exposure to the atmosphere, but, on account of its small quantity, forms no hypostases.

In scurvy the properties of the blood closely resemble those in suppurative fermentation. It has, however, a deeper colour, and gives rise during life to the formation of petechiæ, but not to purulent depositions. Moreover, the blood in scurvy readily induces liquefaction of the tissues (ulcerative destruction), without any trace of reaction or inflammation. The blood of persons addicted to intoxication belongs to the same category.

It is very difficult, indeed impossible, from these statements, and those of other observers, to draw any certain conclusions respecting the changes of the separate constituents of the blood, or the causes of such changes. In fact our whole knowledge respecting the physical and chemical changes of the blood is in the highest degree unsatisfactory, and the statements of different observers vary so widely, that it is impossible to deduce any general laws from them. It is probable that many may regard the preceding observations as unnecessary and aimless; I had a double view in arranging them in this form. In the first place, I was desirous of showing how little certain information we possess on this subject, and how dangerous it is to base theories for whole classes of diseases, and proposals for their treatment, merely on individual observations. Secondly, I trust that they will afford a convincing proof of the number of different acting forces to be kept in mind, in considering the various pathological changes of the blood.

2. CHANGES IN THE QUANTITY OF THE BLOOD.

The amount of blood in the human body may undergo changes, and may either be increased or diminished. An abnormal abundance constitutes plethora or hyperæmia; a diminution, anæmia. Hyperæmia or anæmia may either be general (in which case the whole mass of blood in the body is increased or diminished) or it may be local. In the latter case, it is confined to a single organ, or to a larger or smaller portion of the body, while the remaining organs are either normal in relation to their amount of blood, or are in the opposite condition to the affected organ.

Pathology has for a long time recognized the existence of general hyperæmia or plethora as an established fact, and has described the symptoms by which we may detect it. But all these symptoms (injected countenance, full pulse, tendency to congestion, &c.), are not infallible. We have no certain means of determining whether the whole mass of the blood is actually increased, and still less are we in a condition to determine it with certainty in any particular instance.

The mean quantity of blood in the human body cannot be determined with certainty. Valentin* has pointed out a very ingenious means of ascertaining the quantity of blood in animals, which, if certain necessary preliminaries are determined, might give tolerably accurate results; but this method cannot be applied to man. In fact, all the means hitherto proposed for determining the amount of blood in the human body have been very unsatisfactory. We are usually contented with estimating the amount of blood from the degree of redness in the different parts of the dead body, from the contents of the large vessels, and from the blood that escapes on making incisions in various parts. These means are important, as showing comparatively the amount of blood in the different parts of the body, but they are of little or no value in enabling us to ascertain even approximately the whole amount of blood in the body. To clear up this point, I propose another method, which although difficult and tedious, would yet give far more accurate results. By carefully washing out the vessels of a body by injection with pure water, all the hæmatoglobulin contained in those vessels may be obtained, and after purification can be estimated quantitatively. Any conclusion respecting the whole quantity of blood deduced from the amount of hæmatoglobulin is doubtless always uncertain, in consequence of the varying proportions in which that constituent may be present in the

* Repertorium, vol. III. p. 281, &c.; or, Physiologie, vol. I. p. 490.

blood. In cases, however, when it is possible to institute venesection shortly before death, we might ascertain by the processes already given, the proportions in which the corpuscles occur, and then after death calculate the whole amount of blood with tolerable certainty. Laborious to an extreme degree as these investigations are, they are essential for the perfection of our knowledge of the blood. Until by such, or similar experiments, general plethora becomes better understood than it now is, all that has been stated regarding it must be considered as merely hypothetical.

There is a close parallelism between general anæmia and general plethora. It is certainly an undoubted fact, that by loss of blood the quantity of that fluid in the body is diminished, and that, for instance, a man directly after a copious venesection contains less blood than in the normal state. The loss is probably rapidly made up by the absorption of fresh matter, especially of water, so that the amount of blood may become the same as before. It is true that the blood possesses a different composition than it previously did, containing fewer corpuscles, and more water and albumen, but this condition should not be termed anæmia, but, as has been very properly suggested by Simon, spanæmia;* and the symptoms in the dead body, dependant on this condition, are those commonly associated with the occurrence of anæmia. General paleness, deficiency of red clots in the vessels, and the escape of but little red blood, on making incisions into the different organs, are not always to be regarded as signs of anæmia, since they are equally likely to occur when spanæmia is present.

Local hyperæmia, as it occurs in the dead body, may have its seat in the veins or in the capillaries, sometimes occurring simultaneously in both sets of vessels.

Venous hyperæmia may be detected with the naked eye, or if only the smaller veins are affected, with a lens. The veins usually present a continuous ramifying appearance, are more distended than usual, and contain a blue, violet or reddish

* From σπανός, poor.

brown, or occasionally blackish blood, which escapes on making an incision. On cutting into the part affected, the section reveals numerous isolated blood-spots. Venous hyperæmia is usually accompanied by an effusion of dropsical fluid from the distended veins; in the dead body, this may, however, be absent, or at any rate may escape observation, since local hyperæmia is very limited, and exists only for a short time, and the effused serous fluid may have been resorbed by the lymphatics. The causes of this hyperæmia are partly mechanical—as obstruction of the venous trunks, stoppage of the heart's action, &c., and partly dynamic—as dilatation of the venous walls through the influence of the nerves.*

Hyperæmia of the capillaries.—The capillaries of different parts of the body frequently appear to be dilated to a greater or less degree, and to be over-filled with blood. In the lesser degrees of hyperæmia, the diameter of the capillaries increases by one half; in the more highly developed cases, the diameter is sometimes double, or even treble the ordinary length, and then the vessels not unfrequently become ruptured. The blood so completely fills up the whole *lumen* of the vessels, that the interstices at their border, which in the normal state are free from blood-corpuscles, disappear. The blood-corpuscles themselves are much more closely pressed on each other than is usual, so as to prevent them from being recognized individually, and the whole of the blood forms an apparently homogeneous and coagulated mass; but on removing the blood from the vessels by pressure, &c., the corpuscles again become separated, and the fluid assumes its normal appearance.

The part affected by hyperæmia is redder than usual. This abnormal redness may be either general or local, according to the extent of the hyperæmia; and decreases gradually as it approaches the unaffected parts. Under the microscope, it is observed that the redness is not uniformly distributed over the

* See p. 42.

whole of the affected part, but that it follows the course of the capillaries, while the interstices remain colourless.* On cutting into the hyperæmic organ, a more than ordinary quantity of blood escapes, in which the corpuscles are normal, or only slightly modified. The affected part is also denser than usual; the consistence is either normal or apparently softened; it is never increased, unless, in addition to the hyperæmia, there is also a deposition of coagulated fibrin.

The above relations are sufficient to render the diagnosis a matter of certainty. It can only be confounded with extravasation of blood, and with infiltration of dissolved hæmatin. The points serving to distinguish between them will be found in our remarks on these pathological conditions.

Causes, mode of formation, and termination.—Hyperæmia of the capillary vessels is dependant on two forces (*momenten*) —on a dilatation of the capillaries, and on the accumulation (and retardation) of the blood-corpuscles in them. The causes of these two forces, their mutual dependance, and the manner in which the whole process is conducted, belong to a department of pathology in which our knowledge is by no means accurate. To follow out this subject would lead us into the obscure domain of nervous pathology, and the physiology of tissues; we shall confine our remarks at present to those points which more especially fall within the range of pathological anatomy.

In many cases capillary hyperæmia is undoubtedly dependant on the nervous system; this, from whatever cause it is induced, gives rise to dilatation of the capillaries and relaxation of their walls: the dilated capillaries receive, on purely mechanical grounds, more blood than they previously did; and a capillary which in its normal condition could admit of the passage of only a single row of corpuscles, may now admit of two or three. At the same time an excess of plasma escapes

* See pl. II. fig. 1, B.

through the attenuated walls of the capillaries. The part affected contains an excess of blood-corpuscles, and hence appears reddened. This is the condition which is known in pathology, as congestion; it frequently occurs in the living body in external parts, as in the face, the eye, or the skin; it is, however, more rarely observed in the dead body, since it is seldom a cause of death. Here there is no stoppage of the blood-corpuscles, the whole process being dependant simply on dilatation of the capillaries. If the blood-corpuscles become impeded, the process cannot be referred to mere dilatation. Henle* has made a very ingenious attempt to refer the stagnation of the corpuscles to mechanical and chemical causes. He supposes that in consequence of the exudation arising from the attenuation of the capillary walls, the plasma becomes modified, containing proportionally more albumen and fibrin, but a smaller amount of salts than in the normal condition. This chemical change in the plasma communicates to the corpuscles a tendency to adhere, and this adherence mechanically induces stagnation. Plausible and ingenious as is this theory of the stagnation of the blood, it must only be regarded as a mere hypothesis, against which weighty arguments may be adduced; and we must confess that our knowledge is still uncertain respecting the true reasons of this phenomenon.

As that form of capillary hyperæmia, in which there is no stagnation of the corpuscles is termed *congestion*, so the higher degree—where they stagnate, and the local circulation is arrested—is termed *stasis*. On examining these conditions in the dead body, we find no difference between them. It is likewise perfectly indifferent, whether the process is accompanied with symptoms of nervous irritation (true inflammation) or with depression of the central nervous system, (hypostatic inflammation, passive hyperæmia). The phenomena of

* Henle u. Pfeufer, Zeitschrift für rat. Medicin, vol. II. No. I. p. 130, &c.

dilatation of the capillaries, of the aggregation of blood-corpuscles in them, and of the effusion of serous or fibrinous fluid from them, are in both cases the same, and the pathologist is unable to draw any certain distinction between them.

The further course, and the combinations of local hyperæmia are very numerous, for it is usually associated with the effusion of serous or fibrinous fluid, and frequently with rupture of the vessels and extravasation of blood. Its terminations are: 1, disappearance of the hyperæmia by the dispersion of the impeded corpuscles, and the re-contraction of the vessels; 2, the occurrence of decomposition of the blood, in which case the hæmatin dissolves in the serum; 3, or of gangrene, in which case the whole of the blood undergoes a chemical change. Of this we shall speak presently.

As we have local hyperæmia, so likewise is there local anæmia. It may be recognized by the affected part being paler than usual, and by the effusion of very little blood on making an incision. Its causes are: 1, a constriction or occlusion of the arteries supplying the part; or 2, a contraction of the capillaries dependant on the nervous system, as, for instance, in sudden pallor of the cheeks, &c.

3. EXTRAVASATION OF BLOOD.

It frequently happens that, in consequence of laceration of the vessels, the blood escapes from them and is effused in the cavities of the body or in the parenchyma of the organs, between the histologic elements. The process is termed hæmorrhage, and the blood itself is said to be extravasated.

The effused blood may either coagulate or remain fluid. Generally, we only find it coagulated when it has been effused in large quantity,—as after wounds, in severe apoplectic attacks, and in pulmonary and bronchial hæmorrhage. The coagulation, as in ordinary cases, depends on the solidification of the fibrin, and the clot is composed of that constituent and the corpuscles enclosed in its meshes. Blood effused into the intestinal canal (in hæmatemesis and melæna) coagulates in a peculiar manner; the fibrin remains fluid while the albumen of the plasma becomes coagulated by the free acid of the gastric juice, and encloses the blood-corpuscles. Moreover, this acid converts the red colour of the blood into a blackish brown tint. The process may be imitated artificially by adding hydrochloric or sulphuric acid to defibrinated blood. In other cases we find the extravasated blood remain fluid, especially when it is effused in small quantity. On removing this fluid blood from the body, it usually coagulates spontaneously after a short time; and on examining it under the microscope, the corpuscles are found to be normal or only slightly modified; hence in its essential characters it resembles normal blood.

Extravasations of blood may be divided into: Firstly, those of the capillary system, in which the effused blood either forms small points scarcely visible to the naked eye, or is uniformly distributed through the parenchyma of the affected part, which thus becomes either uniformly reddened, or is else merely covered with red specks. In this case the blood proceeds from the smaller vessels, and this condition, or an alternation of it with capillary hyperæmia, is often noticed. Secondly, effusions of a large volume of blood. The effused blood then forms large masses, which may be easily recognised and distinguished from the surrounding parts. In capillary extravasation, the blood is most commonly fluid, in the other form it is generally coagulated.

The quantity of effused blood is extremely variable; it may be only a few drops or may amount to several pounds.

Causes, formation, and ultimate fate of extravasated blood.—Extravasated blood always proceeds from the vessels, and results from their laceration. The view, that at least some of these effusions of blood may occur without any injury of the vessels, by a mere transudation of blood through the attenuated vascular walls (diapedesis) is altogether untenable, although some even of our recent authors (Carswell amongst others)* still support it. The walls of the blood-vessels—even of the smallest capillaries—are so impervious, that it is impossible for such large particles as the blood-corpuscles to pass through them in an uninjured condition. Moreover, the smaller vessels may be so readily lacerated by numerous internal causes, without any outward injury, that there is no difficulty on the point, and the fact that those sanguineous effusions which occur in the normal state—as the menstrual discharge—are dependant on an injured condition of the vessels, is confirmatory of it. In many cases in which the blood is discharged from larger vessels, we may easily detect the seat of the injury, and consequently the source of the hæmorrhage; if we are not always so fortunate in hæmorrhage from the capillaries, it is owing to the imperfection of our diagnostic aids, not to the absence of a lacerated vessel.

The causes giving rise to laceration of the vessels, and consequent effusion of blood are very numerous; many of them are external, and mechanical or chemical in their nature: as wounds with cutting or stabbing instruments, bruises, blows and concussions; occasionally the vessels are injured by caustic applications, as for instance, caustic potash. The manner in which these different influences work is too obvious to demand any explanation; but, moreover, there are certain morbid processes within the body that frequently injure the vessels, and cause the extravasation of blood, as for instance, violent coughing or vomiting, mortification, suppuration, or softening of tumours, destroying the organic tissues, and hence injuring the continuity of the vessels in a manner presently to be described. Another very frequent internal cause of rupture of the vessels is a disturbed state of the circulation. When, in any part of the body or from any cause, the circulation is either temporarily or perma-

* Patholog. Anatomy, fasc. 6. Hemorrhage.

nently impeded, the pressure of the blood in the vessels of the adjacent parts is increased, and their laceration often results. Hence all the forms of hyperæmia, described in the former section, are frequently associated with extravasation of blood. It is observed in obstruction of the veins, in stoppage of the heart's action, in stagnation in the capillaries, and, indeed, in almost every case of inflammation. Hence it is that extravasation of blood is so frequently combined with hyperæmia, with the effusion of serous or fibrinous fluids, and with suppuration. Moreover, pathological changes in the walls of the vessels themselves frequently give rise to laceration, and it has been especially noticed that the arteries are more easily lacerated than usual under the ordinary pressure of the blood, when their walls have become softened by atheromatous deposits, or have become brittle by the deposition of earthy matter.

Amongst the causes of extravasation, many writers place certain changes in the blood itself, especially those that occur in ordinary and land scurvy, and in the higher degrees of putrid fever and typhus. But we must clearly distinguish between the extravasation of actual blood containing corpuscles, and the infiltration of dissolved hæmatin which transudes through the uninjured walls of the vessels, and will be considered in the next section. This dissolved condition of the hæmatin is entirely dependant on a decomposed state of the blood. In typhus, petechial and putrid fever, &c., the extravasation of true blood is, however, very frequent, but is always dependant on laceration of the vessels; and in producing this laceration a change in the composition of the blood can only act a very secondary part. It can at most only act through a series of means, by favouring congestion and stagnation of the blood. On these points, however, we know very little.

The further course of extravasated blood resembles in all essential points that of a fibrinous fluid. Firstly, it may either be resorbed and thus disappear; or secondly, it may act as a cytoblastema and become organized. A perfect resorption is probably only possible while the blood remains fluid. This fluid undergoes various modifications in its properties, corresponding doubtless with chemical changes with which we are at present only imperfectly acquainted. When blood is extravasated in a part where its changes can be traced with the eye, as for instance, under the epidermis, it gradually undergoes progressive changes of colour; it passes from a dark red into a blue, then into a brown, and lastly into a yellow colour, before it entirely disappears. The causes of these changes are unknown. Sometimes they do not occur; blood which was effused in the conjunctiva from straining during a severe cough, gradually disappeared without any change of colour, the last traces exhibiting the tint of normal blood. Scherer* has carefully examined the changes which blood, extravasated in consequence of a blow on the upper part of the thigh, underwent as long as it remained in the body. After a few days, it lost its power of coagulating, and contained no more fibrin. The blood-corpuscles were still observable, but were spherical and swollen; and the blood itself contained more water, and less solid constituents than in the normal state. Three days later, the corpuscles disappeared, the blood was much more liquid, and contained a few pus-corpuscles, and in the course of a few days it was entirely converted into pus.

When coagula of blood become organized, as in certain apopletic cases, the changes are much more complicated. The clot is usually found after some time to consist of two distinct substances, an inner one, which is soft and forms a reddish brown mass (changed blood-corpuscles), and an outer one consisting of firmer layers, which are white, or at any rate less red than the inner mass, and present a granular amorphous appearance under the microscope. This difference between the outer and inner portions may be referred to two

* Unters. p. 194.

distinct causes: either the coagulum, in consequence of the irritation which it produces, gives rise to inflammation of the surrounding parts, and to the exudation of fibrinous fluid which deposits itself in a coagulated form around the original clot; in which case the outer white layers are new formations, altogether independent of the original clot: or the hæmatin in the outer layers of the coagulum, to which the fluids are readily accessible, may be for the most part absorbed, and the difference in colour between the outer and inner layers thus accounted for. In many cases it is probable that both these causes are in operation; I think, however, that we may conclude, from numerous observations, that every considerable extravasation of blood causes an effusion of fibrinous fluid around it, and is, therefore, generally combined with fibrinous dropsy. In its further course of development, the clot appears to be influenced by the general laws, which form the subject of our next chapter. The most distinct products may be evolved from the blood; pathologically, pus, granular cells, melanosis, &c.; normally, cellular and fibrous tissues, vessels, &c.; also concretions.

Extravasated blood undergoes a peculiar change in gangrene. It becomes converted into blackish brown clots with a cadaverous odour, and frequently covered with black granules in which no blood-corpuscles can be recognised.

Further information on this subject will be found in our section on gangrene. See also pl. IX. Fig. X.

Consequences of extravasated blood, anatomical relations of the surrounding parts, and frequency of its occurrence. The consequences of extravasation of blood are partly general and partly local. The general are chiefly dependant on the amount of blood which is thus removed from the vascular system, and is consequently prevented from discharging its ordinary functions in the body; when the amount is small, they are very trifling, but if it is large, there may be much debility, or even death induced. The local consequences are dependant on the action of the effused blood on the surrounding parts, (chiefly by the pressure and mechanical influences exerted by it); also on the quantity of the extravasation, and on the functions and importance of the organ in which it has taken place. Thus, considerable effusion of blood in the brain produces apoplexy, with its consequences; in the lungs and bronchi it fills the air cells, and checks respiration; in the pleura it compresses the lungs, and in that way impedes respiration; in the urinary bladder, by coagulating in the urethra, it gives rise to a mechanical stoppage, and retention of urine with its consequences ensues. Finally, amongst the evils arising from extravasated blood, we may reckon softening, inflammation, suppuration, ulceration, and gangrenous destruction of the affected part.

The anatomical relations of the surrounding parts differ extremely in different cases. When hyperæmia and stagnation are the causes of extravasation, the surrounding parts appear hyperæmic, even in the dead body; in other cases where the effusion has been very copious, the whole body appears pale and bloodless.

The extravasation of blood is a very frequent occurrence, and may take place in almost any organ containing blood-vessels; in the lungs constituting hæmoptysis, in the brain apoplexy, in the stomach and intestinal canal hæmatemesis and melæna; it is likewise not uncommon in the kidneys, urinary bladder, and uterus. The particulars of these forms of hæmorrhage are further noticed in the chapters on these different organs.

Diagnosis of extravasated blood.—Effused blood may be generally detected with the naked eye; if the quantity is very small, it may, however, be requisite to have recourse to the microscope. The only appearances with which it can possibly be confounded are hyperæmia of the capillaries and infiltration of hæmatin. The distinction between extravasation of blood and hyperæmia of the capillaries is not always obvious, and the difficulty is increased by their frequently occurring together. We may be assured that extravasation has occurred when the redness of a part is not uniform, but distributed in patches, and further, when the specks of blood which we can detect, either with the microscope or the unaided eye, have a larger diameter than the vessels of that part, even when dilated to the utmost. Sometimes other circumstances contribute to strengthen the diagnosis; thus, for instance, there would be great probability in the assumption that blood was extravasated in the lungs, if during life the sputa were observed to contain numerous blood-corpuscles, as occurs in pneumonia, or when in the dead body the bronchi were found to contain bloody mucus. Coagulated blood in the ureters, and bloody urine lead to the inference that there has been extravasation in the kidneys. Fortunately in these cases where the diagnosis between these two conditions is not easy, its accurate establishment is of no great value, for each is intimately combined with and keeps up the other, and the extravasation is most commonly produced by hyperæmia and stagnation of blood.

The difference between the extravasation of blood and the infiltration of hæmatin is explained in the following section.

Blood effused into the stomach and intestinal canal, and either found there on dissection, or discharged by the mouth or the rectum, has, however, a different character. Instead of being red it is of a brownish black colour, and of the consistence of tar, or else flocculent and resembling coffee grounds. Under the microscope there are observed patches of an irregular form and size, but of a deep reddish brown colour, like the blood modified by gangrene,* and in which no blood-corpuscles can be observed. This appearance is caused by the blood coming in contact with the acid of the gastric juice,

* See pl. IX. fig. 10.

and other intestinal fluids, by which its albumen becomes coagulated. When it is found in the stomach, or has been discharged by vomiting, it is liable to be mistaken for bile. The diagnosis is easily effected by the addition of nitric acid, which changes the colour of bile from a dark into a clear green, then into a blue, violet, purple, and, finally, a pale red; while the blackish-brown blood, in the absence of bile, does not undergo these modifications.

4. SOLUTION OF HÆMATIN AND SATURATION OF THE TISSUES WITH IT.

When on making a dissection we observe the various organs of a blood-red colour, we sometimes hastily conclude that there is either extravasation of blood, or hyperæmia, whereas a more careful examination would show that the red colour was due to the saturation of the tissues with serum containing hæmatin in solution. Hæmatin seldom becomes dissolved during life, but often after death. We sometimes observe it during life in gangrene, and in putrid and petechial fevers. In these cases the blood obviously undergoes a chemical change, which causes the hæmatin to dissolve in the serum. The nature of these changes is not accurately known; they probably depend on various causes, such as the occurrence of free lactic acid, or of carbonate of ammonia in the blood, and possibly on a great diminution of the salts. In gangrene there is not unfrequently observed a clear red, or else a turbid brownish fluid in vesicles under the epidermis, constituting gangrenous ichor. This is merely serum tinged with dissolved hæmatin; the brown colour occasionally noticed is probably dependant on a modification of the hæmatin, produced either by an acid or by ammonia, similar to that which occurs in melæna. In those cases in which the hæmatin becomes dissolved during life, the whole mass of the blood is probably not affected, but only a portion, which has either stagnated in or escaped from the vessels.* This change is, however, of

* See the description of fig. 10 in pl. IX.

much more frequent occurrence after death than during life, and we may conclude that when it occurs very soon after death, the blood during life must have had a tendency towards decomposition. In due time it invariably occurs in the dead body, as a consequence of putrefaction; ammonia and other products being formed, which dissolve the hæmatin.

This condition should be carefully studied, for the red colour dependant on it, (which is very frequently observed in the inner surface of the heart and larger arteries, and likewise occurs in the bronchi and other parts,) is very often mistaken in dissection for the redness of inflammation. This redness is for the most part less intense than that from hyperæmia or extravasated blood, and is more uniformly distributed, more subdued, and rather of a purple than a blood-red colour. The microscope will always settle the point; it will show that the capillaries in the affected part are not gorged with blood as in hyperæmia, and that there are no masses of blood-corpuscles as in extravasation. The latter are altogether absent, and, under the microscope, the part appears of an uniformly red colour, but pale in proportion to the magnifying power.

CHAPTER IV.

PATHOLOGICAL EPIGENESES.*

In the primary formation of the body, and subsequently in its nutrition, new formations (elementary particles and tissues) arise, interpolated as it were between those already existing. A somewhat similar process is of frequent occurrence in pathological formations; indeed, so frequent are these morbid epigeneses, that the greater number of the changes which pathological anatomy can demonstrate after death may be arranged under this head. At the same time, they are so various, and the relations of their formation, development, and termination in individual cases so different, (two or more epigeneses being frequently associated and combined,) that a satisfactory description of these conditions, including a clear arrangement and separation of the individual elementary phenomena is a task of the greatest difficulty.

In order not to lose ourselves in the details connected with this extensive department of our science, and at the same time to acquire a clear view of these various relations, we shall attempt to work out, as far as possible, the general laws followed by pathological formations in their development. These laws are very closely allied with those which direct the development and formation of tissues in the normal state; indeed, in many cases, no definite line can be drawn between normal and abnormal formations.

* Neubildungen, literally, new formations.

It cannot be expected in pathological anatomy that the ultimate causes of all morbid changes in the organism should be noticed, any more than that all the symptoms should be described; which generally accompany those changes. On the other hand, it is a most important point to distinguish, as far as our opportunity for observation will allow us, the origin. development and gradual formation of these changes; further, we should investigate the general laws of their formation and development as far as this can be done by cautious conclusions from undoubted observations, and we should compare these laws with those which apply to the normal development of the whole organism, and of its individual parts.

Pathological epigeneses naturally divide themselves into wo groups, the organised and the unorganised.

The distinction between these groups is a double one.

1. *There is a morphologic difference.*—Organized bodies exhibit the same perfect form and internal organization throughout as in their separate parts, and as soon as they become parts of the organism. Unorganized bodies are devoid of organization, the highest and most perfect form they can assume being that of a crystal.

2. *There is a genetic difference.*—Unorganized formations are always produced in accordance with the laws of pure chemistry, while organized formations follow the developmental laws of organic life.

If even in perfectly normal formations, the difficulty in defining the limit between vital organization and mere chemistry is considerable, in pathological formations it is much increased, for each may be combined with, and indeed merge into the other, so that in individual cases, it is not always easy to determine to which group a formation belongs. This does not, however, hinder us from regarding the two groups as representing opposite types. In their chemical compositions there are no essential differences, except that the organized formations consist, for the most part, of the substances known in chemistry as compound radicals; while the unorganized consist in part of inorganic matters, although compound radicals frequently also enter into their composition, and hence the terms *organic* and *organized* are not altogether synonymous in relation to morbid formations.

Like every thing else in nature, pathological growths require a material for their formation—a matter from which they may be produced. To this which may be either fluid or solid, and may vary extremely in its chemical composition, we apply the general terms *plasma*, or *formative matter*.

It is a necessary character of this plasma to be amorphous; it must neither be crystalline, nor have a definite organic form. An already formed structure can only assume that function by throwing off its shape and becoming again structureless.

A plasma may act as formative material either for organized or unorganized products, or for both at the same time. The plasma for unorganized formations, which is usually an aqueous solution, from which deposits are produced or crystals formed in accordance with chemical laws, we shall name a *mother-liquid;* the matter giving rise to organized formations which are chiefly produced by the formation of cells, we shall term a *cytoblastema*,* or, for brevity, a *blastema;* and lastly a plasma, from which organized and unorganized products are developed, will be designated as a *mixed plasma*.

The manner in which pathological formations are produced from a mother-liquid is essentially different from that in which they are produced from a cytoblastema. The former being the most simple will be first considered.

Almost any fluid in the body may act as a mother-liquid for pathological formations, if a portion of the dissolved unorganized or organized matters assumes an insoluble condition and separates as a precipitate. The conditions under which this phenomenon ensues are very numerous; but, as far as yet known, are influenced simply by chemical laws. A deposition frequently occurs from too concentrated a condi-

* From κυτος, a cell; and βλαστημα, growth.

tion of the mother-liquid; substances thus assuming a solid form, from the absence of a sufficient quantity of water to retain them in solution. Such a concentration may occur when a thin fluid, almost saturated with substances difficult of solution, is placed in contact with an animal membrane, on the other side of which is a fluid deficient in water; under these circumstances, it follows from the laws of endosmosis that the original fluid will lose a portion of its water: or when a fluid parts with water by evaporation from a free surface, as for instance in the nasal cavities. There is also another very obvious cause for the production of deposits, depending on the circumstance of the solvent power of acids and alkalies. For instance, human urine in the normal state is acid. The free acid is here the condition by which the earthy phosphates are retained in solution. If for any reason the urine, either in the bladder or in the pelvis of the kidney, becomes alkaline (from the alkaline serum of the blood entering it, or from the decomposition of urea into carbonate of ammonia) the earthy phosphates can no longer be retained in solution, and become deposited in an insoluble state. Again, an excess of free acid in the urine decomposes the urates, and if the secretion is very deficient in water, the liberated uric acid which is not so soluble as its salts, no longer remains in a state of solution. Most of the fluids of the human body contain phosphate of magnesia—a salt of considerable solubility: on coming in contact with ammonia, a very insoluble compound—ammoniaco-magnesian phosphate—is at once produced; hence, when the body undergoes putrefaction, and ammonia is set free, almost all the tissues are bestrewed with crystals of this salt. It is true that the causes for the formation of unorganized depositions are not always so simple and clear as in the above cases, as will be seen on referring to the section on the concretions, where the matter is more fully discussed. It is sufficient in the present place to have shown that all the pathological depositions of whose formation we have any clear idea, are formed in strict accordance with the laws of chemistry, in a manner that can frequently be imitated in the laboratory.

These products may vary in form; sometimes they occur in a very minute granular state, sometimes in indefinite crystalline masses, and sometimes in perfect crystals, which are usually so small that their form cannot be recognized by the unaided eye. These varieties depend, as in ordinary chemical processes, on the rapidity or slowness of the separation, and on the crystallizing or non-crystallizing tendency of the substances.

In chemical composition they vary in accordance with the place of their formation, and the properties of the fluid which acted as the mother-liquid. There are two classes of morbid products which we must distinguish from each other, namely, those which are formed in fluid secretions, possessing specific chemical constituents, and such as occur in the parenchyma of organs, in the cellular tissue, &c. The latter closely resemble each other in chemical composition, from whatever part of the body they are obtained; they usually consist for the most part of earthy phosphates and carbonates, (lime and magnesia,) and their ordinary mother-liquid is the exuded plasma of the blood, which may be regarded in the light of a mixed plasma, that is, it usually gives origin to unorganized as well as to organized morbid products, so that the process is only in part influenced by the laws of chemistry. A few of the depositions occurring in the parenchyma form an exception to this general law; for instance, gouty concretions, which consist of urate of soda. The depositions, on the other hand, which are formed in the fluid secretions, have a varied chemical composition corresponding with differences in the mother-liquid from which they are produced. Earthy phosphates and carbonates occur also here, but many other matters may likewise be present, as for instance, the fatty acids, cholesterin, margarin, bile-pigment, uric and oxalic acids, uric oxide, cystin, &c.

The production of the above morbid products is not always accomplished by means of a finely granular or crystalline precipitate: as a general rule, each simple primary form yields compound secondary forms: the particles of the deposit adhere together by new depositions—by mucus or some other means of connexion—and form larger masses visible to the naked eye, and either soft or firm, according to the nature of their constituents. These are named concretions, concrements, or calculi; they occur for the most part in the fluid secretions, in cavities or canals, and may be either free or connected with the adjacent walls. Their form is usually irregular, being sometimes dependant on that of the cavity in which the concretion was produced, and sometimes on the simultaneous presence of several concretions rubbing against and so flattening each other, and thus often producing a shape almost as regular as that of a perfect crystal. They are frequently composed of concentric layers deposited round a nucleus. Their fracture is occasionally crystalline, as in many urinary calculi, and in gall-stones consisting of cholesterin, and it is but rarely that a definite external form determines the corresponding internal appearance, which, however, appears to be the case in prostatic concretions. In other cases these concretions instead of being free are connected with the surrounding tissues, often so intimately as not to admit of separation by mechanical means: this is especially the case with concretions in the cellular tissue, and in the parenchyma of organs. Inserting themselves between organized parts, the histological elements are compressed to the utmost, and their physical properties as well as those of the whole organ are changed. Such depositions are termed ossifications, although hardness is the only character they have in common with bone, and, histologically, they differ most obviously from recently formed osseous tissue. Occasionally such depositions surround organized parts, forming incrustations and filling up their cavities, so as to exhibit a very regular and, at first sight, extremely surprising form. Thus the epithelium cells occasionally present in the urine become incrusted by urinary sediments, and probably the regular spherical concretions of lime found in the choroid plexus are formed in a similar way by incrustation of the cells.* Intimate as the connexion between these depositions and organized forms sometimes appears to be, the adhesion is never chemical, but merely mechanical, and on removing the unorganized structures, either mechanically or chemically, the organized parts stand forth in their original normal form.

It is deserving of especial mention, that the production of many unorganized formations is dependant on the development of a new secreting organ, previously created by a morbid process. In illustration, we may mention the deposition of crystallized cholesterin in encysted tumours, especially in that form termed by Cruveilhier the laminated nacreous tumor, where the deposition is so abundant, that the whole contents form a connected and often tolerably firm crystalline mass.

ON THE DEVELOPMENT OF ORGANIZED PATHOLOGICAL FORMATIONS.

The development of organized morbid tissues is dependant on laws differing essentially from the chemical laws already considered. The difference is obvious even in the formative material. It is not every mother-liquid that can act as a cytoblastema for organized products. The cytoblastema is usually fluid; it may, however, be solid, but in this case it must of necessity be amorphous, that is, it must not exhibit either a definite organized appearance, or crystallization. The only solid cytoblastema which has yet been noticed in relation to morbid products is coagulated fibrin in its amorphous condition and permeated with water, in the state, for instance, in which it occurs in inflammatory exudations. But even this blastema was originally fluid, and

* Compare Henle's Allgem. Anatomie, p. 10.

only assumed the solid form on the coagulation of the fibrin. It is possible, although it has not yet been observed, that other protein-compounds—albumen, casein, or globulin—may act when coagulated as cytoblastemata. In the production of morbid formations from mother-liquids, the plasma seems never to occur in a solid state : if in the department of unorganized nature, as in chemistry or mineralogy, a crystalline formation can take place in a partially or entirely solid amorphous substance, as for instance, in iron, sugar, silica, &c., nothing similar has yet been observed in the human body.

As fibrin in the coagulated form appears to be the principal agent in solid cytoblastemata, so dissolved fibrin seems of similar importance in those that are fluid; indeed, its presence seems to be a necessary condition for such formations as we are considering. This point is, however, so important that it ought to be accurately determined. It is possible in many cases to isolate, and consequently, when they occur in sufficiently large quantity, to analyse the fluid cytoblastemata of morbid products, as in exudations into the serous cavities, or in the formation of vesicles beneath the epidermis, where they are composed of water, fluid albumen and fibrin, fat, extractive matters, and different salts. That aqueous solutions of salts and extractive matters are of themselves insufficient to act as blastemata for organized products is placed beyond all doubt: they can act the part of mother-liquids, they can, in many cases, even enter into different structures, (as for instance, salts of lime into the bones, and chloride of sodium, according to Lehmann,* into cartilaginous tissue), but organized formations can only be produced in them when a fibrinous fluid is also present, as for instance, when exudation occurs in the cavities of the uropoietic system, or of the digestive canal. The same is the case with the fats; certain kinds admit of crystalline formations, (as cho-

* Physiologische Chemie, vol. I. p. 133.

lesterin in gall-stones), and can also enter as constituents into organized formations, but can never of themselves alone, or in combination with salts and extractive matters, act as cytoblastemata; at least, up to the present time nothing of the sort has been observed. Hence there remain, as the actual and potential constituents of the blastema, only the protein-compounds; although these are never found alone in the body, being always associated with the above named substances. Further, all these protein-compounds are not susceptible of development. Fluids which merely contain dissolved albumen and the above substances never appear to act as cytoblastemata. In the common dropsical effusions, which are always rich in albumen, we never observe any organized products, unless fibrin be also present: this is at least the result of my own observations, which have been very numerous, and I am not acquainted with a single exception to the law.* Moreover, fluids in which casein is the only protein-compound, cannot, as far as observation has yet shown us, act as blastemata. In the milk, for instance, as long as it contains merely casein, we never observe any pathological formations, for the granular bodies belong to the normal process of development of the milk; as soon, however, as any fibrin is present, morbid products, such as pus-corpuscles, may be formed in it. On the other hand, in all fluids which we regard as cytoblastemata for morbid products, fibrin has always been found: hence we must regard it as the necessary and apparently the most essential ingredient in the cytoblastema. This law respecting the necessity for the occurrence of fibrin in the cytoblastemata of morbid products, which I have seen to hold good in several hundred cases, without a single exception, is not at all in accordance with the course of normal development: thus the egg, the prototype of all formative fluids, contains no fibrin; its place being

* See the section on serous dropsy.

apparently supplied by albumen.* In the nutrition of the perfect organism, the general nutrient fluid,—the modified blood-plasma permeating the walls of the vessels,—acts as the general cytoblastema for all new formations. Whether the fibrin is the only essential formative material in this fluid, or whether the albumen likewise takes part in development, is a question which cannot be answered with the same degree of certainty as in the case of morbid products, since the normal fluid of nutrition can never be obtained free from extraneous constituents in sufficient quantity to be accurately analysed.

If it appears certain that the protein-compounds are the only substances capable of development in the human body, the question—which of them can act as a cytoblastema?—does not admit of a positive answer, since we at present possess but a moderately accurate knowledge of a few of the numerous modifications of this substance. This answer must, however, only be regarded as provisional, and will probably require considerable modification when we know more of the nature of the protein-compounds.

When we have once established the principle that the blastema for morbid products must always be amorphous, the old idea is obviously overturned, namely, that a normal tissue may be directly converted into a pathological formation. Direct evidences will be subsequently adduced, when treating of individual morbid products.†

Having now considered the chemical composition of the cytoblastemata of morbid products, another question presents

* There may possibly be some connexion between this fact and the observation of Mulder, that the albumen of the egg contains one atom less of sulphur than the albumen of the blood, and that consequently in its ultimate composition it is identical with fibrin.

† As examples of the amorphous solid cytoblastema, we may refer to pl. I. fig. 14, and pl. II. figs. 2 and 4, with the accompanying explanations. As a good illustration of the fluid cytoblastema, we may refer to the fluid of fibrinous dropsy.

itself—whence do they arise, and from what part of the body are they produced? In the present condition of our physical knowledge, I believe that no one will dispute with me, that without further preamble we may establish the principle as a general law, that the cytoblastema of every morbid product, as also of the tissues in healthy nutrition, is obtained from the vessels, and that its source is always the blood, or in some few cases the chyle or lymph. In normal nutrition the proposition cannot be determined by direct observation; but the grounds on which the probability is founded, are so sound, as to prevent the possibility of denial, for all the nutriment which in the latter instance the formative material conveys to all parts of the body, passes at length into the blood; on the other hand, parts to which the supply of blood is checked or diminished are not at all, or only imperfectly nourished. In pathological epigeneses, it may often be directly observed that in consequence of inflammation, the plasma exudes through the vessels and forms the cytoblastema; and in cases in which we observe no morbid secretion, it is more than probable that the ordinary nutrient fluid escapes through the vessels without inflammatory action, and thus forms a blastema for morbid products.

Information on the processes by which this increased separation of plasma from the vessels is effected, has been already afforded in the section on fibrinous dropsy. I shall advert to the subject more fully in treating of inflammation.

Organized morbid epigeneses are therefore produced in a blastema separated from the blood, and at the expense of the fibrin contained in it. Before we consider the processes which take place in development, we will take a glance at the question,—on what is the development of the cytoblastema dependant? A purely chemical precipitation like those by which unorganized forms are produced, cannot in this case be regarded as sufficient, for while chemistry serves to point out the chemical differences between these formations, we still cannot perceive how the various forms of the fibres and cells can proceed from it. By assuming a vital power, and referring all phenomena to it, we do not gain a single step; since while we substitute these, as the foundation of all phenomena, we are even confessing that the latter is dependant on the entity of the organism, and is inexplicable to us: an insight into the primary causes of all formations is, however, the point that most concerns us at present.

In order to obtain a starting point, let us proceed from hypotheses. There are two different causes which may be supposed to affect the transition of the blastema in development; firstly, the cause may be grounded on the nature of the cytoblastema, and the formation may be developed with the same necessity which, under favourable conditions, compels the separation of certain crystals from their mother-liquid: or secondly, the transition in the development may be dependant on external conditions, independent of the cytoblastema, as for instance, on the influence of the surrounding parts of the body, &c. In order to ascertain which of these two hypotheses is deserving of preference, it is requisite that every one should have perfectly clear and distinct ideas on the following points. We must distinguish between the capacity of the cytoblastema in the progress of development (potentia), and the actual transition (actus). That the capacity for development essentially pertains to the cytoblastema, no one will deny. If it depended merely on external influences, then would any substance placed in similar relations undergo the same process of development—an assumption entirely at variance with experience. In this respect the cytoblastema of a morbid product resembles an egg or a seed; it differs, however, in the circumstance of its actual development (the transition of the potentia into the actus) being much more dependant in external conditions. Its development is not merely dependant on the same general conditions as those of the egg, which is developed out of its mother's body, (namely on the presence of warmth, moisture, and oxygen;) in the majority of cases, it is likewise requisite that it should be connected with the body of a living individual: a blastema for morbid products, can, as a rule, only be developed when it is in connexion with, and reacting on a vital part of a living body. After death no cytoblastema is developed in the body: moreover, in parts of the living organism, in which vitality has been destroyed by gangrene, there can be no further development.

Of course this is not the case with independant organisms. Fungi and infusoria may be formed in the dead body. Moreover the coagulation of fibrinous fluids after death does not fall under this head, for the coagulation of fibrin is a process unconnected with development. We can at any rate include here the fibrinous flakes* (*Faserstoffschollen*), described by H. Nasse, although I could not convince myself of their existence after a series of observations conducted with the greatest care. On the other hand there appear to be isolated exceptions to the above rule, and cases apparently occur in which we must assume that pathological elements, especially pus-corpuscles, can be produced without the contact of organized tissues, indeed, even externally to the body. Thus Helbert† has recently observed, that the fluid of a blister, produced by cantharides, which on its discharge contained no corpuscular particles, after standing five or six hours in a glass contained granular cells (imperfect pus-corpuscles), and he has even followed their progressive formation under the microscope. (Figs. 1, 5, 6, and 7 of the plate attached to his Dissertation.) I shall again refer to this subject in speaking of the formation of pus, when I shall give some other examples of independent cell-formations unconnected with organized parts. The development of a cytoblastema without either the influence of surrounding organized parts, or a previously exciting germ is, however, rare, and appears to be limited to very simple formations, such as pus-corpuscles. Moreover, the greatest caution is necessary in carrying on such observations as those of Helbert. In the microscopic examination of a fluid containing a few scattered particles in suspension, it frequently happens that those particles escape detection, till the fluid has stood for some time, and they have gravitated to the bottom of the vessel. In such cases the observer might be readily deceived, and led to believe that these bodies were actually produced in the fluid in the vessel.

* Müller's Archiv. 1841, p. 437.

† De Exanthematibus arte factis fragmenta, Gottingæ, 1844, p. 16.

If after the above observations it hardly can be doubted that the capacity for development is inherent in the cytoblastema, and that the actual development is modified by external influences; the important question still remains—what share the cytoblastema has in the development, and what share is due to external influences? Taking a general view of the question, we find considerable differences on this point. In the formation of the animal organism from the egg, the share of the cytoblastema is very predominating; there is contained within it not merely the capacity, but likewise the whole quality of the future formation: in fact, the whole of the future organism is included in the egg: external circumstances can hinder, but cannot essentially change it. When speaking of the theory of malformations, we shall consider this subject more closely. In the nutrition of the perfect organism, the case is different; we here observe the various tissues of the different organs evolved from the blood, or rather from the general nutritive fluid, — as cellular tissue, bone, muscle, and nerves. The element of this difference cannot therefore lie in the blastema; it must rather be sought in the ready-formed parts of the body, which influence the blastema to the development of parts similar to themselves. We must accordingly conclude that the formative capacity, which being equally diffused through the egg is impressed on the whole blastema, now acts at special points, and on those individual tissues which have the capability of exciting a development in a suitable blastema, leading to the formation of analogous compounds within its sphere of action, that is, in its immediate neighbourhood. This is a formative act similar to that by which an entire organism enables a cytoblastema to develop an individual similar to itself. The nature of the blastema is not, however, to be regarded as a matter of indifference in this process; it can generally only be traced in the development, when it possesses a definite chemical composition, and on this, as well as on the chemical changes which the blastema undergoes in its development, the chemical part of nutrition is dependant.

Let us now apply this to morbid products. Numerous cases present themselves in which the epigenesis takes place in a manner perfectly analogous to that which occurs in healthy nutrition. Thus, in the process of regeneration and in hypertrophy, where the influence of the cyto-blastema on the nature of the development is at its minimum, the development itself appears to be entirely dependant on the normal histological elements between which the blastema is effused. Thus, in regeneration and hypertrophy, the blastema between areolar tissue, becomes areolar tissue; in the vicinity of bone, it becomes cartilage and bone; between muscular fibres, it is converted into similar tissue; at the extremities of divided nervous fibrils, it forms nervous substance, &c. The circumstance that these and no other structures are formed, cannot in these instances be dependant on the blastema, which as far as chemical analysis goes, seem to be the same; and it is entirely the influence of the surrounding parts that modifies the character of the development. Here then, if we may be allowed the expression, we are entering the department of *solid pathology*.

But it may be further asked: it being granted that in the above cases, the nature of the development is essentially dependant on parts of the body already formed, what is the case with those pathological epigeneses in which the resulting morbid product is perfectly different from the surrounding parts, as in scirrhus, encephaloid, tubercle or pus? Is not the abnormal character of the product dependant on a peculiar pre-existing blastema, so that there is always one kind of blastema for scirrhus, another for encephaloid, and so on?

We are yet hardly in a condition to answer this question satisfactorily. It is quite possible that the elements of the peculiar structures of scirrhus and encephaloid may be traced to the blastemata from which they spring, and that in accordance with the views of the humoral pathologists, the pseudo-plasma may be dependant on an abnormal chemical composition of the blood. Another explanation may be attempted which equally elucidates the appearance of these peculiar morbid products, namely, that the peculiarity of the epigenesis is not dependant on any property of the blastema, but on changes in the properties of the tissues influencing the blastema; and thus the explanation of these phenomena is again transferred from the department of *humoral* to that of *solid pathology*, or, since in many cases these changes are dependant on a change in the nervous influence, to that of *nervous pathology*. It is, however, in the highest degree probable, that in the majority of cases neither the one nor the other of these views alone is strictly correct, that for the most part changes in the cytoblastema and changes in the physiological properties of the tissues are conjointly at work in producing an abnormal epigenesis.

These brief observations on a much-disputed question must for the present suffice. The only possible method of thoroughly testing the subject is by an examination of individual pathological epigeneses.

The nature of the development of pathological epigeneses is dependant on:

1. The cytoblastema, the quantity, quality, and mode of its production. The more rapidly and abundantly it is secreted, and in proportion as the chemical composition (which, however, is certainly not accurately known) differs from the normal blood-plasma, so does the influence of the surrounding histological elements decrease, and the formation proportionally deviate from the normal type. Thus small quantities of exudation become easily organized, and simple hypertrophy usually consists in small exudations repeatedly occurring after long intervals (weeks or months). We can draw no very definite limit between this process and that of healthy nutrition. Abundant and rapidly formed exudations are

rarely organized, usually proceeding to suppuration. Exudations undergoing incipient putrefaction—as, for instance, ichor—do not become organized; and where the composition of the blood, (and consequently the exudation proceeding from it,) differs considerably from the normal type—as is probably the case in typhus and scrophulosis—either no organization follows or else it occurs very imperfectly, as we shall presently see when speaking of typhous matter, scrophulous depositions, and similar products.

2. The nature of the development is influenced by the histological elements of the part in which the epigenesis occurs. If the influence of these parts predominates, the newly formed material resembles the pre-existing normal tissue, and thus in morbid hypertrophy, in regeneration of lost parts, &c., the process is just the same as in ordinary nutrition.* This important law which plays a very active part in pathological epigenesis, I will for brevity term "the law of analogous formation."

The law of analogous formation, is, however, essentially modified by the nature and vital properties of the parts in question:

A. The more complex in structure the tissue is in which the epigenesis occurs, so much the less does it resemble the normal elements. Areolar tissue, osseous tissue and simple (non-striated) muscular fibre are easily reproduced, nerves not so readily and more slowly, whilst complex organs, such as the tissue of the lungs, brain, &c., are either not reproduced at all, or only very imperfectly. The extent of this law varies considerably in different organisms; while in men and the higher animals, the regenerative power is very limited, or, if I may use the expression, the power of producing histological elements from the cytoblastema is at its

* This law is clearly laid down by Meckel; he observes that morbid epigeneses resemble the adjacent normal structures. Path. Anat. vol. II. Part II. p. 213.

minimum, in the lower animals where whole organs can be reproduced, this power is much more energetic.

B. In proportion as the physiological properties of the parent-tissue deviate from the normal type, so much the more heterogeneous will be the epigenesis. Thus in gangrenous parts the exudation admits of no normal development; and the same is the case in parts in which the nerves have been divided. In structures which have been changed by chronic inflammation, or of which the physiological properties of the elementary parts differ for any reason from the normal type, pathological epigeneses are produced distinct from those that occur in healthy parts.

The cytoblastema on the one hand, and the pre-existing tissues on the other, are each factors influencing the formation of organized morbid products, and it is on their different properties that these epigeneses are dependant both for their mode of formation, and for their general characters.

Having dismissed these questions, let us now advert to the processes that take place in these morbid developments. Schwann in confirmation of his cellular theory,* has made the remark, that he has observed its application to a large number of morbid products. Since that date numerous observations have been published which support this view. Schwann's theory of cellular formation has, during the last few years, been attacked from many quarters, or at least adopted with modifications, as by Arnold, Henle, and Vogt,† while Reichert‡ has stood forth as its advocate. According to Schwann, development is always dependant on a formation of cells in an amorphous cytoblastema, and the formation

* Mikrosk. Untersuch. über die Uebereinstimmung in der Structur der Thiere und Pflanzen, 1839.

† Unters. über die Entwicklungsgeschichte der Geburtshelferkröte, 1842, p. 117, &c.

‡ Müller's Archiv. 1842. Jahresbericht über die Fortschr. der mikrosk. Anatomie.

proceeds in this manner. In the first place, one or more minute granules (nucleoli) appear, around which the cytoblast (nucleus) is formed, and this again becomes surrounded with a membrane (the cell-wall) which at first closely envelopes it, but subsequently in the course of its growth, becomes separated from the nucleus, thus leaving a cavity between it and the cell-wall. This is termed the cavity of the cell, and is filled with a substance differing essentially in character both from the nucleus and the cell-wall. In the cell thus produced, the nucleus is not in the central point, but is situated eccentrically at a point on the inner surface of the cell-wall. It is from these cells alone, by a process of further development, that all organized products arise.

That this mode of development from cells occurs in pathological epigeneses may be readily shown in numerous cases. This process can be most obviously traced in the formation of pus-corpuscles, when they are produced from a fluid blastema on a free surface, or in a cavity connected with the exterior of the body. In such a case, we first observe numerous isolated granules,* which become surrounded by a very delicate transparent cell-membrane,† which subsequently forms so thick and opaque a wall, that the nucleus can no longer be seen through it;‡ on the addition of acetic acid, which dissolves the cell-wall, or at any rate renders it transparent, the nuclei again become visible.‖ If it is impossible to trace the whole course of development in one and the same cell, we can yet make out the successive changes of the whole mass of cells with sufficient certainty. These and similar observations, such as for instance may be made on the formation of epithelium, confirm the opinion that in all essential points Schwann's theory is applicable to morbid formations; but that in individual cases, many facts may be observed which

* Plate III. fig. 6, A, b.

† Plate III. fig. 11, A.

‡ Plate III. fig. 6, A, a.

‖ Plate III. fig. 9, B.

do not coincide with this theory, or at least render some modification imperative.

With respect to the early relations of the nucleus and the nucleolus, I cannot convince myself of the existence of the nucleolus prior to the nucleus, or at least that the nucleolus is, as it were, the means of forming the nucleus in the same way as the nucleus forms the cell. In some cases this may happen, but certainly not in all. I must agree with Henle in opposition to Reichert, in believing that Schwann's cellular theory represents only one of the various forms of development, of which the type in different cases may present very numerous differences.

The nuclei of morbid formations present great differences both in form and size; they are round or oval,* or occasionally elongated and pointed, as in the formation of areolar tissue, and simple muscular fibre.† Nucleoli are sometimes clearly visible, usually one or two in number, but occasionally three or four; sometimes, however, no trace of a nucleolus can be detected. In many cases the nucleus has a well-defined, regular outline; in others, this appearance is absent, and it then occurs as an aggregation of minute, indefinite granules, or as a soft mass without any well-defined limit. In this point of view, morbid products of the same kind present great differences, as for instance, pus-corpuscles, in which the nucleus consists of an aggregation of minute granules, sometimes quite unconnected with each other, and sometimes united by a connecting medium presenting perfectly distinct chemical properties, so that in this case great differences occur in the form of the whole nucleus, as well as in the mode of deposition and properties of the individual molecules. The size of the nucleus is always very minute, varying in diameter from the 600th to the 100th of a line, but seldom exceeding the 200th: the only exception is in the case of elongated fusiform nuclei, which may exceed the 100th of

* See Plate I. † Plate IV. fig. 4.

a line. The nucleoli are, however, much smaller, their diameter seldom exceeding the 1000th of a line.

The chemical relations of the nucleus are very remarkable. It possesses the property of resisting the action of acetic acid, a reagent which attacks the solid cytoblastema in which the nucleus is situated, as well as the cell-wall surrounding it, rendering the latter pale and sometimes causing its total disappearance. Hence acetic acid affords the means of rendering the nucleus visible when it is hidden by the cytoblastema or the cell-wall. In pus-corpuscles, where the relations of the nucleus are very peculiar, the addition of acetic acid usually causes it to break up into minute granules. By the prolonged action of a solution of borax, caustic ammonia, and more rapidly by caustic potash, we find that the nucleus and the cell-wall disappear simultaneously, being dissolved by these reagents. After this solution is effected, there usually remain minute granules apparently composed of fat, for on extraction with ether, previously to applying the alkalies, they did not appear. These are regarded by Messerschmidt and Lehmann* as the nucleoli of the pus-corpuscles; but I do not believe that they stand in any special relation to the nucleus, since they do not occur in all nuclei, and may further occur free in a fluid containing cells.

Relations of the cell-wall generally, and especially towards the nucleus.—Observations on the development of morbid products teach us that sometimes the facts are precisely in accordance with the general law laid down by Schwann, but that there are likewise exceptions to this rule. Undoubted cells are sometimes observed in pus-corpuscles, and generally in encephaloid and scirrhus. The form and magnitude of these cells are extremely variable; they are usually round or

* Messerschmidt de pure et sanie, Lipsiæ, 1842, p. 11. Lehmann u. Messerschmidt über Eiter und Geschwüre. Archiv. v. Roser und Wunderlich, vol. I.

oval,* sometimes elongated and fusiform,† and occasionally quite irregular.‡ It is, however, only rarely that we can distinguish in them a decided membranous cell-wall, and a cavity distinct from it;§ the cell most commonly appears as an homogeneous mass (with the exception of the nucleus) so that we can distinguish in it the substance of the nucleus and the substance of the cell, but no cavity. Even in pus-corpuscles the sharp external outline is sometimes absent, so that here we have no definite and limited deposition around the nucleus. This opinion, first suggested by microscopic observation, is confirmed by the laws of endosmosis. For while on the addition of water to pus-corpuscles with an undoubted cell-wall, the membrane constituting the wall becomes first dilated, and then bursts and liberates the nucleus, pus-corpuscles without a decided cell-wall merely become swollen, without rupturing themselves. Hence, in addition to the kind of cellular formation described by Schwann, according to which the cell consists of a constricted membrane surrounding a nucleus, we must assume a second kind, in which a somewhat indefinite precipitation occurs around the nucleus.

Moreover, the relation of the cell-wall to the nucleus in morbid products differs in many points from Schwann's theory. A species of cellular formation occurs in which there are no pre-existing nuclei; thus pus-corpuscles without nuclei are often observed; they are usually of an irregular form, and after the application of acetic acid leave only a few (fatty) granules, and sometimes not even these.‖ These non-nucleated pus-corpuscles are always formed in large quantity in unhealthy suppuration, and apparently not singly amongst normal corpuscles; hence, in these cases the whole process of development appears from some general cause to undergo an

* Plate I. figs. 1—6, and 13.

† Plate I. fig. 12.

‡ Plate I. fig. 11.

§ Plate I. fig. 2.

‖ Plate III. fig. 7.

essential modification. Under this form of non-nucleated cellular formation, we must include the fibrinous flakes (*Faserstoffschollen*) described by H. Nasse,* if their general occurrence be confirmed. I have never yet succeeded in detecting them, although I have repeatedly sought for them both in blood and in exudations, and other observers have been equally unsuccessful. J. Meyer† explains them as being merely epithelium rubbed from the walls of the vessels. The non-nucleated corpuscles, somewhat resembling fibrinous flakes, which occur in encysted tumours, and in pus from glandular organs,‡ I certainly regard as epithelium. Hence the absence of the nucleus may be easily referred to resorption, as certainly the older cells of the epidermis are non-nucleated. Colloid of the thymus presents another non-nucleated structure, which externally appears as if it were cellular. If we agree with Nasse in regarding these formations as not composed of cells, but constructed according to distinct laws, nothing is gained by such a supposition. The cellular theory, if a general law of development is to be founded on it, must take cognizance of all these phenomena, and must endeavour to explain them in accordance with its own doctrines. Sometimes the absence of the nucleus in a cell is only apparent, being concealed by the cell-wall, and coming in view after the addition of acetic acid: in other cases the nucleus is formed and becomes resorbed, as takes place with the cells of epidermis and various epithelia.

Besides the cases in which cells are devoid of any nucleus, there are others to be considered, in which a cell contains more than a single nucleus. This phenomenon admits of a double explanation; firstly, the composite nucleus might be first produced, and a simple cell formed around it; or secondly, another cytoblast may form within a cell containing a single

* Müller's Archiv. 1841, p. 437.

† Froriep's N. Notizen, 1843, No. 560.

‡ Plate I. fig. 3, pl. III. fig. 9. C. D.

nucleus. In fact, both these modes of formation actually occur. It has been already stated that the nucleus of pus-corpuscles is not simple, but consists of several (2—4) portions. We frequently observe that these composite nuclei are present before the cell is formed. Sometimes I have seen, in a pus-corpuscle, several such nuclei consisting of minute nucleoli; once I noticed as many as four, so that the whole of the pus-corpuscle was filled with granular matter, the individual portions of which were not clearly defined. The second mode of formation, that namely in which the nuclei are formed subsequently to the production of the cell, is of ordinary occurrence in vegetable cells and in cartilage. Here the newly formed cytoblasts act as central points for a new formation of cells, and then there arise cells within cells—parent cells and their offspring. Moreover, this process may be observed in morbid products, as in encephaloid, where we often find cells with many nuclei, and parent-cells with their offspring.*

It has been already mentioned that Schwann's opinion, that every cell possesses a decided cell-wall between which and the nucleus there is a cell-cavity filled with a matter differing from the cell-wall, is incorrect. Numerous cases, however, occur in which these points strictly accord with the laws of the cellular theory. A decided wall with a double contour, sometimes occurs in cancer-cells.†

In all probability the cell-wall invariably consists of a protein-compound, and it is chemically distinguished from the nucleus by being rendered transparent by acetic acid, and frequently after prolonged action being altogether dissolved. A similar reaction occurs on the addition of solutions of borax, caustic ammonia, and (more powerfully) of caustic potash. Recent cells have usually a homogeneous cell-wall, which subsequently becomes opaque, and covered with a granular matter, usually insoluble in acetic acid and in alkalies,

* Plate I. figs. 6 and 7.

† Plate I. fig. 2; pl. VIII. fig. 9.

but soluble in ether, and therefore probably of a fatty nature.

The contents of the cell, when they are distinct from the cell-wall, are usually fluid. They cannot be detected by the eye, and their presence can, therefore, only be inferred by the circumstance that the cell collapses when bursting under the compresser, and that its fluid contents escape. They form a tolerably concentrated solution of matter soluble in water, as their relation in respect to endosmosis testifies, for on placing such cells in pure water, they swell till they burst, since their contents by endosmosis absorb water; in concentrated saline solutions, on the other hand, they shrivel, since they lose water by exosmosis. Sometimes the cells contain fluid fat in the form of drops, which may be distinguished under the microscope from the surrounding fluid by their different refracting power.* The solid contents of cells are usually granular, and the granules are most commonly devoid of colour;† but sometimes they are black, brown, or orange. The chemical properties of these contents are various; sometimes the granules consist of fat, and are then soluble in ether; sometimes of calcareous salts, in which case they dissolve in acids. As examples of cells with coloured contents, we may mention those containing black pigment.‡ and yellow bile-pigment.§ Moreover, crystalline deposits sometimes occur within cells, crystalline groups of margarin being occasionally noticed in fat-cells.‖ It is not always easy to distinguish whether granular matter is actually within the cell, or only deposited on its walls.

According to the theory of Schwann, who ascribes the formation of all structure to cells, the process of development is not completed by the above mentioned formation: the cells undergo further changes, and do not follow the

* Plate I. fig. 9.

† Plate I. fig. 2; pl. III. fig. 12 and 13.

‡ Plate I. fig. 10.

§ Plate I. fig. 8.

‖ Plate X. fig. 3.

type in accordance with which they were first formed, but differ very considerably in different structures. These changes may be divided into two groups depending on the properties of the product developed from the cells. It is the very same distinction as we meet with in the consideration of the elementary parts of the normal organism. In the first group we include those organs which, in their highest stage of development, retain their cellular formation, as for instance all epithelia, the blood-corpuscles, and the cellular constituents of the liver, kidney, and other glands. In the second group we include those parts in which the original cells undergo further modifications which destroy their cellular type. This is likewise the case with morbid products, and it may happen that either: firstly, the organized product is completed by the formation of cells; or secondly, the cells altogether lose their characters as cells, and become changed into different tissues, with whose formation and perfection the process of development is concluded, and its object thoroughly attained.

Let us now proceed to consider these possible relations somewhat more closely.

1. *The morbid development may remain as a cellular formation, and the original cells having attained their highest degree of development, may undergo no further metamorphosis into other tissues.*

In the morbid products belonging to this class there are yet further differences to be noticed, namely, *a.* whether the cellular formation is persistent, and in its perfect form constitutes a fixed constituent of the organism; or, *b.* whether the cells are transitory, breaking up and being rejected or resorbed without being of any service to the organism, or contributing any permanent constituent to it.

This distinction has reference not so much to the individual cells as to the tissues formed from them: moreover, in the persistent cellular formations the individual cells become gradually broken up in the process of metamorphosis, but new individuals are developed with the same relations, so that the integrity of the tissue is maintained inviolate, while in the second division the whole structure breaks up simultaneously with the destruction or removal of the individual cells.

a. PERSISTENT CELLS.

The chief parts of the human body which in their perfect condition are composed of cells, either directly connected with one another, or united by a very minute quantity of intercellular substance, are the epidermis, the epithelia of mucous and serous membranes and of vessels, the internal cellular investment of ducts in glandular organs, and fatty tissue. Moreover, the cartilages (with the exception of fibrous cartilage) belong in some measure to this class, if we regard their structureless intercellular substance.

When, by a morbid process, any of the above-mentioned structures are produced anew, the process of epigenesis is exactly the same as that of the original formation in embryo: it follows that the cells formed from the cytoblastema gradually assume the form and properties which pertain to the normal cells of the newly formed tissue. Hence the whole change undergone by the original cells consists in this, that they gradually become similar to the cells of the normal tissue which they are to repair. The changes thus occurring in the primary cells may in special cases be very different; they may become flattened and increase in breadth, as in pavement epithelium, or they may increase in length, and assume a conical form, as in cylindrical epithelium.

This mode of formation of the persistent cells can be most readily observed in the restoration of destroyed epithelium, as after burns or blisters. We shall notice especial instances when speaking of the epigenesis of epidermis and epithelia.

b. TRANSITORY CELLS.

While the above-mentioned persistent cellular formations exist in the normal body and are subservient to organic life, and to certain definite objects—as protection from without, secretion, or absorption—so also in morbid processes, we very frequently meet with a species of cellular formation, in which secondary cells which have proceeded from primary cells discharge no functions connected with the vital process. These do not remain connected with each other, but separate, and are either discharged as foreign matter from the organism, or when this does not or cannot happen, being capable of no further development, gradually break up, until they are at last reduced to a nearly structureless, finely granular mass, which (like any other mass incapable of acting as a cytoblastema) gradually separates, as far as is possible, from the fluids of the body, and at last for the most part or entirely disappears.

A large number of morbid products fall under this head; for instance pus and what are termed malignant epigeneses, such as tubercle, encephaloid, and scirrhus, whose descriptions are subsequently given.

2. *The cells may be converted into other forms.*—Instead of being converted into secondary persistent cells or being altogether destroyed, the original cells may be converted into other structures, which in their perfect state have entirely lost the original cellular form. The processes by which this takes place are very different, depending on the properties of the tissue to be constructed from the cells; they admit, however, of division into two fundamental types.

A. Several cells may be fused together by the uniting of their walls. Thus according to Schwann are formed blood-vessels, nerves and muscular fibre.

B. The cells may become divided, each individual cell separating into different parts. This is observed in the development of cellular tissue.

We shall enter with more minuteness into the genesis of these structures, when treating of the morbid formations occurring in the individual tissues.

The above scheme enables us to take an easy review of the different organized morbid formations, and further, as will be presently shown, it has its practical uses. It is founded on Schwann's theory of development. It presupposes that all organized forms are composed of primary cells,—a supposition which in relation to normal development has been opposed on many sides, and in relation to morbid products cannot be very strictly carried out. In our observations on morbid cells, we have shown that their development does not in every point coincide with Schwann's theory; there are numerous exceptions in the transitory formations, namely, in the tissues which in their perfect condition do not retain the cellular form. In these cases we frequently cannot detect any cellular formation throughout the whole process of development, or at most a mere analogy—a faint tendency to the formation of cells, but no such actual production. This occurs in scrophulous and typhous exudations, and in a great part of the cases of tubercle. Here we first have an amorphous or finely granular exudation (blastema) forming a tenacious and tolerably firm mass, which by degrees breaks up into a more or less fluid magma, exhibiting under the microscope indefinite granular molecules of various forms and sizes, sometimes resembling cytoblasts and cells, but never indicating a decided cellular formation.

Further there are produced in many fluid cytoblastemata, partly together with regular cytoblasts and cells, and partly as isolated formations, minute indefinite granules (elementary or molecular granules) which sometimes appear to form constituent elements of future cells, but as frequently to remain for a long time unchanged, and finally without undergoing any further metamorphosis to disappear or be discharged. They are not invariably, (indeed not even for the most part), fat-vesicles with a definite wall, as Henle* supposes, but solid granules which apparently consist sometimes of fat, and

* Allgemeine Anatomie, p. 163.

sometimes of the salts of lime, or of a modified protein-compound. These elementary granules are frequently arranged in somewhat regular groups, clinging together and forming by their union large granular bodies (aggregate corpuscles) which sometimes so closely resemble cells that scarcely any difference can be observed. Indeed, it appears that such groups of molecular granules may even be invested with an actual cell-wall, and thus form true cells.

In all these cases of morbid epigenesis, we find no decided cellular formation, such as should occur according to Schwann's theory; on the contrary, these cases approximate towards the mode of formation of unorganized depositions, forming a sort of transition between them and organized morbid epigeneses.

The above mentioned elementary granules are of very frequent occurrence, and we shall often have occasion to revert to them. They occur as very minute granules of an indefinite rounded form, and vary from the 800th of a line to a size too small to admit of measuring. Differing as we have shown in their chemical characters, they behave differently towards reagents. Those of most common occurrence seem to consist of coagulated protein-compounds and resist the action of most reagents. Neither acetic nor nitric acid, nor yet caustic ammonia or potash, nor ether cause them to disappear. Those consisting of fat dissolve in ether with the aid of heat. Those finally which consist of calcareous salts (phosphate and carbonate of lime) disappear on the addition of nitric acid, in the latter instance with the development of air-bubbles. There can be no doubt that these elementary granules are always deposited in a fluid condition, and subsequently assume the granular form either by coagulation or chemical precipitation.

In those completely organized morbid products which in their perfect condition, no longer retain the cellular form, it is only rarely that any decided cellular formation can be detected during the period of development, as according to Schwann's theory must always be the case. Thus in the development of areolar tissue and of fibrous tissue, we certainly sometimes find cells which are prolonged into fibrils, but more frequently we meet with mere cytoblasts without decided cells (with a wall, cavity, and contents), and the blastema appears to be converted directly into fibrils: indeed, sometimes we observe the formation of fibrils without even the pre-existence of a decided cytoblast. This and many similar observations which we shall notice when speaking of the different tissues confirm the opinion that Schwann's theory requires considerable modifications before it can be applied to morbid tissues, and further that all perfectly formed tissues do not originally possess a decided cellular formation; this cellular structure in some cases existing only for a short time, as during the formation of the cytoblast, and in other cases not at all. As, however, our knowledge respecting the development of the different morbid formations is still very deficient, we must rest satisfied with the above statement, and refer individual observations to the departments under which they naturally fall.

The processes we have hitherto considered have reference principally to the morphology of development. It has been already stated that with this morphological change there is also a chemical change in the cytoblastema. We have seen that as in the cellular formation of the blastema there are chemical differences, so the nucleus differs in its chemical reactions from the surrounding cell-wall. This chemical change is still more important, when perfectly organized forms, as areolar tissue, muscular fibre or nervous matter have been produced from the original blastema, since all these substances, as a general rule, differ considerably in their chemical composition from their cytoblastema. Thus, for instance, from coagulated fibrin there may be formed areolar tissue consisting of gelatigenous tissue, or cartilage which on boiling yields chondrin, or osseous tissue which in addition to gelatin contains a large amount of calcareous salts. We are far from being in a position to lay down general chemical laws regulating these formations. We can certainly compare the chemical formula for the cytoblastema with that for the product formed from it, and calculate how many atoms of oxygen, carbon, hydrogen, or nitrogen must be deducted or added, in order to convert the one into the other, but such a proceeding is in most cases a mere sporting with formulæ, which in some instances may give probable results, but here, when we are attempting to form general laws, is altogether out of place. I, therefore, reserve the consideration of this subject till the tissues individually are considered.

We have already stated sufficient to show the undeniable importance of Schwann's cellular theory in contributing to our knowledge of the development of morbid epigeneses. This theory gives us the key to the understanding of a large number of processes, by enabling us to take a general view of them. But in its original form it is not sufficient to explain all the phenomena which occur in the development of morbid products. Since, as has been already shown, it is impossible to include all the phenomena relating to morphological relations in our general laws, it is naturally far more difficult to indicate the general causes of development, or, in other words, to give a general theory of the development of organized epigeneses. This is the more difficult since the chemical bearings of the subject, which require as much attention as the morphological, have hitherto been much neglected; and for that reason I shall not attempt to establish any such theory.

SPECIAL RELATIONS OF ORGANIZED PATHOLOGICAL EPIGENESES.

The final results of the development of the pathological epigeneses already described are in special cases very different. Some of the products are of a fluid nature—emulsions, which like the blood, contain organized solid parts suspended in a liquid; others are solid. The latter are tissues which are in all respects identical with those of the normal body, as areolar tissue, epithelia, vessels, cartilage, bone, &c.; or on the other hand, they may be of a peculiar nature to which there is nothing analogous in the normal body, as for instance, tubercle, encephaloid, scirrhus, &c.

In many cases the newly formed tissue is homogeneous; in others, on the contrary, it is composed of very different elements.

In another point of view, the newly formed tissue is either persistent, or in other words, forms a permanent part of the body, and is there nourished like any other portion of the system; or else it is transitory, and after a time softens, breaks up, and is removed.

This is the leading difference between non-malignant and malignant epigeneses.

Further, morbid epigeneses may be classified:

1. Into such as form a reparation of a lost part (regeneration). These regenerated parts are either:

A. Perfectly formed, the newly constructed part being similar to that which was lost, both in its morphological, chemical, and functional characters (true reparation). This true regeneration always follows the law of analogous formation, and in the human body is confined to simple tissues; in the lower animals it exists on a much more extensive scale.

B. Or they are imperfectly formed (cicatrices). Cicatrices are sometimes transitory, existing only so long as the morbid product is continuing to be developed. When it is completed, the new tissue is perfectly similar to the old, and the cicatrix disappears. In other cases the cicatrix is persistent. The new parts then remain undeveloped and half-amorphous, or they are composed of elements of lower physiological importance, as of areolar tissue, while the complicated elements of the lost part, as it normally existed, (nerves, muscular fibres, glands, &c.) either do not occur at all, or at any rate much more sparingly than before: hence the new part can only imperfectly fulfil the functions of its predecessor.

2. Into tissues whose elements are not reparative, but directly increase the bulk of previously normal organs. Hypertrophies—tumours.

These may be distinguished by observing that in cases of hypertrophy, the newly formed parts are continuous with those previously existing, and cannot be anatomically distinguished from them. Hypertrophy may thus, in the same way as regeneration and on the same grounds, be divided into the true and perfect, or the false and imperfect.

In tumours (in a restricted sense) the newly formed parts are not, as it were, fused into the older, as in hypertrophy, but are more or less separate and independent. This is, however, a mere artificial distinction between hypertrophy and tumour.

All these distinctions are, however, of little service; we shall consequently leave them, and seek to resolve the individual epigeneses into their elementary phenomena.

A classification of the different pathological epigeneses is very difficult in consequence of the various relations in which they stand to each other, and of their frequent transitions from one form into another. In accordance with the point of view from which we establish our observation will either the one or the other mode of arrangement be preferred. The surest basement for pathological anatomy is a sound acquaintance with histology, and impressed with that feeling, I intend, in the following pages, to resolve the different morbid formations as completely as possible into their elementary parts, to consider these first in relation to themselves alone, and then as occurring united in large masses (tumours) and thus from that which is simple, to proceed to that which is compound. The connexion between the different pathological epigeneses and the relations in which they stand to each other will be afterwards considered.

CHAPTER V.

PATHOLOGICAL EPIGENESES CONSISTING OF FLUIDS WITH MORE OR LESS ORGANIZED PARTS.

PUS.*

The term *pus*, in the sense in which it is commonly used, conveys with it no very definite idea. We apply it to almost every creamy, white or yellow fluid, occurring in almost any part of the body, the only necessary assumption being that its formation is dependant on a morbid process. On more closely examining this class of fluids, we find that they often present very considerable differences, partly as regards their mode of formation, and partly as regards their microscopical and chemical relations. Thus diffluent encephaloid and tubercle are frequently regarded as pus, indeed, even normal structures, such

* The literature of pus is very abundant. The following are the most important recent works and memoirs on the subject: Th. Gluge, Observationes nonnullæ microsc. fila (quæ primitiva dicunt in inflammat. spect. Berol. 1835; Gueterbock, de Pure et Granulatione, Berolini, 1837; Wood, de Puris Natura atque Formatione, Berolini, 1837; J. Vogel, über Eiter, Eiterung und die damit verwandten Vorgänge, Erlangen, 1838; Henle, über Schleim- und Eiterbildung. Hufeland Journ. f. d. pract. Heilk. vol. LXXXVI. p. 5; Gluge, anatom.-mikrosk. Untersuchungen, Minden, 1838, p. 15, &c.; L. Mandl, Anatomie microsc. Livr. 2. Pus et Mucus, Paris, 1839; Gruby, Observationes microscop. Vindob. 1840. F. E. Braun, der Eiter, &c., Kitzingen, 1841; Messerschmidt, de Pure et Sanie, Lipsiæ, 1842; E. v. Bibra, Chemische Untersuchungen verschiedener Eiterarten, Berlin, 1842. Lehmann und Messerschmidt, über Eiter und Geschwüre; Archiv f. physiol. Heilk. v. B. Roser u. C. A. Wunderlich, vol. I. p. 220, &c.; F. Bühlmann, Beitr. zur Kenntniss der kranken Schleimhaut der Respirationsorgane, Bern, 1843; Henle, Zeitschrift für rationelle Medicin von Henle u. Pfeuffer, vol. II. p. 177, &c.

as epithelium cells which have been rubbed off and formed a sort of emulsion with a fluid, have often from their purulent appearance and from the omission of accurate observation been mistaken for pus. Hence the necessity for dividing fluids which appear purulent into true genuine pus, and into spurious or false pus.

But even true pus presents many differences in the form and properties of its corpuscles, in the proportions of the corpuscles to the fluid portion, &c. Hence genuine pus must be divided into many varieties, which it is necessary that we should know and be able to distinguish, if we hope to have a clear understanding of the variations presented by the process of suppuration in different cases.

1. TRUE GENUINE PUS.

Normal pus (pus bonum et laudabile) is that which is yielded by healthy-looking wounds healing by suppuration, and by mature abscesses. This is the best adapted for showing the properties of perfectly formed pus as well as the mode in which it is produced.

Normal pus forms a creamy, thick, opaque and homogeneous fluid, containing no flocculent matter, depositing on standing no caseous, grumous precipitate, and communicating a soft and fatty feeling when rubbed between the fingers. It has a faint yellow, and sometimes a white or faintly green tint, and develops, as long as it remains warm, a peculiar, mawkish animal odour, which it loses on cooling. It is somewhat sweet, and insipid, and has a specific gravity of 1030—1033.

Normal pus consists essentially of two distinct parts, of very minute organized particles—the pus-corpuscles, and of a colourless aqueous fluid—the serum or liquor puris in which the pus-corpuscles are suspended as in an emulsion.

The pus-corpuscles are quite invisible to the naked eye, and we can only begin to distinguish them by a magnifying linear power of 50—100; but in order to study with accuracy their properties and structure, they should be magnified 200—400 diameters.

Their form is in general spherical,* and is regular in proportion as the pus assumes a normal character. Sometimes they are irregularly rounded, elongated, oval, or rugged; and generally speaking, they are irregular in proportion as the pus deviates from the normal type. Their diameter varies from the 200th to the 300th of a line; it seldom exceeds the 150th or falls below the 400th. These fluctuations in size are apparently dependant on the individual from whom the pus is obtained, or on the nature of the disease; sometimes we find that all, or the greater number of pus-corpuscles from an abscess or wound are small; in other cases that they are all large.

In some cases the pus-corpuscles are very delicate, pale and transparent, and their surface smooth and even;† but more commonly they are opaque, tough, uneven and granulated, that is to say, studded with very minute particles from the 1000th to the 1500th of a line in diameter.‡

When observed separately, they appear colourless; in heaps, they exhibit a yellow tint. They are only slightly elastic, but very soft, and under the compressor are reduced to an amorphous magma. They are specifically denser than the serum, and gradually fall to the bottom.

Many deviations of the corpuscles from the normal form will be described in our observations on abnormal pus.

The corpuscles of genuine pus are organized forms, for the most part of a cellular nature, with a nucleus, cell-wall, and contents.

The cellular structure with a decided nucleus, appears only

* Plate III. fig. 1 and 2. † Plate III. fig. 11, A.
‡ Plate III. fig. 1.

in unchanged pus-corpuscles, when the cell-wall is very thin and transparent.* In the majority of cases, the nucleus is covered by the granulated opaque cell-wall,† and does not become visible till the latter is dissolved or rendered transparent by acetic acid.‡ In other cases, in which the development of the pus-corpuscle is imperfect, we see only the nucleus and no cell-wall.§

The nucleus does not lie in the centre of the pus-corpuscle, but as is the case with all cells, is situated eccentrically, and is usually attached to the inner surface of the cell-wall. We may convince ourselves of this by allowing pus-corpuscles to float and rotate in the field of the microscope.‖ It is only the larger nuclei that form an exception to this rule, for they are sometimes so large as to occupy the whole space of the pus-cell. The nucleus of the pus-corpuscle presents many peculiarities, and is so different from other nuclei, as to require a somewhat careful consideration.

In other cells the nucleus is a simple body, but in the pus-corpuscle this is not always, or indeed generally the case; it is usually composed of several (2—5) minute granules forming a composite multiple nucleus. Sometimes on treating fresh pus-corpuscles with acetic acid, or a solution of salt, a single nucleus becomes apparent, indented like a trefoil leaf, or cloven into 2—4 smaller nuclei.¶ But it is not every nucleus that undergoes this change; in some cases it appears to resist the action of these reagents. The single large pus-corpuscles with a diameter of the 100th to the 80th of a line, exhibit several (two, three or four) such nuclei, each of which is composed of smaller bodies insoluble in acetic acid.

The corpuscles which form the nucleus, when, by the addi-

* Plate III. fig. 2, b, and fig. 11, A.

† Plate III. fig. 1.

‡ Plate III. fig. 3.

§ Plate III, fig. 7, A, b.

‖ Plate III. fig. 11, A.

¶ Henle, fig. 8—12.

tion of acetic acid, they are clearly brought before us, present various forms; sometimes (generally in good pus) they are elliptic, and present an excavated cup-like form, resembling fresh blood-corpuscles;* sometimes, however, they present a spherical or oval appearance.† In some cases they are distinct from each other, even lying in different parts of the cell-cavity; but they are more frequently in apposition, and joined together, so as to present the figure of a trefoil leaf, or some other form.

This composite character of the nucleus in the majority of the corpuscles, as revealed by the action of acetic acid, is very characteristic of normal pus. The only other instances in which this occurs are in young gland-cells, and in the most recent layers of pavement epithelium, but in these cases they are never so general as in pus. Hence it follows that the size of the nucleus is liable to great deviations; from being entirely absent it may occupy the whole cell. Its usual limits are the 800th to the 400th of a line. Nucleoli are rarely found in the nuclei of pus-corpuscles.

I shall show further on, that the granules which remain after treating pus-corpuscles with alkalies or borax, and which Messerschmidt‡ considers as nucleoli, cannot be regarded in that light, since they occur as much out of the nucleus as within it. If some writers altogether deny the existence of nuclei, or have seen them otherwise than as we have described, it must arise from imperfect observations, or from the circumstance that normal pus was not examined. The above differences in the nuclei are connected with their chemical composition, and with differences in the mode of formation of the pus-corpuscles. I shall again return to this subject and attempt to elucidate it.

The cell-wall of the pus-corpuscle varies in thickness, and surrounds the nucleus more or less closely. In delicate and young pus-corpuscles, it is very thin, smooth, membranous and transparent: in older and many peculiar sorts

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* Plate III. fig. 3; fig. 9, B. † Plate III. fig. 6, A.
‡ Op. cit. p. 8—10.

of pus, it is thick, tough, opaque, and studded with minute granules. In many cases, pus-corpuscles have no definite or distinct cell-wall, consisting merely of a nucleus, and an irregular deposition around it, without any clearly definite outline, as may be shown not merely from microscopic investigation, but by their relation towards endosmosis. This is especially the case with young imperfectly formed pus-corpuscles.

Moreover, there are many differences in the contents of the cell occurring between the cell-wall and the nucleus. In pus-corpuscles with a single nucleus, a well-marked membranous cell-wall, and consequently a cavity between them,* we often find no solid body in the cell-cavity, excepting the nucleus. The contents must therefore be fluid, and doubtless identical with the serum of the pus, containing dissolved albumen; for the corpuscles are rendered turbid and opaque by reagents which coagulate that substance. In other cases, in addition to the nucleus, granular contents are seen, with independent chemical reactions. Sometimes the contents seem as it were so thoroughly fused into the cell-wall, that the two form only a single substance, a solid but soft mass in which the nucleus is imbedded.

Endosmotic and chemical relations of the pus-corpuscles. When either solid or fluid substances are allowed to react on pus-corpuscles, numerous changes, dependant on two different causes, are observed to take place. One of these causes is the endosmotic activity of the pus-corpuscle itself; the other is the chemical action of the reagents on the various materials entering into the composition of the pus-corpuscle. Generally speaking, both forces are simultaneously in action; we shall, however, consider them separately, in order to determine with greater accuracy the effect of each individual reagent.

When pus-corpuscles are submitted to the action of fluids,

* Plate III. fig. 11 A.

very deficient in solid constituents, they imbibe water by endosmosis, and become tumid. Conversely very concentrated saline solutions, or dried hygroscopic substances, such as chloride of sodium, sugar, or chloride of calcium, have just the opposite effect; they withdraw water from the pus-corpuscles, and cause them to contract. The former of these processes being termed endosmosis; the latter, which only differs in the opposite direction of the current, is for the sake of distinction named exosmosis.

The changes produced in the pus-corpuscles by endosmosis are most obvious when they are placed in contact with distilled water: they then swell, become larger, and assume a spherical shape; in most cases the distended cell-wall becomes more transparent, and the nucleus more obvious, the nuclei retaining for some time their cupped appearance. By prolonged action, those cells with a perfect wall increase until they ultimately burst, on which the regular form of the external contour disappears, and the corpuscles assume an irregular ragged appearance. By further prolonged action the nucleus imbibes moisture, and its individual portions lose their cupped form, and become spherical. Some corpuscles present exceptions to the reaction; they swell to a less degree, and the capsule is not distended to actual bursting. This is the case with those that possess no regular cell-wall, but consist merely of an irregular, badly defined precipitate around the nucleus. In this case, however, the nucleus becomes changed.

To observe the phenomena of exosmosis, the pus-corpuscles must be placed in a concentrated solution of common salt, or else dried salt must be added to the pus: the corpuscles then assume a contracted appearance, and present a plicated and clear outline. Generally they become considerably smaller; pus-corpuscles whose diameter was the 200th of a line, afterwards do not measure more than from the 300th to the 400th of the same measure. Others are not so much affected, especially those which possess no regular cell-the addition of water, the pus-corpuscles reassume their original form and character.

Many chemical reagents produce a modifying effect on pus-corpuscles; but when they are applied in a very dilute or very concentrated state, they combine the action of endosmosis or exosmosis with their own peculiar chemical reactions. We shall here give merely the most important reactions, those namely which elucidate the chemical composition of the pus-corpuscles.*

Dilute acids render the substance of the capsule transparent, and burst it by endosmosis, but do not, even by prolonged action altogether dissolve it. They cause the nucleus to stand clearly out, and for that purpose, dilute acetic acid is the best reagent. Moderately dilute solutions of most of the neutral salts, as of hydrochlorate of ammonia, chloride of sodium, or nitrate of potash gradually dissolve the substance of the capsule and the greater part of the contents, with the exception of the nucleus, and even this they render tumid, so that it loses its shape and outline, and forms an indefinite mass.

Solutions of the alkaline carbonates and borax, convert the pus-corpuscles into a viscid mass, and the same effect is more rapidly induced by the caustic alkalies. Both capsules and nuclei disappear and there remain only very minute, dark molecules, with a diameter less than the 1000th of a line. Lehmann and Messerschmidt regard these molecules as nucleoli; I cannot, however, accept this opinion unconditionally, since they are scattered among the half-dissolved pus-corpuscles without any definite order; and further, since they are sometimes absent in pus-corpuscles with undoubted nuclei, and are present in other abnormal pus-corpuscles in which no nuclei are apparent; and lastly, since they are

* A full and very accurate account of these reactions is given by Lehmann and Messerschmidt. Op. cit. p. 226.

found in the serum, altogether independent of the pus-corpuscles.

Substances which coagulate fluid albumen, such as metallic salts, tincture of iodine, alcohol, &c., render the pus-corpuscles opaque, a sign that they are infiltrated with an albuminous fluid.

Saliva, mucus, urine, blood, and other animal fluids, do not as a general rule produce any very essential change in the pus-corpuscles; bile, however, seems to break them up, possibly in consequence of its containing soda.

Boiled with concentrated hydrochloric acid, pus-corpuscles react in the same manner as the protein-compounds, forming a violet coloured fluid.

From these reactions we may conclude that pus-corpuscles consist of several substances differing in their chemical characters, and we can distinguish:

1. The substance of the capsule, which is soluble in solutions of the caustic alkalies and their carbonates, of borax, and for the greater part, in saline solutions, as those of hydrochlorate of ammonia, nitrate of potash, &c., and in part soluble in dilute acids, as acetic acid. It forms the wall and a portion of the contents of the cell, and is doubtless a protein-compound, very similar to, and probably identical with that modification of albumen which is precipitable by water, and is again dissolved on the addition of neutral salts or acetic acid.*

2. The substance of the nucleus, insoluble in acetic acid, swelling in saline solutions, and dissolving in solutions of borax, the caustic alkalies and their carbonates. This likewise is a protein-compound, and is probably identical with the modified form of coagulated fibrin which swells in a saline solution.†

3. The substance of which the minute molecules consist,

* Lehmann and Messerschmidt's a fibrin.

† Lehmann and Messerschmidt's b fibrin.

which remain undissolved on treating pus-corpuscles with solutions of the caustic alkalies and borax. They are regarded by Lehmann and Messerschmidt as nucleoli, and in some cases probably this may be the true explanation, but they certainly also occur within the cell, but at the same time externally to the nucleus.

Lehmann and Messerschmidt regard this substance as a protein-compound analogous to keratin, and in many cases this is doubtless true. Sometimes, however, these molecules consist of fat; they are then soluble in ether, and if the pus-corpuscles are boiled in that menstruum, before the addition of the alkali, they do not make their appearance.

Many kinds of "pus bonum" contain nothing corpuscular besides pus-corpuscles; others, on the contrary, contain minute rounded molecules,* often in very considerable quantity. They are always very minute, for the most part less than the 1000th of a line in diameter, and swim either alone or in heaps in the serum and between the pus-corpuscles which are frequently studded with them. These molecules present great differences in their signification and chemical constitutions; sometimes they are protein-compounds analogous to the substance of the capsule, of the nucleus, or of the molecules insoluble in alkalies—elementary granules and partially-developed or abortive pus-corpuscles. In other cases they consist of fat. Finally, there are sometimes infusoria present, minute *monades* and *vibriones*, especially in pus from foul ulcers. As long as the animalcules are alive, we then observe an active motion, and I have sometimes been enabled, by feeding them with carmine, to bring into view the minute spots representing their stomachs.

Moreover, we sometimes find accidental admixtures in healthy pus, some of which may be easily distinguished by the microscope, as epithelial cells or fragments of epidermis, crystals of cholesterin or of ammoniaco-magnesian phosphate,

* Plate III. fig. 1, b.

and flocculi of amorphous or semi-organized fibrinous exudations.

The liquor puris, or serous fluid, in which the corpuscles swim, may be separated by allowing thin pus to stand for some time in a high and narrow glass; the pus-corpuscles then gradually sink to the bottom, while in the upper part of the glass there is pure serum.

This fluid is identical both in its physical and chemical characters with the serum of the blood: it is an aqueous solution of albumen, extractive matters, various salts, and fat.

The qualitative composition of this serum is tolerably constant, but the quantities of the different ingredients vary considerably, as we have already seen to be the case with the dropsical effusions. It is upon these slight differences in the chemical composition of the serum that the varying action of pus on vegetable colouring matters is dependant. If the alkaline carbonates (?) or basic phosphates predominate, the pus has an alkaline reaction, as is usually the case with fresh and good pus. Subsequently an acid (lactic ?) is developed in it, which first renders its reaction neutral and then acid.

The serum of pus occasionally contains a viscid matter, which may be distinguished by its being precipitated by acetic acid and by alum. It was first described by Güterbock, under the term *pyin*, and regarded by him as characteristic of pus. This is not the case: pyin rarely occurs in good, and more frequently in abnormal pus; it likewise occurs in other morbid products, as for instance, in carcinoma; and even at the present time too little is known regarding its properties and chemical composition to allow of its being known by a definite name.

Taking a comprehensive view of the quantitative analyses of pus, it appears in essential points to coincide with the plasma of the blood, or fluid of fibrinous dropsy. There is only this difference, that a portion of the protein-compounds which are dissolved in the latter, exist in pus in a coagulated state, forming the pus-corpuscles.

I give below a few analyses of pus, selected at random,* and by their side, for the purpose of comparison, I likewise place the composition of the plasma of the blood.

1000 parts contained:

	Blood-plasma		1	2	3	4
Water . . .	906		902	907	862	769
Corpuscles (fibrin) .	3.4	80.4	60	63	91	180
Fluid albumen . .	77					
Extractive matter .	3			20	29	19
Salts . . .	8		13	(6)	(9)	(9)
Fat . . .	3		25	9	12	24
	1000		1000	999	994	992

1. Was taken from a small-pox pustule and analyzed by Lassaigne.
2. Was taken from an abscess in the neck and analyzed by v. Bibra, op. cit. p. 41.
3. Was taken from an abscess beneath the breast and analyzed, by v. Bibra, op. cit. p. 96.
4. Was taken from an abscess in the cheek, v. Bibra. op. cit. p. 27.

Hence it is obvious that the analyses of the blood-plasma, and of pus may present great variations without destroying the analogy which subsists between them. The conversion of the blood-plasma into pus always occupies a certain time, during which it is exposed to all the modifying influences of metamorphosis and endosmosis, to which must be added that a considerable evaporation of fluid takes place from suppurating surfaces. Hence pus is usually more concentrated, and contains less water than the plasma from which it is formed.

Formation of pus. The formation of pus is dependant on two very distinct circumstances. In the first place, a fluid must be secreted or separated to act as a cytoblastema; and secondly, the pus-corpuscles must be formed in and from this cytoblastema. The latter follows the general laws regulating organic development.

The cytoblastema of pus is always the fibrinous fluid which has already been described in our observations on fibrinous

* Numerous analyses of pus will be found in the works quoted in the note in p. 133, especially in the Treatise of v. Bibra.

dropsy. Consequently the formation of pus must invariably be preceded by the exudation of a modified blood-plasma.

The opinion that healthy pus can be produced from the tissues of the body by their decomposition or solution, is at the present day unworthy of a serious refutation. That broken up fragments of tissue may be contained in abnormal pus will be presently shown. It appears certain that pus cannot be formed from a merely serous fluid containing no fibrin, like that of serous dropsy. Moreover extravasated blood can only act as a cytoblastema for pus, in so far as it contains plasma.

The formation of pus-corpuscles from the cytoblastema does not take place in a very uniform manner; it occurs in one way when the plasma remains fluid, in another when the fibrin coagulates previously to the formation of pus.

The process of the formation of pus from a fluid cytoblastema can be best observed in fresh wounds cleansed from blood. In examining the fluid secretion from a wound, we first observe minute granules, less than the 1000th of a line in diameter, which are chemically identical with the molecules insoluble in the alkalies and in borax. There then appear, partly around these molecules, and partly independent of them, somewhat larger corpuscles, soluble in the alkalies, but not in acetic acid, identical with the nuclei of the pus-corpuscles. These nuclei appear sometimes isolated, sometimes in groups of twos or threes,* thus forming composite nuclei; around these the cell-wall is subsequently developed, first appearing as a pale transparent membrane,† and subsequently becoming thickened and granular; and thus the pus-corpuscle is formed. The production of pus-corpuscles in this manner is tolerably rapid; in the course of three or four hours after the first appearance of the nuclei perfect corpuscles may frequently be seen; in other cases the process is slower.

If the above observations describe the general type of the formation of pus in a fluid blastema, there are in special cases

* Plate III. fig. 6, A, b.

† Plate III. fig. 11, A.

many exceptions which show that nature does not always strictly adhere to the same models, but induced, as it were, by new requirements, permits of many exceptions. The nucleus of the pus-corpuscle sometimes contains a molecule, which must be regarded as a nucleolus; in other cases this is absent. The nucleoli do not here, at any rate, play the part which has been assigned to them; they appear to serve merely as the most favourable points for the formation of the nucleus, in the same manner as an urinary calculus, for instance, is formed by deposition around a nucleus: they are, however, not essential to the formation of the nucleus. Nuclei are invariably formed in healthy pus: hence they may be regarded as essential to perfect pus-corpuscles; but they are sometimes single, sometimes double, treble, or even quadruple, and their individual parts present almost innumerable differences in relation to size, form and arrangement. The differences are perhaps the most marked in the formation of the cell-wall and contents. Sometimes the formation proceeds in entire accordance with the scheme laid down by Schwann: we observe a simple and apparently vesicular nucleus placed eccentrically in a transparent, elastic, and round cell-wall: with a well-defined external contour. The nucleus, contents, and cell-wall are all destined to undergo, at a subsequent period, further simultaneous metamorphoses. In other cases, as we have already observed, there is only a nucleus, and an indefinite, granular, amorphous precipitate around it, without a clear outer circumference, and, as its behaviour in relation to endosmosis shows, without a surrounding cell-wall. I have sometimes found in an isolated, very large pus-corpuscle (one sixtieth to one eightieth of a line in diameter) three or four separate nuclei, each of which, on the addition of acetic acid, falls into two or three distinct portions. Around these several nuclei only a single cell-wall is formed. In pus-corpuscles the nucleus is, however, always formed previously to the cell-wall.

We are not at present in a condition to state with certainty what are the causes leading to these differences in the formation of the pus-corpuscle.

Let us now throw a glance on the chemical process occurring in suppuration. Lehmann and Messerschmidt* have made an attempt to explain it. In the first place molecular granules become separated from the fluid plasma. These may consist of a peculiar protein-compound, or of fat, are of no very great importance in the normal formation of pus (since in healthy pus they frequently do not amount to one hundredth of the mass of the corpuscles) and very often are not converted into true pus-corpuscles. The nuclei are then formed, which doubtless consist of coagulated fibrin. Whether the capsules of the pus-corpuscles are likewise composed of coagulated fibrin, or whether as Lehmann and Messerschmidt assume, they are formed from the albumen of the plasma, is a point which I shall leave undecided. With our present deficient knowledge of the protein-compounds we can merely offer conjectures. At all events the two following points may be regarded as established. Firstly, pus-corpuscles cannot be formed from albumen alone. Secondly, after the full development of the pus-corpuscles, the amount of fibrin in the plasma is exhausted, and the remaining serum of the pus resembles the serum of the blood, or the fluid of serous dropsy.

The latter point was placed beyond all doubt by a case of empyema, which I observed three years ago at Munich. It is the case referred to in p. 47, and the composition of the fluid is given in analysis 3. The fluid discharged by the two first operations of paracentesis contained fibrin in solution, and in a short time coagulated. On the third occasion it no longer contained fibrin, but, on the other hand, pus-corpuscles. A few days after the last operation the patient died. On dissection it was found that the pleural cavity was completely invested with a thick pseudo-membrane, which was already half-organized, and must therefore at all events have existed several days previous to death. The pus could therefore only be formed in the fluid; but since the fluid which

* Op. cit. p. 247.

was first discharged contained fibrin, it is clear that this constituent was not originally absent, but was doubtless consumed in the formation of pus.

Pus formed in this manner from a fluid cytoblastema is of frequent occurrence in the human body. We observe it in the suppuration consequent on wounds, on the external skin after burns or the application of blisters, in fibrinous dropsy into serous cavities, in pleuritis and peritonitis with exudation, and on mucous membranes, as in catarrhs, bronchitis, gonorrhœa, and many other analogous cases. This mode of formation is frequently combined with that which is now to be described, when the fibrin has in part coagulated previous to suppuration. Pus discharged externally usually exhibits in these cases, perfect corpuscles; there are frequently, however, seen amongst them, imperfect ones of an earlier development, and indeed in some cases, when the pus has been rapidly discharged before its corpuscles can be completely developed, it contains little more than nuclei without any external capsule.*

The mode in which pus-corpuscles are formed from a solid cytoblastema of coagulated fibrin is somewhat different from the above. In this case, changes take place in the plasma identical with those described in the section on fibrinous dropsy, which accompany the coagulation of the dissolved fibrin. In the coagulated fibrin, and from it alone are the pus-corpuscles formed. The process of development is here much more difficult to observe than in the fluid cytoblastema. We seldom perceive the corpuscles till they are altogether formed; they then appear enclosed in a stroma of amorphous or indefinitely fibrous fibrin.† By acetic acid the stroma becomes transparent and invisible; the capsules of the pus-corpuscles likewise disappear, and their nuclei become apparent. The mode of formation is very probably the same as that already described. At first the pus-corpuscles are scan-

* Plate III. fig. 6, and its explanation.

† Plate III. fig. 5.

tily dispersed over the stroma; subsequently, however, they become more abundant, and ultimately occupy the whole stroma, being separated from each other by intervening serum; finally the solid portions of fibrin disappear, and the whole of that constituent is converted into fluid pus.

In this manner pus is formed in all abscesses in which the softening is dependant on the coagulated fibrin changing into fluid pus: in this manner it is formed in solid exudations from the pleura or peritoneum, in gray hepatization of the lung, and in a hundred similar cases. It frequently happens that this mode of formation is combined with the preceding, so that some of the corpuscles are formed from the coagulated, others from the fluid portion of the fibrin. In this or some other way, pus may be formed from exuded blood, as the daily experience of surgeons teaches, and the experiments of Gendrin and others demonstrate.

It does not always happen that pus produced in the latter manner is perfectly formed when discharged from abscesses, &c.; it frequently contains flocculi of coagulated fibrin, which indicate no change, or merely an incipient conversion into pus. These have been termed "ventriculi puris" (*Eiterpfröpfe*).* We sometimes observe them forming a viscid mass (pyin?) in which are imbedded perfect and distinct pus-corpuscles.

It is scarcely necessary to observe that most of the opinions that have been promulgated regarding the formation of pus are undeserving of a serious refutation; as, for instance, the view maintained by Gendrin that pus-corpuscles are nothing more than modified blood-corpuscles. In fact they have required no refutation since the works of Wood, Güterbock, myself, Henle, Valentin, Gluge, &c., have opened a new path in the theory of the formation of pus. During the last few years Gendrin's ideas on the subject have been revived by Braun, v. Bibra, and Barry, but unsupported on any new grounds. I consider it unnecessary to state, in this place, all the points which are adverse to this opinion, for one is sufficiently convincing: namely, that the above described mode

* See Ascherson in Casper's Wochenschr. 1837. No. 46.

of formation of pus-corpuscles from a fluid cytoblastema has been directly observed, whilst on the other hand, no one has ever yet succeeded in following under the microscope the conversion of blood- into pus-corpuscles. Other objections to this view may be found in the above-named works on pus, and in Henle.* Another opinion to which I have already alluded, namely, that pus-corpuscles are modified epithelium cells, was promulgated at a time when we had no knowledge of the general laws of cell-formations, and knew very little even of the epithelium. This view, like the opinion of Gerber and Valentin, that pus-corpuscles are formed by the higher development or retrograde formation of the so-termed exudation-corpuscles, rests more on the interpretation than on the morphological development of the structure. We shall have occasion to revert to the exudation-corpuscles at the end of our section on pus.

Diagnosis of normal pus. The recognition of this morbid fluid is apparently so easy that any one after once seeing it, and observing the above physical properties, would trust himself to distinguish whether or not a fluid was actually pus: and yet there are numerous sources of deception. Fluids containing fragments of epithelium-cells in suspension may readily be mistaken for pus, and in examining the body after death, we sometimes believe that we have discovered suppuration, where in fact no morbid process had been going on. The examination of the fluid by the microscope is the best, and, indeed, the only certain means of guarding against such deceptions. If this instrument reveals the presence of normal pus-corpuscles, and on the addition of acetic acid, the characteristic nuclei appear,† then we may be sure that we have been examining pus, and normal pus.

As I have repeatedly witnessed the above deceptions, I will by way of warning mention two cases. A woman died from pleuritis, with considerable purulent exudation into the pleural cavity. On examination I likewise found in the pelvis of the kidney, and in the ureter on each side a whitish-yellow, thick, creamy fluid, which had all the physical characters

* Henle und Pfeufer, Zeitschrift für rationelle Medizin, vol. II. p. 202.

† Plate III. fig. 1—3.

of pus, and was mistaken for that fluid by the physicians who were present. As during life there were no symptoms of disease of the kidneys, and as dissection did not reveal any morbid change in these organs, the case was regarded as a demonstration of the resorption of pus, and of its subsequent removal by the kidneys. I examined this assumed pus microscopically, and found in it no trace of pus-corpuscles, but merely broken cylindrical and pavement epithelium* from the pelvis of the kidney and the ureter. In another case in which the patient died from peritonitis with exudation, the stomach and upper part of the intestinal canal were perfectly free from remnants of food and chyle, but contained a large quantity of a thick yellow fluid, which was mistaken for pus. In this case also the microscope showed that the fluid contained no pus-corpuscles, but merely the cylindrical epithelium of the intestinal canal.

Formerly great importance was attached to the distinctions between pus and mucus, and numerous pus-tests were published, which at present possess merely an historical value. They were based for the most part on the chemical relations of the pus-corpuscles towards various reagents. In addition to many which were founded on no sure principle,† we may mention the following. Grasmeyer‡ treated diluted pus with carbonate of potash. The mixture became converted by prolonged stirring into a thick viscid gelatinous mass, capable of being drawn out in threads. Caustic ammonia acts in a similar manner (Donné's test). Both alkalies cause the pus-corpuscles to swell and gradually to dissolve into a viscid mass. These pus-tests explain a peculiar change which pus sometimes undergoes in the body, especially when mixed with urine. When, in disease of the bladder, alkaline urine containing a large quantity of carbonate of ammonia is mixed with pus, the pus-corpuscles undergo the same change in the bladder from the alkaline reaction of the fluid contained in it as they do in the preceding pus-tests; they become converted into a viscid mass which physicians often mistake for mucus, thus altogether losing sight of its true signification. Gruithuisen's§ pus-test was founded on false premises; he supposed that pus and mucus during decomposition contained different forms of infusoria. Moreover, Güterbock's‖ test, based on the circumstance that pus being fatty burned with a clearer flame than mucus, is of no practical

* Plate III. fig. 4.

† Compare J. Vogel, Untersuch. über Eiter, &c. p. 96, &c.

‡ Abhdlg. v. Eiter u. d. Mitteln ihn von ähnlichen Feuchtigkeiten zu unterscheiden, 1790.

§ Naturhist. Unters. über den Untersch. zw. Eiter und Schleim. 1809.

‖ Op. cit.

use. The microscope renders all these chemical pus-tests superfluous; it enables us not merely to distinguish pus from mucus, broken epithelium, blood, &c., but likewise to determine approximately the amount of these different substances, which chemical analysis has never succeeded in doing. It is only in a few cases that no certain conclusions can be deduced from microscopic examination. We sometimes find in normal mucus, that is to say, in the product of the secretion of healthy mucous membranes, isolated corpuscles, similar to those of pus; they are termed mucus-corpuscles and are probably epithelium-cells in a very early stage of development. When we find these corpuscles in the secretion of a mucous membrane, it is difficult to distinguish them from a small number of pus-corpuscles; but in all these doubtful cases a very accurate diagnosis is of no importance, for if amongst millions of epithelium-cells, we do find a few pus-corpuscles, so slight a process of suppuration is unimportant to the physician. By the help of the microscope we can not only distinguish pus from the normal fluids of the body, but also good pus from that which presents an unhealthy appearance, from ichor, or from the detritus of encephaloid or tubercular masses, as will subsequently be shown.

ABNORMAL PUS.

We have hitherto described pus in its ordinary normal characters. The deviations from this type, are, however, so numerous and distinct, that a whole series of slight, hardly appreciable changes might be given, at one extreme scarcely differing from normal pus, at the other there being a fluid so different in its characters from pus, as no longer to deserve its name. These deviations are dependant on various causes.

A. *On the admixture of foreign ingredients.*

Blood may be mixed with pus. On opening an abscess some blood often gets mixed with it, forming red streaks or flocculi in which undoubted blood-corpuscles can be recognized. Or if the pus is formed in consequence of a contusion, or of extravasation, the mixture of blood with it is much more intimate. Here the effused blood acts as the cytoblastema for the formation of pus-corpuscles, and the blood-corpuscles are more or less injured or dissolved; indeed, they often entirely disappear. In addition to the more or less perfect pus-corpuscles we observe an indeterminate, grumous, and often reddish-brown mass. This pus is impure.

Mucus is often mixed with pus in suppuration of the mucous membranes: it then contains mucin which renders it tenacious and capable of being drawn out in threads, in addition to epithelium-cells, and other substances of accidental occurrence. On the addition of acetic acid the mucus coagulates, entangling the nuclei of the dissolving pus-corpuscles.* Moreover, pus from abscesses without containing any of the secreted products of the mucous membranes, sometimes appears tenacious and stringy, its serum containing a viscid substance in solution, which is coagulable by acetic acid and alum (pyin ?).† Moreover, the cells of the epidermis or of glands, flocculi, and crystals of cholesterin or of ammoniaco-magnesian phosphate, are not unfrequently mixed with pus.‡

B. *On changes in the structural portion of the pus itself, malformations of the pus-corpuscles, &c.* The pus-corpuscles sometimes differ more or less from their normal type, losing their regular rounded form, and becoming angular or club-shaped.§ The nuclei also frequently appear changed.‖ Sometimes, on the addition of acetic acid, no nuclei make their appearance, (being apparently entirely absent), and we observe only the minute molecules which are noticed after treating pus with alkalies or a solution of borax.¶ In many cases the quantity of the granular molecules, which consist either of modified protein-compounds or of fat, appears to be increased in the pus, and sometimes, from the simultaneous deficiency of pus-corpuscles, it would seem as if these granules had taken their place, being either broken up or abortive corpuscles. These modified conditions of pus

* Plate III. fig. 6, B.

† Plate III. fig. 11, and its explanation.

‡ Plate III. fig. 8 and 9.

§ Plate III. fig. 7 and 10.

‖ Plate III. fig. 10, D.

¶ Plate III. fig. 7, B.

appear in numberless forms; they occur in unhealthy suppuration, in abscesses, in gouty and scrofulous persons, &c.

C. *On the diminution of the corpuscles in relation to the serum. Formation of ichor.* Pure ichor contains no corpuscles, but is a fluid of a reddish or brown-red colour and a more or less sickly odour. It is the serum of the blood coloured by the pigment of the dissolved corpuscles, but frequently contains, mixed with it, the detritus of various textures. A perfect formation of ichor entirely prevents suppuration, being a consequence of the decomposition of the blood, and the death of a portion of the body (gangrene). Both processes, however, frequently occur together and their products become mixed.

These modifications of true pus form an uninterrupted series, ultimately extending to morbid fluids hardly deserving the name of pus. Of these we shall now speak.

I select the following, by way of illustration, out of the large number of instances of abnormal pus and ichor which I have had the opportunity of examining. They may perhaps serve to show the mode of examining and describing such cases. For other cases see the explanation of Plate III. The abdominal cavity of a woman who died from peritonitis with exudation, contained several pounds of a thin yellowish white fluid, in which were soft flocculi, varying from the size of a lentil to that of plum-stone. It had a faintly alkaline reaction, and after standing for some hours separated into a yellow sediment, and a supernatant colourless serum. The reactions of this serum were precisely those of the fluid of serous dropsy. The sediment contained minute granules, which in the irregularity of their form and size differed essentially from normal pus-corpuscles. They were of a somewhat indefinite roundish form with rough angular points, and in size they varied from the 400th to the 150th of a line. On treating them with acetic acid, there were no decided indications of nuclei: under the prolonged action of that reagent they almost totally disappeared, nothing being left but very minute dark granules, about the 1000th of a line in diameter. These molecules were very unequally distributed amongst the corpuscles, some containing none, others three or four. An aqueous solution of borax, allowed to act for some time, produced no material change in the corpuscles. The larger flocculi were very soft, of a yellowish white colour, and consisted of an aggregation of the same corpuscles, sometimes arranged in a definite manner, sometimes in an amorphous mass.

Pure ichor from a vesicle on the gangrenous arm of a typhus-patient, was a perfectly clear fluid of a reddish colour, and to the eye resembled light red wine. It had an alkaline reaction, and under the microscope, no solid bodies—neither blood- nor pus-corpuscles—could be detected in it. It coagulated on the application of heat. In 1000 parts there were obtained by evaporation 60 of solid residue, consisting of albumen with some saline constituents. This fluid was therefore the serum of the blood coloured by dissolved hæmatin.

A woman with ascites frequently underwent the operation of paracentesis; and finally the canula was allowed to remain, in hopes of exciting adhesive inflammation. The fluid which then escaped was brownish-grey turbid ichor, of a cadaverous odour. Under the microscope, no pus-corpuscles could be detected, but there was an indefinite granular matter similar to that which is thrown down on the addition of corrosive sublimate or an acid to a fluid containing albumen in solution. This granular matter was insoluble in acetic acid, ammonia, and potash, and was not even rendered gelatinous by the alkalies. It appeared to be a protein-compound, since it dissolved in boiling concentrated hydrochloric acid, forming a violet coloured liquid.

2. SPURIOUS PUS.

The abnormal sorts of pus which we have described form a gradual transition-series to other morbid fluids which have usually been included under the general name of pus, but are formed in a perfectly different manner, namely by the breaking up and liquefaction of distinct morbid products, such as tubercle, encephaloid, scirrhus, &c. These products will be described in a future page, and their distinctions from pus clearly indicated.

In the present section we must describe certain granular forms, which are sometimes found in true pus between the corpuscles, and sometimes occur alone in serum, forming an apparently purulent fluid. In form they present many differences, and their mode of production, and their signification is by no means invariable. They were first described by Gluge, who termed them *compound inflammatory globules ;* to me, the term *granular cells* appears more appropriate, since their connexion with the inflammatory process is not more intimate than that of various other organized formations occurring in exuded fluids, and they are formed under conditions in which there is very little probability of their resulting from inflammation, as for instance, in cysts in the thyroid gland.

When these granular cells occur in a perfect condition, they vary in diameter from the 200th to the 80th of a line; some of them are perfectly round, others oblong, irregular and even angular. At first sight they appear as an agglomeration of minute granules, varying in diameter from the 800th to the 1000th of a line. By refracted light they appear dark, of a brown or blackish colour;* by reflected light, white. These granular cells are not affected by water; if exposed to the prolonged action of acetic acid or ammonia, they separate into the individual granules of which they are composed. Caustic potash and ether sometimes, but not always, dissolve these granules.

From my own observations I should say that the formation of these granular cells is best observed in inflamed lungs, where it appears to occur in the following manner. Cells with a nucleus and a nucleolus, differing from pus-corpuscles in their larger size (the 200th to the 100th of a line) and in having a single nucleus, are formed in the fluid or coagulated exudation (fibrinous dropsy). These become gradually filled with minute granules, which at first, when only few in number, readily admit of the nucleus being seen; subsequently, however, they conceal it, and the originally smooth cell-membrane becomes rugged, the granular cell appearing as a spherical agglomeration of granules. Subsequently the cell-wall appears to vanish, the enclosed granules to separate from one another and to fall into irregular heaps, and each individual granular cell to undergo, in a minute scale, the very same process which a mass of coagulated fibrin undergoes in its conversion into pus-corpuscles.

* Plate III. figs. 13, 14 and 15.

This view of the formation of granular cells is confirmed by Bennett.* According to Gluge,† they are formed by the adherence of the nuclei of dissolved blood-corpuscles: but the nucleus of the human blood-corpuscle is itself of doubtful existence, and I have sometimes observed the development of these cells, as distinctly as, considering the difficulties of the case, could be expected.

From their chemical relations the granules appear to consist partly of fat, soluble in ether, partly of a modification of protein similar to the molecular granules of normal pus, insoluble in the alkalies and in borax, and partly of salts of lime (the carbonate and phosphate). I am convinced that the true granular cells are formed from cells which as a general rule first appear pale in colour, containing a nucleus, and with fluid homogeneous contents, which subsequently become granular. It is true, that this process cannot be directly observed; I have, however, seen in very many cases where these granular cells were present, that when the development was not very far advanced, there were undoubted cells without any or with only a few granules;‡ that when the development was somewhat further advanced, the cells appeared for the most part, or entirely filled with granules;§ and finally, that when the development was perfect, they formed irregular granular heaps and scattered granules.‖ The whole course of events in that form of pulmonary hepatization which does not proceed to suppuration, but disappears by resolution, confirms the above view. It is true that in this case, we have only the opportunity of instituting microscopic observations, when the patient is carried off by some other disease during the stage of resolution; I have, however, met with several such cases. Here we observe in the first place, that so long as the mass remains firm, there are only a few granules, but numerous undoubted cells; as development progresses, the cells diminish and the granules increase in number, and finally, after perfect softening, there are fewer cells and fewer granular heaps; the latter being broken up into separate granules. Some observers, especially Henle and Bruch,¶ have declared themselves against my view regarding the mode of formation of granular cells, but still I cannot help

* Pathological and Histological Researches on Inflammation of the Nervous Centres, in the Edinburgh Medical and Surgical Journal. Oct. 1842, and April 1843.

† Anat. Mikrosk. Unters. p. 12, et seq.

‡ Plate III. fig. 12.

§ Plate III. fig. 13.

‖ Plate III. fig. 14.

¶ Das körnige Pigment der Wirbelthiere, p. 18.

firmly maintaining the correctness of the above description, at least with reference to some of the forms. Their reasons are for the most part theoretical, and founded merely on analogy, and may be refuted by a similar mode of argument. Theoretically, it is not more improbable that granules should be formed from a fluid in the cavity of a cell, than that they should be formed from a fluid not enclosed within a cell. We observe, however, similar processes in most vegetable cells. Moreover, in encephaloid and scirrhus, cells at first perfectly homogeneous become afterwards filled with granules. Hence, for this mode of formation also, there is no lack of analogies. On the other hand I will not deny that occasionally the mode of formation may be reversed, namely, that isolated elementary granules may be first produced, which subsequently collect into groups, and finally become invested with a cell-membrane. Indeed, I believe that I have sometimes observed this process, that I have seen the accumulated granules gradually invested with a membrane, and granular cells or very similar forms produced. This I have witnessed in expectoration.

There is also a third case of frequent occurrence. There arise in the solid or fluid cytoblastema, elementary granules, which either remain single or accumulate into irregular heaps without any cellular formation. They entirely resemble the molecular granules which have been already noticed as frequent constituents of normal pus. Cases also frequently occur where exudations, without any trace of cellular formation, break up directly into these elementary granules. Practically, it is often hard to distinguish whether this process or the formation of granular cells has existed. The difficulty arises when there has been no opportunity of observing the development in its earlier stages, but when the final results alone are subjected to microscopic examination; these final results being the same in both cases. Yet as a sufficient number of cases have been observed, wherein on the one hand there is a mere distribution of the elementary granules without any trace of granular cells, and on the other, there are distinct granular cells without any isolated granules, we may consider ourselves well entitled to separate, theoretically, the two processes from each other.

The diagnosis of granular cells is easy in those cases where they are perfectly formed and occur in large quantities. The granular bodies of the colostrum* have a close resemblance to them. But the constituent molecules here are of unequal size, and the entire corpuscles less regular than the true granular cells. In examining the fluid from an inflamed breast, the two may be confounded together, as I myself on one occa-

* Plate III. fig. 16.

sion saw. With practice they will, however, be easily distinguished. Where imperfectly formed granular cells occur together with the elementary granules previously described, the diagnosis of the individual corpuscles becomes almost impossible.

Having thus described the morphological and chemical constitution of the different fluids embraced under the somewhat general name of pus, we may now take a general view of the formative relations, and the pathological importance of these morbid products.

Pathological anatomy has, in this respect, a much more difficult office than pathology, for the latter is able to follow the entire series of processes from their first appearance in the vascular system to the perfect formation of these products, and to consider them in their mutual relations; whilst the former is often confined to the observation of results, which must be retraced with many interruptions and obscurities in the connecting links. I refer, therefore, for the completion of this fragmentary outline to my article on "Inflammation and its Results,"* and to the rigidly critical development of inflammation and its results by Henle.† We shall return in a future page to the connection of these processes.

Suppuration consists essentially in the fact that the parts of the exuded plasma capable of such formation, undergo a peculiar organization—an organization on which the character of pus is dependant, and which distinguishes it from other morbid products. When this capability of organization in the plasma is clearly manifested, true pus-corpuscles, or completely formed granular cells occur; when it is less strongly declared, we observe either pus-corpuscles, or simply accumulations of elementary granules. These elementary types—true pus-corpuscles, abnormal pus-corpuscles, granu-

* Wagner's Handwörterbuch der Physiologie, vol. I.

† Zeitschrift f. rationelle Medicin, vol. II.

lar cells and elementary granules—are, however, but the final results of a continuous morphological series, between which there exist an infinity of intermediate points.

All these formations have a definite mode of development from which they never deviate; they are capable of no higher stage of completion, that is to say, they are not in a mere transition-stage to a more perfect organism. From a pus-corpuscle or a granular cell nothing higher can be produced. Hence the importance of this formation to the organism. It is never permanent, but is removed either by internal resorption, or by external rejection.

When pus arises from a fluid blastema, then its formation hinders the coagulation of the fluid. But when pus arises from a solid blastema, that blastema itself becomes dissolved and rendered fluid by the formation of the pus, and thus its external rejection becomes possible. The uses of the formation of pus to the organism consist in this, that by its means exudations which were originally fluid, and would have become solid, are prevented from coagulating; and those already coagulated again become fluid, and thus the conditions requisite for their removal are effected. The distinction between genuine suppuration and the formation of granular cells depends upon the way and manner in which the exudation is removed. In genuine suppuration there is an effort to reject the fluid products externally. In pus forming upon membranes in free connexion with the external surface of the body, this discharge is directly effected, as on the mucous membranes and the external skin. When it occurs in enclosed portions of the body, as in the parenchyma of organs, this tendency to external rejection is not less remarkable. The pus collects in cavities, forming abscesses, and escapes either by seeking for itself an external outlet, or its evacuation is assisted by art.

In the formation of granular cells the exudation is likewise rendered fluid. But the minute granules into which the granular cells at last break, are very much smaller than the pus-corpuscles, and with them the tendency to external rejection is less strong: they are much more easily resorbed than pus-corpuscles.

Hence genuine suppuration may be characterized as the liquefaction of an exudation with a tendency to external rejection; the formation of granular cells, as liquefaction with a tendency to resorption. This is, however, but an elementary type of either process. Both may occur together, or either may be converted into the other. Thus, in many cases pus enclosed within the parenchyma of an organ may disappear without having been rejected externally; its corpuscles breaking up and gradually becoming resorbed. But these are exceptions; in the majority of cases the enclosed pus finds for itself a way by which it reaches the external surface, though its course may be a slow one, as in deep-seated abscesses, psoas abscesses, &c. Conversely, the formation of granular cells may cause an abscess, especially in very tender and delicate organs. A frequent example of this is afforded in inflammatory softening of the brain. Hence it follows that the formation of granular cells is that form of suppurative process by which the organism is the most spared, and the same is the case with suppuration on free surfaces. When pus is formed in the parenchyma, especially when an abscess is produced, and the pus forcibly seeks to obtain an external outlet, there must be some destruction or injury of the organized parts. This injury or destruction is in different cases of very varying intensity. Thus, there is the healthy abscess, where the loss of substance is soon replaced, and the part shortly after the rejection of the pus returns to its primitive condition; and there is the malignant phagedenic abscess or ulcer, where the loss of substance continually increases, and the ulcer gradually extends.

In attempting to explain these processes we are led to investigate the causes which give rise to the formation of pus, and the reasons why in some cases normal pus, in others granular cells, or abnormal pus are produced.

Let us first consider the question—why does pus arise from exuded plasma? Does this arise naturally from the chemical properties of the exuded plasma, or is it dependant on external influences?

The exudation possesses in itself a certain tendency to the formation of organized products; there are produced in it, independently of external influences, more or less perfect pus-corpuscles. In the case of empyema mentioned in page 147, pus was formed in a large quantity of fluid, which was excluded from all communication with the external parts of the body by a thick layer of fibrin. A very accurately performed experiment recently submitted by Dr. Helbert to our Physiological Institute, gave a singularly striking proof of this tendency.* Fresh plasma taken from beneath the cuticle raised by an ordinary blistering plaster, exhibited no corpuscles of any kind. After standing in a glass for five or six hours, minute corpuscles were formed exactly analogous to those which appear in wounds when the formation of pus commences. Repeated experiments invariably gave the same results. Hence there was an incipient formation of pus even in plasma which was entirely separated from the body.

On the other hand, it is a known fact that the formation of pus can be obstructed or promoted by the application of external means. The application of moist warmth promotes it; of cold, retards or even prevents it. Further, it is certain that large quantities of exudation are most easily converted into pus, while small quantities are most liable to be converted into persistent tissues. Again, in individuals of vigorous constitution, and possessing that peculiar disposition of the nervous system in which the inflammatory process is especially intense and rapid, normal pus is easily formed, while in weak cachectic persons with feeble vital energy, and where there is a tendency to gangrene, and in persons

* Helbert, de exanthematibus arte factis fragmenta. Götting. 1844, p. 16. See also the remarks in p. 84 of this volume.

with very torpid chronic diseases, there is a tendency to the formation of unhealthy pus. There is no doubt that in these cases certain chemical, physical, and vital influences, dependant upon the nervous system, and unknown to us, combine together; and through this multiplicity of conditions we are prevented from obtaining an exact and definite acquaintance with the acting causes. If a certain impulse is once given in directing the formative process, then the elaborated product tends to sustain it, for fully developed pus, in the same manner as neighbouring healthy structures, excites a local tendency to the formation of a substance similar to itself. This explains the old observation that pus makes pus, and that when an abscess is too early opened, perfect suppuration is delayed or prevented.

The distinction between healthy and malignant suppuration admits of the following explanation. In healthy suppuration the formation of pus proceeds very rapidly; in three or four hours after its effusion the exudation may be converted into pus; although in many cases, the process requires three or four days for its completion. When the elementary textures of an organ are surrounded, and, as it were, enclosed by the coagulated exudation, so as to be excluded from the influence of the nerves, and to be deprived of the circulation of the blood, it is only by the conversion of the exudation into pus that their liberation is effected; and, if this is accomplished sufficiently early, no destruction of tissue results. Again, normal pus is a bland substance, devoid of all deleterious properties, and its constituents are analogous to those of the blood-plasma. Hence normal suppuration is not destructive to tissue, which is only affected mechanically, as by the collection of pus in an abscess causing local compression, or by the surrounding parts ultimately giving way.

It is otherwise with malignant suppuration, the course of which is usually chronic, lasting for weeks, and even months before the exudation liquefies. Through this prolonged exclusion of the nerves and capillaries, the normal tissue becomes partially destroyed; it dies away, breaks up, and its remains are thrown off with the pus which is at the same time formed. Further, there are dynamic causes which influence the formation of malignant pus, and simultaneously act upon the constituents of the parenchyma: in unhealthy suppuration, and when there is a tendency to gangrene, the histologic elements of the tissues are much more easily destroyed than in their normal condition. Finally, unhealthy pus frequently exerts a chemical action on the surrounding parts, sometimes containing free acids, carbonate of ammonia, or other constituents which chemically exert an injurious effect.* In this way malignant suppuration becomes immediately connected with those abnormal epigeneses, which under the names of tubercle, encephaloid, cancer, &c., form alike the terror of the physician and of the patient. We shall in a future page return to the consideration of these formations.

But the process of suppuration stands also in the most intimate connection with healthy epigeneses, with the process of regeneration, and the formation of granulations; of this also subsequently.

With regard to the cause of the formation of granular cells, even less is known. I can here only repeat what I have already elsewhere observed respecting it.† It is observed principally in very composite organs—in the brain, the lungs, the liver, the spleen, the thyroid gland, &c.,—and it occurs in those cases where the result of the exudation is most favourable, namely where resolution occurs. Sometimes, indeed, as in the brain, it leads to softening of the parenchyma. This formation appears to be carried on most favourably when the quantity of exudation is small, and its effusion is very gradual.

In conclusion, we must offer a few remarks on the resorp-

* According to Dumas, even hydrocyanic acid may be formed in the process of suppuration. Comptes rend. 1841, vol. XIII. p. 144.

† Wagner's Handwörterbuch d. Physiologie, vol. I. p. 345, 355.

tion of pus and on what are termed metastatic abscesses. An actual resorption of pus can only occur when its corpuscles become liquefied and fluid. This process is, indeed, very rarely observed, and an extremely long time is requisite for it, since the fluids of the body in which the pus-corpuscles must be dissolved usually exert no great solvent power upon them. The resorption of pus often appears to occur in a comparatively short period, for the serum of a fluctuating abscess becomes suddenly resorbed, causing the fluctuation and all physical signs of the presence of an abscess to disappear, while the pus-corpuscles, however, remain long uninjured, and are only very gradually resorbed.

Frequently also the term "resorption of pus" is applied to the occurrence of pus in the circulating system. Pus, however, never occurs in the veins or lymphatics, in consequence of resorption through the uninjured vessels. It is either generated in the veins themselves, or is admitted into them through openings caused by some injury. It is only the serum of pus which can be conveyed unchanged into the vessels by means of resorption; this subject we shall again notice in the special part, when we treat of the vascular system.

I have in the preceding part described four morphological elementary types of the corpuscles presented in pus—true pus-corpuscles, abnormal pus-corpuscles of irregular form, and without any, or with an irregular nucleus, granular cells, and elementary granules. All these structures are essentially distinct from those which occur in exudations developing permanent structures, and which will be treated of in the next section. The structures described by Henle and Gluge as inflammatory globules, I regard partly as broken up granular cells, and partly as aggregated elementary granules; and the name which they have adopted appears to me unsuitable, because all kinds of pus may be the product of inflammation just as much as these inflammatory globules, and further, because these sometimes occur under circumstances where no inflammation, at least in the common acceptation of the term, can have taken place. Valentin,* and with him some others, have

* Repert. vol. III. p. 173.

distinguished the proper pus-corpuscles from the exudation-corpuscles, which latter are of a whiter colour, and lie upon each other in a tessellated manner; afterwards, however, according to them they assume a yellower tint, and are converted into pus-corpuscles (through the absorption of fat?). To me it appears unsuitable to designate pus-corpuscles in their early stages by a separate name; but that other structures—cells already clearly characterized as of a different sort—can be converted into pus-corpuscles, I do not believe. At an earlier period, when I had chiefly considered the formation of pus upon mucous membranes, and at a time when the importance of cellular formation in its earliest stages was scarcely recognized, I did, indeed, believe in the possibility of the conversion of immature epithelium-cells into pus-corpuscles. Now I regard the formation of pus, as a peculiar product of the exudation which occurs immediately on the appearance of the first formative molecules; and this leads me to believe that structures intended for other objects cannot be converted into pus-corpuscles, and conversely, that pus-corpuscles can never be converted into the elements of a persistent tissue; of the latter I am decidedly convinced. Millions of pus-corpuscles have been brought under the microscope before my eyes, but never have I perceived the least indication of a transition towards another structure. On the other hand, I have very often examined the earlier stages of the development of persistent tissues, in which cells do indeed appear, which an unpractised observer might confound with pus-corpuscles, but due examination shows an essential difference between them. After being subjected to acetic acid, they never show the nucleus with two, three, or four granules characteristic of pus-corpuscles, but merely a simple nucleus. I do not believe that such a cell can, by a retrograde metamorphosis, be converted into a pus-corpuscle. I am not acquainted with any case wherein the nucleus of a cell has experienced in its development so important a transformation as that which is here assumed. One out of many similar examples that I might adduce will serve to prove this. Two dogs received at the same time flesh-wounds. After the lapse of twenty-four hours these were perfectly similar in appearance. There was little discharge, for the dogs as is usual, frequently licked the wounds. The fluid contained blood-corpuscles, and also very many round colourless corpuscles varying in size from the 400th to the 300th of a line. They were smaller than the ordinary pus-corpuscles in dogs, but when treated with acetic acid, they showed the same composite nuclear structure, (containing 2, 3, or 4 granules) as ordinary pus-corpuscles. Hence there can be no doubt that these were young pus-corpuscles. In addition to the flesh-wound, one of the dogs had received a small wound penetrating the abdominal cavity, into which a dilute solution of hydrosulphate of ammonia was injected. The animal seemed to suffer violent pain from the injection, and was very ill for a quarter of an hour; he then began to amend, and in forty-eight hours, when he had apparently quite recovered, was killed. The intestine was covered in several places with coagulated fibrinous exudation, which being examined with the microscope appeared to be partly amorphous, and partly to contain cells which were either fusiform or tolerably large round primary cells (from the 200th to the 100th of a line) with a single nucleus which was not affected by acetic acid; they were, therefore, entirely different from the above described rudimentary pus-corpuscles. The wound in the intestine was nearly closed, and exhibited thinly scattered granulations which contained pus-corpuscles with nuclei capable of being broken up by acetic acid, and perfectly similar to those above described. Since, however, the cells occurring in exudations are distinct from their very first origin, and we can distinguish between those which become pus-corpuscles and those which develope themselves into persistent tissues, it appears quite unnecessary to regard exudation-corpuscles as peculiar structures; especially since there is no certain mark by which they can be distinguished from any other primary cells. If it were proposed to designate as exudation-corpuscles all those primary cellular forms which occur in exudations, and whose nature is not accurately determined, the proceeding would be illusory, and more than that, superficial observers would run the risk of applying the name of exudation-corpuscles to all cells occurring in exudations. On this last ground it appears to me that the name is particularly objectionable. Such an objection might not be sufficiently strong to cause the disuse of a name already established, but it is weighty enough to have its effect when new ones are to be adopted.

SOLID PATHOLOGICAL EPIGENESES.

Although the variety of forms exhibited by fluid morbid products is very considerable, this is still more strikingly the case with the solid epigeneses; in order to facilitate the consideration of our subject we will divide it into two parts. The first of them embraces the elementary structures which occur in regeneration after the loss of tissue, and in hypertrophy. The second concerns the composite structures which are commonly designated by the name of tumours, and embraces partly the same elementary structures either singly or in combination, and partly also other distinct elements.

EPIGENESES OF THE ELEMENTARY TISSUES.

Imperfectly organized structures.

In dissections, it very frequently happens that solid epigeneses are found, which without belonging to the class of concretions, yet examined by the microscope offer no trace of organization. They are designated according to circumstances by various names, as solid exudation, coagulated lymph, fresh pseudo-membrane, and so forth. They are characterised by the fact, that under the microscope they appear perfectly amorphous ;* and when treated with acetic acid, ammonia, or potash, they become paler and more transparent, until at length, in some cases, they entirely disappear. In many cases they are mixed with granular elements—vesicles and granules of fat—which when treated with ether disappear; or with protein-compounds in a granular state—elementary granules in which no decided cellular formation can be discerned.† This granular appearance usually remains unchanged after the application of the above-named reagents. Solid epigeneses of this kind sometimes cover the surfaces of internal organs, as for instance of those parts which are invested with serous membranes, and sometimes they are deposited in the parenchyma, thickening the elementary textures, and thus giving rise to imperfect hypertrophies or tumours. They always exhibit a lardaceous appearance. Chemically they re-act like coagulated protein-compounds (fibrin) with a certain amount of fat, and more or less saturated with serum. They always arise from fibrinous dropsy, of which the fibrin has coagulated, and are to be regarded as solid cytoblastemata, whose further development was interrupted by the death of the organ which was attacked. Had the vitality of the organ been prolonged, they would, according to circumstances, have been changed

* Plate II. fig. 2.

† Plate II. fig. 3 and 5.

into the several kinds of epigeneses—into concretions, areolar tissue, fibrous tissue, pus, non-malignant or malignant tumours; or they would have been resorbed.

It is unnecessary to multiply examples* of these imperfectly organized epigeneses, since they are of extremely frequent occurrence, and are found without exception in all vascular parts of the body, in which fibrinous dropsy occurs. When they present themselves as isolated tumours, they are very frequently regarded as tubercle; indeed, one half of the cases of supposed tubercle belong to this class. To this subject I shall have frequent occasion to refer in the special part of this work. These imperfectly organized epigeneses are of very frequent occurrence in the most dissimilar organs. With regard to the unprofitable question, whether they are always the product of inflammation, I must refer to the section which treats of the pathological anatomy of that morbid process.

EPIGENESIS OF AREOLAR TISSUE.

The development of areolar tissue is one of the most common pathological epigeneses. It occurs in regeneration succeeding loss of tissue, in cicatrices, and in hypertrophy of those parts which in the normal condition consist principally of areolar tissue; but also in independent tumours, and in short under the most variable conditions. Since areolar tissue enters into almost all organs, and is a constituent of most parts of the body, the frequency of its pathological development is the more easily understood, in accordance with the law of analogous formation, when it happens that in any part or from any cause an increased secretion of blastema takes place. The cytoblastema of this tissue is sometimes fluid; sometimes solid. It is formed from a fluid cytoblastema in the healing of wounds by suppuration, in granulations, in the gradual hypertrophy of parts consisting principally of areolar tissue, in warts, condylomata, &c. Here the formation is gradual, and is supported by a long continued increased secre-

* See the descriptions of fig. 2, 3 and 5, in Plate II.

tion of blood-plasma (the nutrient fluid) kept up by inflammatory irritation. The epigenesis of areolar tissue, and with it the increase of hypertrophy, continues so long as the secretion of the formative material continues augmented. It would appear, therefore, in its power to be unlimited, for such epigeneses as condylomata, warts, or the proud flesh of granulations often attain a very considerable size.

Again, areolar tissue is very frequently formed from a solid cytoblastema. In these cases the formative material is always the coagulated fibrin of fibrinous dropsy, as in false membranes on serous surfaces, as for instance in the pericardium, the pleura, or the peritoneum, or after inflammatory induration of the subcutaneous cellular tissue. Hence this epigenesis is as a rule confined to the metamorphosis of the exuded and subsequently coagulated fibrin, and ceases when this is perfectly converted into areolar tissue.

Morphology of its development. Normal areolar tissue consists, as is well known, of fine transparent fibres, varying from the 2000th to the 1000th of a line in diameter; and the same is the case when it is pathologically reproduced. But, as in pathological structures generally, the product is frequently less perfect than the normal type. The individual fibres are not always so clearly separated from one another, being more or less fused into an amorphous cytoblastema; the arrangement of the fibres in the mass, their division into fasciculi, &c., is less regular than in the normal areolar tissue. This is most especially the case when the formation is recent: very old morbid formations of areolar tissue, as adhesions, pseudo-ligaments, &c., usually consist of areolar tissue which in no respect differs histologically from the normal type. Also the nucleated fibres described by Henle, which are distinguished by their resisting the solvent action of acetic acid, are frequently found in larger or smaller quantities in newly formed pathological areolar tissue.

The process of development is the same for morbid as for normal areolar tissue; the fibres proceed from a more or less distinct cellular origin. In the former case, there are formed in the cytoblastema nucleated primary cells, which are lengthened at both their ends, and assume a fusiform shape; the extremities of these unite with one another, and there are thus formed long varicose fibres.* From these caudate cells arise the fibres of areolar tissue; a cell being either converted into a single fibre† or else by assuming a grooved arrangement, and these grooves deepening, finally splitting into a bundle of fibres.‡ In other cases the process is less clearly indicated, and deviates more from the cellular type. We often observe in the cytoblastema very pale gelatinous nuclei arranged lengthways in regular order, sometimes mixed with elementary granules, but not surrounded with clearly defined cell walls.§ From the blastema thus imperfectly converted into cells, the fibres are directly produced.

In other cases the cells are indeed clearly defined, but irregularly and for the most part laterally fused together.‖ Sometimes there are seen very pale, irregular and apparently non-nucleated cells: the nuclei are, however, not really absent, for after the application of acetic acid, they become clearly visible. In the nuclei we can usually, but not always observe nucleoli. From these statements it follows that, in idea, areolar tissue in its pathological epigenesis follows the cellular type, but that in some cases peculiar influences seem to throw the type very much in the back ground, if not entirely to obliterate it. This explains the variation in the statements of different observers, as for instance, Schwann and Henle, respecting the normal development of areolar tissue.¶ Some-

* Plate I. fig. 12; Plate IV. fig. 1, C, and 2, a; Plate VII. fig. 3, B, E, 4, D.

† Plate VII. fig. 3, D, 4, D.

‡ Plate IV. fig. 1, D, 2, b, c; Plate VII. fig. 4, C.

§ Plate IV. fig. 1, A; Plate VII. fig. 3, C.

‖ Plate IV. fig. 1, B.

¶ Bischoff has collected the different opinions on this point in his *Entwicklungsgesch.* p. 452.

times, indeed, the cellular formation is so obscure, that the most careful observer can discern no trace of nuclei or cells, and the fibres of areolar tissue would appear to spring immediately from an amorphous solid cytoblastema. It is necessary here to guard against confounding the indefinite fibrillæ and lines which the coagulated fibrin, while yet undeveloped, sometimes exhibits,* with the fibres of areolar tissue. Whether the nucleated fibres which here and there occur in morbidly formed areolar tissue, and which by their great thickness, their usually winding, or even spiral course, their occasional dichotomic separation, and their insolubility in acetic acid, are distinguished† from true areolar tissue and range themselves with elastic tissue—whether these, as Henle believes, arise from a prolongation and fusion of the nuclei, or whether they are to be regarded as another structure altogether distinct from areolar tissue, between whose elements they insert themselves—I will not venture to decide.

A perusal of the descriptions of the plates will throw considerable light on the above remarks. I have made a large number of examinations (upwards of 50) respecting the pathological development of areolar tissue, partly on the human body, and partly on animals, after wounds, subcutaneous division of tendons, &c. They yielded the results which have been above described, and sometimes even more varied ones ; I have never been able to establish a general law that would explain why the cellular formation that accompanies this development is sometimes clearly and sometimes only indistinctly apparent.

Chemistry of the development. Perfectly formed areolar tissue consists chemically of a gelatigenous substance (colla), while the cytoblastema consists of fibrin, as may be clearly demonstrated in those cases where areolar tissue arises from an exudation of coagulated fibrin. Fibrin and colla differ, however, from each other not only in their chemical properties, but also in their elementary composition. In the deve-

* Plate III. fig. 5.

† Compare Henle, Allgem. Anat. Plate II. fig. 6, 7, 8.

lopment, the morphological change must be simultaneously accompanied by a chemical change of the blastema; this is first shown by the appearance of the nucleus, which differs chemically from the cell-membrane. This chemical change is not a sudden but a gradual one. This is seen in the fact that immature areolar tissue when boiled yields no gelatin; and the same is the case with that of the fœtus (Schwann), and with that of granulations and condylomata (G. Simon and Güterbock). On boiling this substance, both obtained a fluid which after filtration gave the same reaction as if pyin were present.

In my own investigations of recently formed, or forming areolar tissue, I have frequently found a fluid which coagulated on the addition of acetic acid, and therefore in this point of view resembled pyin. Hence we may presume that in the chemical changes which ensue, some of the elements of fibrin are thrown off and form pyin, whilst others are converted into colla. But the chemical properties of these substances are as yet too little known to admit of more than mere supposition on these points.

The above description is equally applicable to the morbid formation of fibrous tissue, of the fibres of tendon, and of other tissues, which histologically accord with areolar tissue.

The time requisite for the formation of areolar tissue cannot be precisely determined. It is longer than that which is necessary for the formation of pus. Yet it is short in comparison with that which appears to be required for the formation of other organized structures. I believe from repeated observations that I am justified in concluding that from four to five days after the formation of the cytoblastema, fibres of areolar tissue may occur in it; the formation, however, of large masses of this tissue appears to require at least one, and frequently several weeks.

Gelatin, whose ultimate chemical composition is doubtless identical with that of areolar tissue, contains according to Mulder, 50.4% C.

63.% H, 18.0% N, 25.3% O, while fibrin contains 54.6% C, 6.9% H, 15.7% N, 22.1% O with 0.7% S and P. Hence in the conversion of the latter into the former, carbon and hydrogen must be given off and oxygen added, while the nitrogen remains unchanged; or nitrogen and oxygen added, and carbon and hydrogen removed. All attempts to determine these changes accurately by calculation must fail, and lead only to a useless sporting with formulæ with the semblance, but not the reality of exactness. We know far too little of the chemical composition, and especially the atomic weight of these organic substances to obtain from such attempts any certain results. These are the elementary relations of the above-mentioned epigenesis; to enter more minutely into their varied modifications, would in the present place be superfluous, since they will be frequently brought forward in the following pages.

EPIGENESIS OF THE BLOOD AND VESSELS.

Blood-vessels occur very frequently as pathological epigeneses in the restoration of lost parts, in granulations, in pseudo-membranes, in various hypertrophies, and in tumours. But our knowledge of the process of this development is still defective, especially since the normal formation of the blood-vessels in the embryo is only imperfectly understood. It has been much disputed whether new vessels occur simply as a prolongation or further development of the old, or whether they may be formed independently and without connection with the normal vessels.*

From a large number of observations, I believe myself justified in concluding that new vessels arise directly in the blastema, and only at a later period connect themselves with the previously existing normal vessels, indeed, that this is usually the case; further, that not only the vessels themselves, but also their contents—the blood—can be produced anew in this manner. In support of this formative process the condition in the embryo may be adduced, where the blood, as well as the vessels, is formed from the common cytoblas-

* See Hasse's Pathological Anatomy, English edition by Swaine, p. 192.

tema; it is supported also by direct observation. In the midst of newly formed substance, (inflammatory exudation, &c.) accumulations of blood-corpuscles surrounded with more or less clearly indicated walls without any connection with the normal vessels are observed. It is true that we might be easily deceived on this point, since extravasated blood, which might be mistaken for a new formation, is mixed with many exudations; there remain, however, plenty of cases in which the attentive observer need be in no danger of being misled.

According to my own observations* the process seems to be as follows: in an amorphous blastema (coagulated fibrin) red points are formed, which are commonly of a size sufficient to enable the observer to discern them with the naked eye. Under the microscope each point appears as a group of blood-corpuscles of various sizes, in form roundish, and without the central depression observable in perfect blood-corpuscles; they have usually a clearly defined outline and a yellowish-red colour. Their diameter is generally something smaller than that of normal blood-corpuscles, being from the 600th to 450th of a line. I have never observed that newly formed blood-corpuscles in any pathological structure were (as is the case with the formation of blood in the embryo) greater than normal ones. They dissolve in water and acetic acid, without yielding any indication of nuclei: the groups of these blood-corpuscles have not at first a very distinct contour, but appear at the edges to merge into the surrounding exudation; their form is indefinite, roundish, elongated, or annular. It is only after some time that these groups appear clearly distinct from the parenchyma; they then throw off rays or branches of a defined form; still, however, destitute of true walls.† Probably the walls of the vessels are formed around them at a later period, when areolar tissue, muscular tissue, and epithelium, in accordance with the general laws of

* Plate v. fig. 1—4.

† Plate v. fig. 4.

development, surround and inclose the ramifying masses of blood. When the new vessels are perfectly formed, the walls become distinctly visible;* indeed, when subjected to the action of acetic acid, they exhibit a regular nucleated arrangement which manifestly appertains to the walls of the vessels and corresponds with the cells in the different layers of the walls.† The perfectly formed vessels, with their contents, enter earlier or later into communication with the original vessels in their neighbourhood, and then take a part in the general circulation. At the earlier periods of their existence the blood which they contain, although fluid, is motionless.

The vessels whose pathological epigenesis I have observed were all larger than capillary vessels: they were not formed from cells, as Schwann imagines to be the case with capillary vessels, neither were they formed in intercellular spaces; for the formation of blood always took place very early, before the formation of any other cells, and even before the formation of areolar tissue. It is, however, not improbable that in the formation of capillary vessels the process is as Schwann‡ describes it, namely, that in the first place ramifying groups of cells are formed which contain blood, and which opening into one another, form a net-work of vessels, so that the original cell-walls which enclosed the blood become the walls of the subsequently formed capillaries.

There are two ways of explaining the formation of vessels from the original vascular trunks. Either some of the original trunks are ruptured, and blood is effused from them, which channelling its way through the cytoblastema becomes subsequently enclosed within walls. But this is an explanation against which much may be alleged; for it is not easy to see why the blood effused in the cytoblastema should not be equally distributed, instead of confining itself in certain ramifying courses, and finally again discharging itself into other normal vessels.

* Plate III. fig. 5.

† See Plate III. fig. 7, 8, 9, of Henle's Allgem. Anat.

‡ Mikrosk. Unters. Plate X. fig. 12.

On the contrary it is not very probable that extravasated masses of blood, can, in the like manner, as newly formed blood become surrounded with regular walls. This much, however, is certain, that extravasated blood cannot always give rise in this manner to the formation of new vessels; it may, indeed, suffer many other modifications, as has been already mentioned, and will be often again noticed. On the other side it may be supposed that in accordance with the law of analogous formation, there arise from the normal vessels, walls, which are at first altogether closed, but which afterwards communicate with them, and receive blood from them. This process would differ from the former only in this, that here the vessels are formed without their usual contents (blood). Future experience must decide whether any thing of this kind actually occurs.

What are the *causes* of the epigenesis of blood and vessels? It may be supposed that here also the law of analogous formation plays a part, since the influence of the normal blood-vessels calls forth this process of formation from the exudation; in fact we find that this epigenesis of vessels is not only of most common occurrence in highly vascular parts, as, for instance, upon the skin, but is also most frequent under those circumstances where the vessels are most replete with blood and where hyperæmia exists, as for instance in granulations. Whether the extravasation of blood facilitates the epigenesis of vessels must remain yet undecided. We must at all events acknowledge that the true causes of this epigenesis still remain in much obscurity.

Sometimes the epigenesis of vessels only become apparent when the previously invisible capillaries become enlarged, receive more blood, and thereby become visible to the naked eye. This is the case in hyperæmia of most parts of the body, at least of such as are superficial, and can be observed during life, as for example the conjunctiva of the eye. The time requisite for the epigenesis of blood and of vessels appears to be very short in proportion to that required for the development of other epigeneses. I have myself seen blood arise in an exudation within forty-eight hours after its effusion. Home observed numerous vessels formed within the course of twenty-nine hours. Usually, however, a much longer time is required for its formation.

The chemical relations of this epigenesis are very imperfectly understood; in the formation of vessels, the same chemical forces are doubtless exerted as in the formation of areolar tissue, of elastic tissue, and of simple muscular tissue; that is the protein-compounds of the blastema become converted, partly into a substance yielding gelatin, and partly into other substances, with whose chemical composition we are still more ignorant. With respect to the chemistry of the formation of blood there is not the least difficulty in accounting for the production of the blood-plasma from the exuded fluid; both being in fact identical. Moreover there is no difficulty in supposing that the globulin of the blood-corpuscles is formed from the protein-compounds of the exudation, although it has not yet been artificially procured. The formation of the hæmatin is equally obscure in this case, and in the ordinary formation of blood.

EPIGENESIS OF EPITHELIUM AND EPIDERMIS.

The epidermis, as well as most forms of epithelium, as for instance the pavement epithelium consisting of several layers, exhibits in the normal condition a continuous epigenesis on the one hand, and a continuous destruction on the other. On the surface which is turned to the subjacent cutis or mucous membrane, new cells are continually forming from the blastema afforded by the vessels of the subjacent membrane; these become further developed, undergo the ordinary changes, and at length having arrived at the surface, are gradually rubbed off and removed.

A precisely similar process takes place when these formations, after being destroyed by any morbid cause, are reproduced—the most frequent class of all pathological epigeneses. In a case of this nature so long as any inflammatory irritation is present, the cytoblastema afforded by the vessels of the subjacent membrane becomes converted into pus. Usually as this irritation decreases the formation of pus ceases, and in its place there is the production of epidermic or epithelial cells which follow the same process in their development as is observed in their normal formation. An identical law of formation is pursued when the epithelium or epidermis becomes thickened, or when epithelium is pathologically formed where in normal circumstances it does not exist, as for example, in encysted tumours; the cyst on its inner surface being very generally invested with epithelium.* The chemical like the morphological relations of development in all these cases precisely follow the normal type.

GRANULATIONS.†

In the preceding sections the epigeneses of areolar tissue, of vessels, and of epithelial structures have been considered as so many isolated processes. Cases are, however, frequently observed where all these formations are combined, where they simultaneously occur at one and the same part of the organism from the same cytoblastema, and are usually accompanied with suppuration. Such complicated epigeneses are usually distinguished by the term *granulations*. They occur under extremely various circumstances—in suppurating wounds, on the surfaces of serous membranes, in abscesses, fistulæ and so forth. They are produced by the simultaneous formation of areolar tissue, vessels, and pus, from a solid, or more commonly fluid blastema. The physical and histological characters of granulations vary in accordance with the preponderance

* Plate v. fig. 6. Plate IX. fig. 2.

† Compare Henle in Hufeland's Journal, vol. LXXXVI. p. 56; Travers on Inflammation, London, 1844, p. 110, &c.; Güterbock, de pure et granulatione; and the principal works on Inflammation, as those of Hunter, John Thomson, Allen Thomson, Kaltenbrunner, &c. Liston has published a description (with instructive plates) of the formation of new vessels in granulations. Medico-chirurg. Transactions, 1840, p. 85, &c., Plate I.

of one or other of these products, and according to the degree of development in which they occur. When the vascular formation predominates, they appear of a blood-red; when there is a paucity of vessels, they are of a pale colour; when the areolar tissue prevails, they are firm; when the blastema remains amorphous, they have a lardaceous appearance; when it contains a large number of pus-corpuscles, they are soft and spongy. Hence granulations, when examined under the microscope, sometimes exhibit numerous blood-corpuscles, (the walls of the vessels being seldom clearly indicated, but sometimes becoming so on the addition of acetic acid,) sometimes numerous pus-corpuscles, sometimes a perfectly amorphous mass, sometimes areolar tissue in various stages of development, and sometimes all these elements together; they generally contain a fluid which coagulates on the addition of acetic acid (pyin). Granulations represent a transition state. They are an epigenesis in the act of development. In proportion as the granulations become further developed, the formation of pus disappears, and the cytoblastema becomes more and more changed by the formation of areolar tissue, vessels, and sometimes also of other elements, as cartilaginous and osseous tissue, simple muscular fibre, &c. and at last they form a solid persistent epigenesis. They occur both on the external and internal free surfaces of the body, and finally become invested with epithelium or epidermis. Beyond this stage of their progression, they are no longer termed granulations, but receive names corresponding with their future relations.

Since granulations in most cases contain vessels which are usually in a state of hyperæmia and consequently give rise to an effusion of fibrinous fluid, they supply the cytoblastema requisite for further development. And since a portion of the blastema is converted into pus, we can understand why granulations secrete pus; but the formation of pus is not necessarily associated with the presence of granulations.

EPIGENESIS OF FAT AND ADIPOSE TISSUE.

Fat occurs in the normal body under very different conditions. It is present as adipose tissue, when cells with an amorphous cell-wall contain fluid fat; as fat-globules, or granules (the latter being usually very minute) in many fluids; and as dissolved or imbibed fat.

There are as many, and, indeed, greater differences in those fats which result from a pathological epigenesis. Those of most common occurrence are morbidly formed adipose tissue, as in fatty hypertrophy (the fatty dropsy, or polysarkia of some writers); abnormal adipose tissue, as in the fatty degeneration of many organs, for example, of the muscles and the kidneys; independent fatty tumours, which either consist entirely of fatty tissue, as *lipoma*, or of a union of that with areolar tissue, forming *steatoma*. All these formations are characterized by the fat being enclosed in peculiar cells (fat-cells), which more or less resemble those of normal adipose tissue.* These fat-cells sometimes (especially when cold) contain crystalline depositions of margarin.† In other cases, the newly formed fat occurs free, in larger or smaller vesicles, which are usually so minute, that they can only be recognized with the microscope. They may be distinguished by the peculiar manner in which they refract light, and by their solubility in ether. These fat-globules occur either free amongst other histologic elements, as, for instance, between the hepatic cells in many forms of fatty liver; between the different coats in obliterated vessels; in the substance of encephaloid; and in certain fluids, as in blood, pus, &c.; or, they are found in the interior of cells, as in those of the liver.‡ Where these accumulations of fat do not occur as distinct globules, but infiltrate the tissues

* Plate VII. fig. 1. † Plate X. fig. 3.
‡ Plate I. fig IX.

of the body, they are then recognizable by chemical analysis rather than by the microscope. Depositions of fatty granules occur under the same circumstances as those of fat-globules; in fact the two are usually associated, and the latter are only distinguished by containing chiefly solid fat—margarin, cholesterin, and serolin—whilst the former consist of fluid fat (olein). The fatty granules are for the most part small (elementary granules); sometimes single, sometimes in groups, and forming various kinds of aggregate corpuscles and granular cells, and often deposited in very considerable quantity. They must not be confounded with the elementary granules arising from the protein-compounds which occur under similar circumstances, but differ from fat-granules by their insolubility in ether. Many deposits of fat assume a crystalline arrangement; thus, margarin and margaric acid form acicular crystals united in tufts and stars,* while cholesterin forms rhomboid tablets.† Pathological depositions of fat form the transition between organized and unorganized epigeneses; whilst newly formed adipose tissue must be regarded as truly organized, crystalline depositions of fat must undoubtedly be regarded as concretions.

The horny scales described by Valentine‡ and Gerber§ are doubtless crystals of cholesterin; so, also, in all probability are the rectangular tablets described and depicted in several places by Gluge.

The *causes*, *morphology*, and *chemistry* of the *development* of these products present very great differences. The question concerning the ultimate causes of this formation of fat is connected with the still imperfectly understood theory of nutrition, and this brings us to the much disputed subject

* Plate x. fig. 3. † Plate x. fig. 1.

‡ Repertorium. 1837. p. 265.

§ General Anatomy of Man and the Mammalia. English Edition, by Gulliver, London, 1842, p. 136.

respecting the formation of fat from the food, which we shall not at present consider, in consequence of the undecided state in which it remains. Very probably, in all cases where fat is produced, not only the cytoblastema, but also the blood from which it is derived, is more than usually abundant in fat. We often, indeed, meet with fat occurring as fat-globules and granules in many amorphous blastemata; this fat remains, whilst the rest of the blastema disappears either by resorption or organization, and in this manner those pathological collections of fat are formed which we find in a crystallized state. Whether fat can arise from the protein-compounds of an exudation, or from its other constituents, through a chemical metamorphosis, must be left at present undecided, as also must the question, whether, under certain conditions, a plasma consisting entirely or principally of fat can be separated from the blood; in other words, whether the vessels can in a direct manner secrete fat. If this were the case, the process of the formation of fat would be much simplified, and more easily explained. There is no doubt that in many cases actual fat is secreted by peculiar morbidly formed secreting organs, similar to the sebaceous glands of the skin, the ceruminous glands, &c. which in the normal state secrete fat. This is, for instance, the case in many kinds of encysted tumours.

Of the development of organized adipose tissue and fat-cells we have no certain knowledge; indeed we do not know in what manner the normal formation of fatty tissue occurs. We may assume that in accordance with the general scheme of cellular formation, cells arise from a cytoblastema more or less similar to the blood-plasma, and that at a later period they become filled with fat, or that a cell-wall occurs as a secondary formation around the fat-globules, whereby, probably, Ascherson's* theory of the formation of the haptogen

* Müller's Archiv. 1840, p. 44, &c.

membrane might find a practical application. I have never met with a case tending to give either of these explanations a greater degree of probability than the other. The law of analogous formation appears to be here so far in force, as, that pathological fat-cells are most frequently formed in those parts where in the normal condition an accumulation of fat exists, as we shall show when we speak of fatty tumours.

The chemical elements of morbidly formed fat are the same as those of normal fat. Olein is the prevailing element in fluid, and margarin and cholesterin in solid fat. Sometimes butyrin is found in small quantities, recognizable by the peculiar odour of butyric acid, which it evolves on becoming rancid. Whether serolin, and the brain-fats, of which we know very little, occur in morbid formations is unknown.

EPIGENESIS OF MUSCULAR TISSUE.

The normal muscles are divided into those containing simple, non-striated fibres, and those consisting of compound striated, primitive fasciculi. The same division holds, also, with regard to morbidly formed, muscular substance.

a. Muscles with compound, striated, primitive fasciculi. To these belong, in the normal body, the voluntary muscles of the trunk, head, and extremities, and the muscular walls of the heart.* There is no doubt that muscular substance of this kind may be produced by a morbid process, but this can only be argued from consequences, and not directly observed. This epigenesis always consists in a hypertrophy of muscular substance existing in the normal condition, and is of most frequent occurrence in the heart. It appears that the volume of the muscles is increased without the single primitive fasciculi gaining in thickness; hence, it must be concluded that their number is increased; that is, that new

* See Henle's Allgem. Anat. Plate IV. fig. 4.

ones have arisen amongst those previously existing. This epigenesis is sometimes the consequence of a morbid process, as in hypertrophy of the heart; sometimes it results from normally increased nutrition, as in the case where a muscle is strengthened by exercise, and consequently increases in the thickness and number of its primitive fasciculi. This is one of those cases where no decided boundary can be established between a normal and morbid process, and where our division becomes arbitrary. Here the epigenesis entirely follows the law of analogous formation; the cytoblastema is, doubtless, the general nutrient fluid which continues to be secreted in increased quantity for a considerable time. The newly formed muscular fasciculi so closely resemble the previously existing normal formation, that they cannot be distinguished from each other. The morphology of this epigenesis is, therefore, unknown; even the normal development of this form of muscular tissue is still in several respects unexplained.* The chemical relations of this epigenesis are, probably, very simple, for the chemical composition of muscular tissue is very similar to that of the protein-compounds.

It is an interesting observation that after loss of substance in the muscles, new muscular substance is not formed even in cases where a large quantity of cytoblastema is at once secreted. The cicatrices seen in muscular tissue, are formed from areolar tissue, and the exudation from the surface of muscular tissue (as for instance of the heart), is converted, not into muscular substance, but into areolar tissue. These facts serve to confirm the general law that the cytoblastema more readily follows the law of analogous formation in proportion as it is given out in small quantities, and that very compli-

* The different opinions respecting the development of this tissue may be seen in Henle's Allgem. Anat. p. 600; Bischoff's Entwicklungsgeschichte, p. 446; and Valentin in Wagner's Handwörterbuch der Physiologie. vol. I. p. 715.

cated tissues are only formed when its quantity is very small.

Those cases in which it has been asserted that the formation of muscular fibres from large masses of exudation, after inflammation, and similar morbid processes, has been observed, are doubtless, founded on error. In fact, the microscopic examination (the only decisive test), had been altogether neglected, as in the cases observed by Leo-Wolf.* Since the tendons of the muscles are, histologically, closely connected with areolar tissue, so also is there an intimate analogy between these pathological epigeneses in cases of regeneration.

b. Simple, non-striated muscular fibres.—These are found normally in the muscular coat of the stomach and intestinal canal, in the excretory ducts of glands, in the ureters, the bladder, the uterus, and the fallopian tubes. They are often morbidly produced, causing thickening (hypertrophy) of the walls, either at circumscribed points, or over a considerable extent of surface; and as independent (fibroid) tumours. They likewise sometimes form a constituent of scirrhus.

In the majority of cases this epigenesis is to be explained by the law of analogous formation, for a cytoblastema secreted in excess is, through the influence of the surrounding tissue, converted into a similar substance, as in cases of hypertrophy. In this point of view it is interesting to observe that independent tumours of simple muscular fibres (fibroid) so far, at least, as my experience reaches, are only to be found where in the normal condition simple muscular fibres were previously existing; as in the substance of the uterus, which is their most common seat, and in the muscular coat of the stomach and intestinal canal.

Morphology and chemistry of their development. The pathological and normal development of simple muscular fibres

* Tractatus anatomico-pathologicus sistens duas observationes rarissimas de formatione fibrarum muscularium in pericardio atque in pleura obviarum. Heidelb. et Lips. 1832, and Wutzer's Critique on it in Müller's Archiv. 1834. p. 451.

are perfectly identical. In both cases nuclei are formed in an amorphous, and, usually, a fluid cytoblastema, which are at first roundish, but subsequently become elongated and pointed, somewhat in the form of an oat grain, and sometimes arched. Around these there are formed elongated cells, which gradually join at the extremities, and at length become fibres.* It is not, however, always that this mode of formation can be clearly detected during development. In many cases we see only perfect nuclei, whilst the rest of the cytoblastema between them seems to be converted into muscular fibre without any preceding formation of cells, as has been previously described in the development of areolar tissue. After complete development, the newly formed muscular fibres sometimes perfectly resemble the normal ones. Homogeneous fibres, varying in diameter from the 800th to the 400th of a line and parallel to each other, are formed with nuclei scattered lengthways over them.

These nuclei are often distinctly visible, or, at any rate, always become so after the addition of acetic acid.† It is not always, however, that newly formed muscular fibres are so distinctly marked; sometimes an aggregation of them will form a more or less amorphous mass, in which the tendency to fibrillation can be discerned, but the separate fibres cannot be clearly distinguished. On treating such a mass with acetic acid, the nuclei appear in consequence of the fibres vanishing. These are cases where the development of the muscular fibres is either incomplete, or where it remains stationary at a lower and imperfect stage. They occur most frequently in tumours, where, probably, in consequence of too large a quantity of cytoblastema, the law of analogous formation only acts imperfectly, and the epigenesis never attains its true type. Large masses of simple muscular fibres, such as frequently occur in morbid epigeneses (both in

* Plate IV. fig. 4.

† Plate IV. fig. 4. Plate VII. fig. 2. Plate VIII. fig. 2 and 7.

cases of hypertrophy and in tumours), manifest on being cut through so close a similarity, in their physical appearance, with cartilaginous tissue, that they are frequently mistaken for it. Both are of milk-white colour, are semi-transparent, apparently homogeneous, and very solid, so as to craunch under the knife. Many morbid growths described both by ancient and modern authors as morbid cartilaginous tissue consisted, without doubt, of this newly formed muscular tissue. The difference between these tissues is perfectly obvious under the microscope.

The chemical processes in this epigenesis appear to be extremely simple, for this muscular substance in its chemical properties, and probably, also, in its ultimate composition, differs but slightly from the coagulated protein-compounds.

As in the tissues consisting normally of fibrin, there is immense variety in the volume of the fibres, rising gradually from the fibres of areolar tissue, which are the finest and most delicate, and have a diameter varying from the 2000th to the 1200th of a line, to the thickest simple muscular fibres with a diameter varying from the 400th to the 300th of a line; so does the same variety exist in the morbid epigenesis of fibrous tissues. Newly formed fibres are frequently met with, which seem to hold an intermediate place between those of areolar and those of muscular tissue; so that it is no easy matter to decide to which they belong. This is the case in some imperfectly developed formations.

The above observations respecting the similarity of many of these formations to cartilaginous substance holds, also, with regard to many of those structures which consist of imperfectly developed areolar tissue.

EPIGENESIS OF ELASTIC TISSUE.

Elastic tissue consists of fibrous elements, and closely approximates, histologically, to the fibres of areolar tissue, of fibrous tissue, and of simple muscular fibre. The chief distinction between it and them is a chemical one, namely, the insolubility of its fibres in acetic acid; it is also morphologically distinguished from the above tissues by the fact that its fibres are thicker than those of areolar and fibrous tissues; while, on the other hand, they are thinner than those of simple muscle. It is further characterized by a frequent dichotomic separation, and reticulated ramification of its fibres. The nucleated fibres of areolar tissue range themselves immediately with those of elastic tissue; they may, indeed, be considered as a degeneration of these latter.*

Pathological epigeneses of this tissue doubtless sometimes occur; they are, however, but imperfectly known. It has been already observed, that in pathological epigeneses of areolar tissue, nucleated fibres sometimes occur amongst its ordinary elements. In scirrhus, I have myself frequently observed an epigenesis of genuine reticulated elastic tissue, as I shall show in the section on that morbid process.

MELANOSIS.

In the normal body, granular pigment holds a very subordinate place. It is found only in the eye, and in some individuals also in the hair, and in some parts of the skin.† It consists of fine granular molecules of brown or black colour, which are usually enclosed in cells of different forms and size. This is the case in the choroid coat of the eye and

* Full information respecting the histological relations of this tissue may be found in Henle's Allgem. Anat. p. 399. Plate II. fig. 9, 10, 11. Valentin in Wagner's Handwörterbuch der Physiologie. vol. I. p. 667.

† See Bruch's Untersuch. z. Kenntniss des körnigen Pigments. 1844. Henle's Allgem. Anat. p. 279.

in the coloured portion of skin, in which latter, however, in addition to pigment-granules, coloured nuclei are also present (Bruch, Krause*).

Pathological epigeneses of granular pigment are, however, very frequent. They appear as colorations of the skin, in the form of sun-burn, freckles, &c.; in the internal organs they appear as melanosis in the lungs and bronchial glands, on the surfaces of the liver and of the spleen, on the inner and outer surfaces of the intestinal canal, and in tumours; also as frequently accompanying suppuration in the walls of foul abscesses. The morphological and chemical relations, as also the causes of these morbid formations of pigment are very various, and therefore a general consideration of them is difficult. The following may be offered as a mere provisional sketch.

In some cases the newly formed pigment is contained in true cells, analogous to the normal pigment-cells, which are surrounded with a distinct cell-wall, provided with a nucleus, and enclose very fine granular pigment-molecules of a brown or black colour. Such pigment-cells are found in melanotic tumours, in melanosis of the lungs and bronchial glands, and in the skin. They are more or less perfectly formed, but seldom or ever so regular as the pigment-cells of the choroid coat. They are usually of an indefinite roundish form.† I have never seen them united in a continuous layer, and so greatly compressed as to form polyhedra. In animals, (the horse and calf), where collections of pigment occur in the conjunctiva after inflammation, they ramify and sometimes assume a stellar form. Bruch appears to classify the granular cells under this head; but they contain molecules, which consisting of fat, only appear dark in refracted light, and are rather, on the contrary, white when seen by reflected light; they therefore differ essentially from

* Article, Haut in Wagner's Handwörterbuch der Physiologie.

† Pl. I. fig. 10; pl. IX. fig. 7. See also Bruch, op. cit. fig. 22, 23, 25.

the dark-coloured molecules of true pigment which appear dark by reflected light. Sometimes the cells enclosing pigment-molecules are very indistinct, or appear to be entirely wanting; indeed, in one and the same melanotic lung, aggregations of pigment are often found, some of which, when carefully sliced and examined under the microscope, are found to be enclosed in cells, whilst other aggregations in the same lung, on the most careful examination, present no enclosing cells, but the pigment-molecules appear to be deposited in a state of freedom in the parenchyma.

I have never yet succeeded in directly observing the process of development of these pigment-cells. It may be supposed that the cells are first produced, and that at a later period, the pigment-granules are by a metabolic power generated within them; in favour of which view, we may quote those cases occurring in children with leucosis (albinos), in whom the pigment, originally absent, was afterwards developed.* We know also that in white rabbits, whose choroid membrane contains no pigment, it is only the pigment-granules and not the cells which are deficient. When, therefore, pigment is subsequently produced in albinos, it can only happen by the originally empty cells becoming afterwards filled with pigment-granules. According to this view, the above cases in which pigment-granules without surrounding cells occur, may be explained by the supposition that the cells were originally present; but that after the deposition of the pigment in them, they became again resorbed, whilst the pigment itself remained. On the other hand, it may be supposed that the pigment-granules are first formed, and become afterwards surrounded by cells. I believe that I have myself once observed this occurrence in pigment-cells in expectoration, where aggregations of black pigment-granules were surrounded by cells more or less clearly indicated, and it appeared as if secondary cells formed around the pigment-granules, just as in pus-corpuscles they form around the nucleus. But these observa-

* A case of this nature is recorded in Müller's Archiv. 1836. Jahresbericht, p. 192.

tions, which from their nature are most difficult, I do not regard as decisive.

In a chemical point of view, the newly formed pigment closely resembles the normal pigment of the eye. The intensely black pigment, in melanotic lungs and bronchial glands, rendered as pure as possible by boiling in hydrochloric and diluted nitric acid, and then extracting with water, ether, and alcohol, appears from my repeated observations to be insoluble in sulphuric and hydrochloric acids, caustic ammonia, potash, and dilute nitric acid; it dissolves only in concentrated nitric acid, at the same time undergoing decomposition. It is not decolorized by chlorine, though Bruch asserts to the contrary. Dr. Schmidt analysed in our laboratory two portions taken from different bodies, which appeared to correspond in their chemical relations, and in their action towards the above re-agents; the first, taken from the intensely melanotic lung of a miner in Clausthal, gave, after the deduction of 12.48% of ashes, consisting of 10.6 silica (pulverized quartz), and 1.88 sulphate of lime:—

Carbon	72.95
Hydrogen	4.75
Nitrogen	3.89
Oxygen	18.41
	100.00

In the other experiment, on a lung, hepatized inferiorly, and whose bronchial glands were thoroughly melanotic, the determination of the hydrogen could not be regarded as certain, in consequence of the smallness of the quantity subjected to analysis. It gave, after the deduction of 3.735% of ashes, consisting of silica (powdered quartz):—

Carbon	66.77
Hydrogen	7.33 ?
Nitrogen	8.29
Oxygen	17.61
	100.00

These two analyses show but little similarity. It would appear from them, that the newly formed pigment has a variable composition, which is probably connected with its development. They prove that the opinion that the pigment deposited is pure carbon, is, at least in these cases, altogether incorrect. Further, they show that this pigment is not the same as the normal pigment of the eye, in which Scherer* found 58% carbon, and 13.7% nitrogen; yet with all the respect that I entertain for Scherer's accuracy, it appears to me that the analysis should be repeated in consequence of the extreme difficulty of obtaining the pigment of the eye in a state of purity.

Another kind of morbid pigment evidently arises from decomposed blood, and from a change in its colouring matter. Extravasated blood has sometimes, for instance in gangrene, and when it has a tendency to become decomposed, a brownish red, or even blackish colour, forming either soft clots or a granular mass.† This change appears not only to affect extravasated blood, but also that which is still contained in the vessels; whilst some parts of vessels contain red blood, in other parts it becomes brownish or almost black. This change of the blood appears to be of a purely chemical nature, since it is observed in those cases where blood is extravasated into the stomach. It is then always changed in the above-mentioned way, for the acid of the gastric juice communicates to the colouring matter of the blood a brown or blackish tint, and at the same time coagulates the albumen of its serum in larger or smaller masses, so that ultimately the well-known "coffee-grounds" appearance is produced which occurs in all cases when blood has been effused into the stomach during the presence of the gastric juice. In fact, the same takes place, and may at any time be produced out of the body, when defibrinated blood is mixed with sulphuric or

* Liebig u. Wöhler's Annalen d. Chem. u. Pharm. vol. XL. p. 63.
† See pl. IX. fig. 10.

hydrochloric acid. What is done in these cases by acids, appears in others to be effected by gases, especially by sulphuretted hydrogen and hydrosulphate of ammonia, as for instance in the course of the intestinal canal and in the adjacent parts. In other parts also, changes of the blood into a mass similar to granular pigment are presented without our being able to perceive their chemical cause. An interesting case of this kind was recently communicated to me by my colleague Ruete. In a case of hæmorrhoids with disease of the liver, there occurred without any apparent cause an effusion of blood under the conjunctiva of the eye, in the form of knots, by which the conjunctiva was projected forwards; the effused blood was not resorbed, but gradually became of a black colour. The knots broke, and discharged a mass which was immediately brought to me for examination. It was intensely black, and with the naked eye could not be distinguished from the black pigment of the choroid. Under the microscope it appeared as an undefined granular mass, with blackish brown portions. Neither pus-corpuscles nor granular cells were to be seen, nor any other trace of organization or cellular formation. The pigment was not changed either by nitric acid or by chlorine; in its appearance it resembled blood-pigment changed by grangrene or by acids.

The chemical composition of this abnormal pigment is not accurately known, but this much is certain, namely, that it is not changed by chlorine, or by acids; and this is important as a means of distinguishing it from the following variety.

A third kind of morbidly formed granular pigment is not an organized epigenesis, but a simple chemical precipitate, and consists of sulphuret of iron. It appears most frequently as a black or blackish blue pigment on the walls of unhealthy fetid abscesses; but also as a slate-grey pigment on the surface of the liver, spleen, and intestinal canal. Under the microscope it appears as an aggregation of black granules of indefinite form—of molecules varying in size to the 100th of a line in diameter. These molecules are found sometimes singly, sometimes collected together in larger or smaller quantity between and among the elements of the tissue. In some few cases these granules are enclosed in cells.* This pigment has morphologically a great similarity to the first kind, but chemically the two are easily distinguished. It dissolves in acids, (acetic acid, nitric acid, &c.) whilst the first and second kinds are not affected by them. By supersaturating the acid solution with hydrosulphate of ammonia, it apparently returns to its original form, that is, it is again precipitated as sulphuret of iron. Concentrated acetic acid is the best test, for the other acids, by coagulating the albumen, conceal the minute black granules, just as if they dissolved them.

The second and third kinds of morbid pigment-formation, sometimes occur together. On making a microscopic examination, we then observe black granules of sulphuret of iron between the brown patches of altered and coagulated blood.†

After the preceding observations, the conditions under which the two last kinds of morbid pigment occur may be easily explained. Acids change the blood-pigment in the stomach, and probably also in gangrene, since gangrenous fluids frequently have an acid reaction. Sulphuretted hydrogen and hydrosulphate of ammonia, which frequently occur in the intestinal canal, effect changes in the blood-pigment, either in that canal, or (escaping from it by endosmosis, or in cases of perforation through the newly formed opening,) upon the surfaces of the spleen and the liver. When, either simultaneously or independently, the iron of the blood is dissolved, and by means of hydrosulphate of ammonia is again precipitated, the deposition of sulphuret of iron takes place. But there is still much that is obscure in these processes. How happens it, for example, that the iron of the

* See Plate IX. fig. 5. † See Plate IX. fig. 10.

blood-pigment is so easily dissolved, when it is so difficult of extraction in normal hæmatin, as Mulder* has shown to be the case. Probably the preceding decomposition of the blood plays an important part in this stage of the process.

There can be no doubt but that the second kind of morbid pigment arises from the blood, and, further, from its colouring matter. Many writers, amongst whom Bruch is found, trace the origin of all kinds of granular pigment to the colouring matter of the blood. This is not impossible, but it can be nothing more than a supposition. For that both are coloured in the same way is no proof that the one arises from the other. We are acquainted with many examples in zoochemistry where colourless matters give rise to coloured products; and it is highly probable that in the formation of blood in the embryo, the hæmatin arises from colourless matter. I have made a number of experiments by injecting blood into the abdominal cavity of animals, with and without the addition of sulphuretted hydrogen and hydrosulphate of ammonia, in order to convert it into granular pigment; but all my attempts have been unsuccessful, nor was I more fortunate in producing even a trace of granular pigment by treating either fresh or putrid blood with various reagents. The generality of writers designate the pathological epigenesis of granular pigment by the general name of melanosis. But the three kinds above described must each have distinct names. In the following pages I shall, therefore, designate the first kind as true melanosis, and the two last which depend upon chemical changes in the blood-pigment, and on the formation of sulphuret of iron, I shall name false or pseudo-melanoses.

Gluge laughs at this distinction, and observes that the latter has

* Marchand u. Erdmann's Journal für praktische Chemie, 1844, No. XI. p. 186, &c.

nothing false but its name.* Names have always formed a subject of contention, although they are of little importance. Happily facts can never be set aside by witticisms. Further details on melanosis will be given in our observations on melanotic tumours, and in the special department when we treat of the individual organs.

EPIGENESIS OF NERVOUS TISSUE.

The normal nervous substance consists of many elements histologically differing from each other. There are primitive nervous fibres which again are divided into cerebro-spinal, sympathetic (Volkmann and Bidder), and central; further there are central and peripheral nervous corpuscles (ganglionic vesicles).†

The pathological epigenesis of nervous tissue is rare, and only a few of the above named elements have been observed to be morbidly produced. In the way of regeneration, it is confined so far as we at present know to the epigenesis of nervous fibre (cerebro-spinal and probably also sympathetic), since after division, and indeed after the excision of small portions of the primitive fibres, the separated extremities unite with one another by newly formed nervous tissue.‡ The nervous fibres thus formed are very similar to the normal fibres,§ only that according to Nasse, they are somewhat smaller. The morphological process in this formation is little known, but indeed our knowledge of the normal process is very deficient. Doubtless the nervous fibres are

* Atlas d. patholog. Anatomie. Fasciculus. 3 Melanosis. pp. 7 and 16.

† Compare Henle's Allgem. Anatomie, p. 613, &c.; Valentin in Wagner's Handwörterbuch der Physiolog. vol. I. p. 686, &c.; Volkmann u. Bidder. Die Selbständigkeit d. sympath. Nervensystems, Leip. 1842.

‡ Compare C. O. Steinrück, de nervor regeneratione, Berol. 1838; H. Nasse in Müller's Archiv. 1839, p. 405; Günther u. Schön. Müller's Archiv. 1840, p. 270.

§ Plate v. fig. 10 and 11.

formed from a fluid cytoblastema—the general fluid of nutrition—in accordance with the law of analogous formation. But the formation is very slow, being not complete till five weeks, sometimes till three or more months after the injury. It is much slower than the formation of areolar tissue, blood-vessels, &c. Here as in all tissues of composite structure and of high physiological dignity, the epigenesis is limited, that is, all the fibres that have been destroyed are not again formed, and the regeneration itself only proceeds under favourable conditions. Probably there are similar relations in force here as in the striated muscles previously described.

Whether central nervous fibres and nervous corpuscles (ganglionic vesicles) can be again formed, is unknown.

That encephaloid is not a morbid production of the nervous system, as was formally supposed, is shown in the section on that subject. Further details concerning hypertrophy of the nerves, nervous tumours (neuroma), regeneration of the substance of the brain, &c., will be given in the special department.

EPIGENESIS OF CARTILAGINOUS AND OSSEOUS TISSUES.

These two tissues, in relation to their pathological epigeneses, are so intimately connected, that we shall consider them together.

Normal cartilage consists of two elements histologically distinct—the cartilage cells, and an intercellular substance. The latter differs in the different kinds of cartilage; in true cartilage it is amorphous; in fibrous cartilage it consists of fibrous tissue; in other cartilages it exhibits an intermediate character, being sometimes amorphous and slightly channelled, at other times fibrous.*

The morbid production of cartilaginous tissue is not un-

* See Henle's Allgem. Anat. p. 791, and Valentin in Wagner's Handwörterbuch der Physiologie, vol. I. p. 720.

common, but still it is confined within narrow limits; true cartilage is not regenerated, the loss of substance being supplied not by fresh cartilage, but by areolar tissue. This, arising from the perichondrium, in accordance with the law of analogous formation, depends in part upon the fact that true cartilage has no vessels, and that therefore after its destruction, the cytoblastema in its vicinity is chiefly supplied to the areolar tissue of the perichondrium, and follows its law of formation. This circumstance is, however, insufficient to explain the fact that in bone similar conditions occur, and yet it is commonly true osseous substance, and not areolar tissue which is formed as a consequence of regeneration. Fibrous cartilage, on the other hand, which does contain vessels, is regenerated, but not so much by the new formation of cartilage-corpuscles as by the reproduction of fibrous tissue. The morbid production of true cartilaginous tissue is confined to cases of morbid formation of bone, (which are commonly, if not always preceded by the formation of cartilage), and to the formation of a peculiar kind of tumour consisting of cartilaginous substance, and named *enchondroma*. To this we shall return when we come to speak of tumours. It has been already mentioned that many morbid formations of an apparently cartilaginous nature, consist in reality of fibrous tissue, more or less perfect areolar tissue, or simple muscular fibre. Normal osseous tissue consists of different histological elements—of radiating bone-corpuscles, and of an intermediate amorphous substance; these in their union form tubes or laminæ, which are differently arranged in different bones, and indeed in different parts of the same bone, and in this manner are produced the osseous canals, the cortical substance, the spongy tissue, &c. in whose interstices other substances foreign to the true osseous tissue are deposited, as marrow, vessels, nerves, and areolar tissue.* The pathological epi-

* See Henle's Allgem. Anat. p. 813, and Valentin, op. cit. p. 723.

genesis of osseous tissue is of frequent occurrence, as in the regeneration of destroyed or fractured bones, in hypertrophy of normal bone, which is sometimes local, forming a protuberance on the external surface (exostosis) and is sometimes extended over the whole bone, or over several bones (hyperostosis). It sometimes occurs in parts, where in the normal condition no bone existed; as in the dura mater, the sesamoid bones, ossification of tendons, &c.; in osseous tumours (osteoid), and in the ossification of cartilages which in the normal condition do not ossify, as for example, the larynx. In all these cases the newly formed osseous tissue more or less resembles normal bone; it exhibits the osseous corpuscles with their intermediate substance, and bony lamellæ,* whilst the arrangement of these elements offers, as in normal bone, the greatest diversity.

The *morphology* and *chemistry* of *development* are here as in normal bone, still in many points obscure. What our experience has as yet taught us is as follows. In an amorphous cytoblastema which is either liquid or solid, and yielded by the nutrient fluid or by fibrinous dropsy, cartilage-cells are first formed, and between them the amorphous intercellular substance of cartilage; in short true cartilage. Simultaneously with this process, the original protein-compounds of the cytoblastema are converted into chondrin, which then changes into bone. In the first place the cartilage-corpuscles are increased in size or number, so that they preponderate over the volume of amorphous intercellular substance, and adopting a peculiar arrangement, collect together in groups. From these groups of cells, cavities are formed, which by connecting with each other, produce the future medullary canals, and the cells of the spongy tissue. In them are formed marrow, vessels, &c. The intercellular substance separating the cavities, simultaneously undergoes a change; it separates itself into layers—the future osseous

* Plate IX. fig. 7—9.

lamellæ—in which the osseous corpuscles are formed. But since these ramifying canals extend over the original cartilage-cells (indeed frequently the canals proceeding from the different bone-corpuscles appear to be in contact) they must enter the intercellular substance either by resorption or prolongation. Together with these morphological changes, some of a chemical nature take place. The osseous substance becomes impregnated with calcareous salts, whilst its organic basis either remains chondrin, as in most pathological formations of bone, or is converted into common gelatin (colla).*

Whether a formation of cartilage invariably precedes the pathological formation of bone has never been determined by direct observation; the analogy of the normal formation, however, renders this probable. In the regeneration of bone the pre-formation of cartilage is undoubted. Very many of what are termed pathological formations of bone or ossifications are nothing more than concretions, of which we shall speak hereafter.

In the foregoing pages we have considered the most important of the elementary tissues which admit of pathological re-formation: there are some others whose epigenesis can only occur under definite and very limited conditions—as hair, nails, teeth, and glands, which will be considered in their proper places.

* For full particulars respecting the morbid as well as the normal formation of bone, the reader may consult, in addition to the works of Henle and Valentin already quoted: Bischoff's Entwicklungsgeschichte, p. 432; Miescher de inflammatione ossium eorumque anatomia generali, Berol. 1836; Mayer in Müller's Archiv. 1841, p. 210; Fleischmann in ditto, 1843, p. 202; Bidder in ditto, 1843, p. 372.

TUMOURS.

When the pathological epigeneses of the elementary tissues, treated of in the preceding pages, do not serve to unite portions of the body severed by wounds, or to restore loss of substance; when further they do not, as in hypertrophy, increase the mass of an organ by the addition of new substance similar to, and not to be distinguished from the original; but when, on the contrary, the newly formed mass is more or less distinct from the surrounding parts, and when the scalpel of the anatomist can separate it from them and isolate it, such an epigenesis is commonly named a *tumour*. The idea attached to the word *tumour* is, however, very indefinite, and there is no distinct line drawn between tumours and regeneration of lost parts and hypertrophies. Again the tumours occurring in individual cases show an endless variety. There occur as elements in their composition, not only the several tissues of whose epigeneses we have already spoken, but also many others which find no place in the normal body; and these several elements appear in certain cases under infinitely varied combinations. Hence a classification of tumours is extremely difficult, and all attempts to arrange them (as we do animals and plants) into genera and species must necessarily fail; this does not, however, prevent us from ranging them in some sort into groups, in order that we may the more easily proceed in our consideration of them; but we must always bear in mind that there is no definite division between one and another of them, and that through the various combinations of their composite elements, they offer an infinite variety of form.

In a histological point of view, tumours may be arranged in two great divisions. To the first belong those whose elements may be considered histologically to agree with those of the normal body, and which further being once formed, discharge the duties of the normal constituents of the body, take a part in the general metamorphosis of tissue, and are nourished and increased like other parts. These are homologous, non-malignant tumours.

In the second division, we must place those whose elements in a histological point of view differ more or less from those of the normal body, and which (as in the process of suppuration) from their nature give way, soften, and destroy the organic parts which surround them or which they enclose—heterologous, malignant tumours.

But even this division cannot in all cases be strictly adhered to, for if there are not peculiar intermediate structures, there are at any rate combinations of tumours, in part belonging to the one, and in part to the other division; as for instance, scirrhus, in which there is invariably a combination of homologous with heterologous elements.*

Although there are many tumours which can be most distinctly separated from all others, as for instance, many encysted, adipose, and fibrous tumours, and some forms of encephaloid and colloid, yet in many, indeed, in the majority of cases this is not possible; hence such divisions as have been attempted by Plenck in accordance with the suggestion of Baglivi, into genera and species, necessarily fail, at least for the higher problems of science. Pathological anatomy must attempt to arrange them according to their histological elements, but since these in indi-

* The most important literature on the general relations of tumours, and on their classification, is embraced in the following works: J. J. Plenck, novum systema tumorum, Viennæ, 1767; Dictionn. des sciences médic. vol. LVI. p. 107; J. Abernethy, an attempt to form a classification of tumours. Surgical observations, London, 1804; Laennec in the Dictionn. des sciences médic. vol. II. p. 54; Meyen, Unters. über die Natur parasitischer Geschwülste, Berlin, 1828; Joh. Müller über den feineren Bau und d. Formen der krankhaften Geschwülste, Berlin, 1838, or Dr. West's English translation, London, 1840; F. Th. Frerichs de polyporum structura penitiore, Leeræ, 1843; and the various treatises on pathological anatomy by Voigtel, Meckel, Andral, and Lobstein.

vidual tumours are combined in the most varied manner, and to a certain degree appear vicarious in relation to one another, it is impossible to arrange them as species, and we can only classify them according to their formations.

The above leading division of tumours, into homologous or non-malignant, and heterologous or malignant, whilst it avoids the danger of misleading, appears to me to be conformable to nature, and practically useful. Lobstein has preceded me in adopting it. Objections have recently been raised against it on the ground that heterologous epigeneses depend on the same laws (cellular formation, &c.) as the normal, and that in some of them, homologous formations likewise enter, as in scirrhus. This objection seems to refer only to epigeneses in the mass, and not to the individual elements. The more accurately we become acquainted with these, the more sure shall we be that in the second division of these tumours, elements actually occur which are foreign to the normal organism, and that these foreign elements are the true ground of their malignity. The fact must, however, be borne in mind that these heterologous elements cannot at every degree of their development be with certainty distinguished from the homologous, and consequently many cases arise in which after the most careful histological examination, it is impossible to discover whether a tumour is of the non-malignant or the malignant class. Finally it has not always been clear wherein consisted the non-malignant or the malignant character of a tumour. It has been generally agreed that the non-malignity of a tumour consisted in the circumstance that it would not be reproduced after extirpation ; those which after extirpation were again produced being held as malignant. This view I regard as incorrect; tumours which are manifestly non-malignant, as for instance encysted tumours, may again reappear though the same originating force which first produced their development, whilst tumours notoriously malignant may never return after their extirpation, or may even vanish of themselves provided that the disposition to their formation no longer exists, as has been undoubtedly shown in relation to pulmonary tubercle. The malignity which forms the grand principle of division between these two classes of tumours is connected with the very nature of the tumour itself, and depends upon its histological elements. Indeed the clear distinction between malignant tumours and unhealthy suppuration, &c., disappears; but this separation is only artificial and not based on nature. The above provisional remarks are sufficient to give the reader an idea of the principles I adopt in the classification of tumours.

OF NON-MALIGNANT TUMOURS ANALOGOUS TO THE NORMAL ELEMENTS OF THE BODY.

To this class belong those tumours whose elements agree with the newly formed tissues, occurring in cases of regeneration and hypertrophy. The tissues which occur in them are areolar, fibrous, and simple muscular tissue, adipose tissue, vessels, granular pigment, cartilaginous and osseous tissues, and in a few cases also hair, teeth, &c. Sometimes they consist principally of a single tissue, but more frequently of several in conjunction, and in the utmost possible variety of combinations. Some of them are intimately connected with the surrounding normal parts of the body, and arising from the same elements, form as it were a sort of hypertrophy. Others are quite distinct from the surrounding parts, sometimes even so far as to be surrounded by a membrane which either consists of the normal elements of the surrounding parts (chiefly areolar tissue) compressed by the tumour, or else is itself a pathological epigenesis. This membrane is most clearly seen in those tumours which are termed encysted.

As in their histological composition, so also in their modes of origin and development, there is an entire similarity between these tumours and cases of regeneration and hypertrophy. They follow in all respects the general law which has been previously laid down for the pathological formation of the elementary tissues. They further resemble cases of regeneration and hypertrophy in their physiological functions and in their further progress. Like them they exhibit various properties in their several stages of development; like them they are nourished and increased, and form persistent constituents of the body, often enduring many years before death supervenes, usually increasing and very rarely becoming smaller. It is upon these circumstances that their non-malignity depends. In those cases where they become hurtful to the organism, and even soften like malignant tumours, that depends not on their own nature, but on fortuitous external circumstances. They may, for instance, become injurious from their size, and from their pressure on surrounding parts; they may proceed to inflammation and suppuration when they are situated on the outer surface of the body, where from their prominent position they are particularly exposed to mechanical injuries, as blows, the pressure of dress, &c. They may also be combined with malignant growths, especially with tubercles and encephaloid, which may be deposited in them exactly as in normal parts of the body. In scirrhus as we shall presently see, such a union of non-malignant and malignant elements occurs.

Pathological anatomy has as yet done but little in elucidating the causes of their formation. In their commencement they are usually small, and they undoubtedly depend on the formation of a cytoblastema which becomes organized and gradually forms a tumour. Sometimes a mechanical injury, as a thrust or a blow, appears to produce a cytoblastema of this kind, which is then doubtless extravasated blood and coagulated (rarely fluid) fibrin.

A cytoblastema of this kind appears, however, usually to be produced by internal causes, such as locally increased secretion with hyperæmia of the capillary vessels, and only seldom to arise from true inflammation. The organization of this blastema usually follows the law of analogous formation; thus in adipose regions of the body, tumours appear which consist principally of fatty tissue; in parts consisting chiefly of areolar and fibrous tissue, we have fibrous tumours; and in muscular coats, tumours of simple muscular fibre; under the skin we often find encysted tumours whose membranes have a histological composition analogous to that of the cutis, with glands, hair-bulbs, and epithelium. But all the relations connected with the formation of non-malignant tumours, do not admit of this mode of explanation. Many of them are quite inexplicable, as, for instance, the formation of hair, teeth, and bone in encysted tumours of the ovaries. When a tumour is once formed, it takes its share with the rest of the body in the general metamorphosis of tissue, and the part is often an active one, since most of these tumours possess considerable vascularity, and there can be no doubt that they usually owe their increase to the irritation which they set up in the surrounding parts, their vessels becoming hyperæmic, and therefore yielding more than the ordinary quantity of cytoblastema.

Most of the above tumours may be arranged under one of the following groups.

FIRST GROUP.

TUMOURS CONSISTING PRINCIPALLY OF VESSELS.

Vascular Tumours.

Non-malignant tumours which consist principally of blood-vessels with small quantities of intermediate areolar tissue have received the name *Telangiectases*. More or less synonymous with these are those denominated: *Aneurysma per anastomosin*, *Tumeur érectile*, *Tumor splenoides*, *Hæmatoma*, *Hæmatoncus*, *Nævus vasculosus*, &c.

These tumours are of red or bluish-red colour, of various forms and sizes, more or less firm, and more or less capable of temporary erection, like the normal erectile tissues. They generally appear on the external skin, or in the subjacent cellular tissue upon various parts of the body; as on the head, scalp, cheeks, eyelids and lips, also on the trunk, the arms and the lower extremities. They are usually congenital but afterwards increase in size; in some cases, however, they are first produced after birth; and occur both in children and in adults, often without any perceptible cause, but sometimes after a mechanical injury, as for instance, a contusion.

On examining one of these tumours in the dead body, or after extirpation, it usually appears white and bloodless, because the fluid contents very rapidly escape; but on placing a small portion under the microscope immediately after extirpation, the smaller vessels, at the least, will be seen partially filled with blood. A section after being thoroughly washed, is observed either by the naked eye, or by a lens, to have a cribriform appearance, the orifices corresponding with the sections of the divided vessels.* On examining carefully prepared sections under the microscope, the walls of the vessels may be discerned, and between them perfect or partially developed areolar tissue, caudate cells and nuclei. The vessels have usually a tolerably large diameter, being very distended capillaries, small arteries, and small veins; when arteries predominate, the tumours during life exhibit pulsation; and when veins, they present a bluish colour.†

Their development depends either on dilatation of the normal capillaries, the ends of arteries and the commencement of veins, at first only temporary and produced by the same causes which give rise to local hyperæmia and subsequently becoming permanent; or else on an epigenesis of vessels in the manner previously described. When Telangiectases form true prominent tumours, in addition to the formation of vessels, there is always an epigenesis of areolar and fibrous tissue.

True Telangiectases are never encysted, but are intimately connected with the surrounding parts, and are altogether non-malignant. When they are situated in the subcutaneous cellular tissue, they may sometimes become dangerous, by the gradual tension and attenuation of the skin, by spontaneous rupture of their vessels, bleeding, inflammation, suppuration, &c.

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* J. Müller, über den fein. Bau und die Formen der krank. Geschwülste, Plate III. fig. 15 and 16.

† J. Müller, op. cit. Plate III. fig. 17.

Most kinds of tumours, non-malignant as well as malignant, are in some degree furnished with vessels. These tumours when the vessels predominate, may be regarded as a combination of some other form with the vascular. Such combinations frequently occur at a certain stage of malignant tumours, namely when they soften, break up and form on their surface luxuriant and very vascular spongy granulations. Hence arises a peculiar form of malignant epigenesis, termed *Fungus hæmatodes*, of which we shall speak hereafter, and which must not be confounded with true Telangiectasis.

Common as vessels are in other forms of tumours, yet except in the case of common vascular tumour, they play only a subordinate part, the characteristic properties being dependant on other tissues. Hence that appears an unsuitable arrangement of Abernethy,* in which he places tumours containing vessels in a class or species by themselves; for his "common vascular or organized sarcoma," embraces within its range many tumours differing exceedingly from one another in their essential properties. In our observations upon the different tumours, we shall continually return to the consideration of the relation in which vessels stand to the remaining elements of their composition. With regard to the varieties of vascular tumours, we shall say more in the special part in which we treat of tumours in the different organs.

SECOND GROUP.

TUMOURS CONSISTING PRINCIPALLY OF ADIPOSE TISSUE.

Fatty Tumours.

In many tumours fatty tissue is the prevailing element; indeed some tumours consist of it alone. To such we apply the term *Lipoma*. In appearance they resemble normal fatty tissue: when recent, they present to examination a soft mass of yellowish colour, with a fatty feeling, which on being dried or heated gives out fluid fat, forming greasy spots upon paper.

* Abernethy's Surgical Observations, p. 19.

Under the microscope they appear to be composed of an aggregation of fat-cells, which perfectly accord with those of the normal fatty tissue. These fat-cells vary from the 12th to the 21st of a line in diameter, and are round or else laterally compressed into a polyhedric form. They consist of an amorphous cell-wall which sometimes, but not often, encloses an undoubted nucleus, and of fluid fat contained in the interior. The fat may be thoroughly taken up by boiling alcohol or ether. It is chemically identical with the ordinary human fat, and consists of a mixture of olein and margarin. Sometimes the latter is present in so large a quantity, that as the body cools after death, or the tumour after extirpation, it forms acicular crystals, which appear either singly or in stellar groups in the interior of the fat-cells.* The cell-wall probably consists of a protein-compound.

When a fresh tumour of this kind is submitted to pressure under the microscope, some of the fat cells burst, and the fat escapes from them in the form of oil-globules. These appear, therefore, to be an artificial product.

In a true lipoma, I have never seen free fat-globules. In the normal fatty tissue, there are vessels and fibres of areolar tissue, in greater or less abundance, between the true fat-cells; and the same is the case in fatty tumours. Sometimes the vessels, and more especially, the areolar tissue are very sparingly found. In other cases, on the contrary, the areolar tissue abounds, forming tough fibrous partitions between the parcels of fatty cells.† The tumour is firm and solid, assuming more or less the physical qualities of lard, in proportion as the areolar tissue abounds. It then receives the name of lardaceous tumour (*Steatoma* or *Tumeur lardacée*). Fatty tumours are thus histologically combined with the next group, namely, fibrous tumours.

* Plate x. fig. 3.

† Plate VII. fig. 1.

Between the true fatty and the true fibrous tumour, there seems an almost infinite number of transition forms.

Fatty tumours are more or less clearly distinct from the surrounding parts. Sometimes they are most intimately connected with the normal fatty tissue, and these must be regarded as cases of local hypertrophy. In other cases they are more or less clearly surrounded by a cyst. This cyst usually consists of a kind of sheath of areolar tissue, which is, however, generally very imperfect and of different thickness at different parts; it is connected with the inner layer of areolar tissue which penetrates the tumour, and thus serves rather to connect the tumour with the surrounding parts than to separate it from them. In some cases, however, this sheath is more clearly formed, becoming, indeed, a perfect cyst, entirely dividing the tumour from the parts in its vicinity. These cases form the transition between the true fatty tumours and the genuine encysted tumours. Of this transition we shall speak hereafter in our observations on encysted tumours. The vessels in fatty tumours are usually few, and for the most part small, as is also the case in normal fatty tissue. Fatty tumours are sometimes congenital, but they likewise arise at every age and in various parts of the body; commonly in the subcutaneous fatty tissue of the shoulders and the buttocks, but also on the face, the extremities, and the internal parts of the body, especially the omentum. They appear to be more frequent in women than in men (v. Walther, Chelius). Their growth is more or less rapid, and they often attain a very considerable size. Those of the size of a cherry have been observed increasing to the size of an apple, and indeed to that of the head, and have been known on extirpation to weigh as much as twelve, twenty-one, or twenty-five pounds, and even more. They sometimes appear singly, sometimes several occur simultaneously on different parts of the body of the same individual. Fatty tumours are in themselves always non-malignant, yet they are apt frequently to reappear

P 2

after extirpation.* They may be injurious to the organism in many ways and may even prove dangerous. By pressing upon nerves they sometimes cause frightful sufferings (Weidmann, v. Klein). These injurious effects increase with their size. Those occurring on the external parts disfigure the appearance and distend the skin, causing dilatation of the superficial veins in consequence of their having to take on the duties of the deeper vessels, which are compressed by the tumour. They become incommodious from their weight. The distended skin and compressed adjacent parts inflame, suppurate, and ulcerate, and these actions proceeding with increasing virulence, the patient ultimately sinks from hectic fever and exhaustion. Many steatomatous tumours are combined with malignant growths and become scirrhus; at least so it is believed, though as histological proof is wanting, it is not impossible that sometimes their destruction by suppuration may have been confounded with the formation of carcinoma.

The causes giving rise to fatty tumours are still very obscure. It may be that the first foundation of these tumours is in a local increased deposition of cytoblastema converted into fatty tissue. In this change the law of analogous formation takes an active part, for these tumours principally arise in those regions which in the normal condition abound in fat. External causes frequently give rise to an increased secretion of blastema; a blow or thrust may cause it; but, as often, we can point to no external cause. This need not surprise us, when we consider how frequently, without any appreciable external cause or even symptom, extravasations of blood and collections of fibrinous fluid, coagulated fibrin, &c., present themselves in the interior of the body, which under favourable circumstances might doubtless be converted into fatty tumours. As in the normal formation of fat, there is much that is still obscure, so in the formation of fatty tumours,

* See the description of Plate VII. fig. 1.

we are still more in the dark in relation to the mode in which their nutrition is conducted. It is further probable, that sometimes as Abernethy* has conjectured, an imperfectly formed tumour of another kind, as for instance a fibrous tumour, through a change in the mode of its nutrition, may take up fat and thus become converted into a fatty or lardaceous tumour. When a tumour has once formed, it increases in accordance with the law of analogous formation, which in this case is identical with the laws regulating normal nutrition. As the histological examination of tumours is only of very recent origin, it is difficult and often impossible to determine the nature of the tumours described by the earlier observers.

From the absence of microscopic examination and description, it is impossible to identify the tumours described by the older writers.† Of the tumours belonging, according to the old terminology to this group, there are: *lipoma*, some cases of *lupia* (many belonging to encysted tumours), some cases of *steatoma* (which, as has been already remarked, forms the transition to fibrous tumours), and a small portion of the cases of *sarcoma* (Abernethy's adipose sarcoma; most, however, belonging to the group of fibrous tumours). Müller‡ distinguishes the following varieties of lipoma: 1. Lipoma simplex—the true fatty tumour. 2. Lipoma mixtum, with penetrating membranous layers—the combination with the fibrous tumour, forming steatoma; and 3. Lipoma arborescens—

* Surgical observations, p. 9.

† The following works constitute the most important literature of the subject: Abernethy's Surgical Observations, 1804, p. 26; Ph. Fr. v. Walther, über die angebornen Fetthautgeschwülste, Landshut, 1814, m. 2 Tab.; J. P. Weidmann, Annotatio de steatomatibus, Moguntiaci. 1817, acc. 5 Tab.; J. Fr. Meckel, Handb. der Pathol. Anatomie, vol. II. Part. II. 1818, p. 119, &c.; v. Klein, über Speckgeschwülste, v. Graefe und v. Walther's Journal, vol. I. p. 109; Chelius, Handb. d. Chirurgie unter Fettgeschwulst und Steatoma; J. Müller, über den feineren Bau und die Formen der krankhaften Geschwülste, 1838, p. 49; G. Gluge, Abhandlungen zur Physiologie u. Pathologie, 1839, p. 130, 1841, p. 185; D. Heyfelder de lipomate et steatomate, 1842; numerous references to, and quotations from the older authors, are given in these works.

‡ Op. cit. p. 50, or West's translation, pp. 153—4.

ramifying productions consisting of fatty tissue, and occurring in the joints, especially at the knee joint. Growths of this sort are covered by a prolongation of the synovial membrane, and hang loosely in the cavity of the joint, forming arborescent tufts somewhat swollen at their extremities. V. Walther* distinguishes as a peculiar variety, the *Nævus lipomatodes*, a lipoma appearing at birth in the subcutaneous fatty tissue, and connected with a change in the cutis. Gluge† describes under the name of *Lipoma colloides*, a particular kind of fatty tumour, upon which I can at present offer no opinion. The chemical relations of fatty tumours may be easily deduced from the foregoing observations.

After the preceding observations, it will not be expected that we should attempt a division of fatty tumours into precise species and sub-species; but if it be desired to form a tolerable idea of the several possible and actual forms which they take, or changes which they experience, the following arrangement may be serviceable. The true fatty tumour may pass:

1. Into general infiltration of fat (polysarcia, obesitas), by local hypertrophy of the adipose tissue.

2. Into fibrous tumour, by the accession of areolar tissue.

3. Into encysted tumour, by the production of a decided cyst.

Probably there are occasional transitions into other kinds of tumours, even into those of a malignant nature.

The transition into the vascular tumour is doubtful, since vessels in fatty tumours always play a very subordinate part.

In reference to their diagnosis it must be mentioned that many forms of malignant tumour—as encephaloid—have in their physical properties, the greatest similarity to fatty tumours, and can only be distinguished from them by microscopic examination. For particulars on this subject we must refer to the section on malignant tumours.

* Op. cit. p. 22.

† Op. cit. 1838, p. 131, &c.; 1841, p. 185, &c.

THIRD GROUP.

TUMOURS CONSISTING PRINCIPALLY OF FIBROUS TISSUE.

Fibrous Tumours.

Tumours of which the prevailing element is fibrous tissue are very frequent, but they appear under so many varieties of form, not only in their physical properties, but also in their histological arrangement, that it is difficult to assign to them any general characteristic. Their varieties are not merely dependant on their being combined with other forms of tumour, but also on the different stages of development of the tissue.

We shall therefore in the first place attempt to give certain elementary types of these tumours. The forms which are most definite and easy of determination, are those where the fibrous tissue appears perfectly formed. This tissue as seen under the microscope consists of fibres, which can be more or less easily separated, and are sometimes very fine, sometimes tolerably thick, their diameter varying between the 2000th and the 400th of a line. The fibres of the same tumour, are, however, pretty generally of nearly the same thickness. Histologically these fibres resemble either those of normal areolar tissue, in which case they are fine and measure from the 2000th to the 1200th of a line; or they resemble those of the normal fibrous tissue, as of fibrous membranes and tendons, in which case they are somewhat thicker, and measure from the 1200th to the 900th of a line; or lastly they resemble normal simple muscular fibre, in which case they are broader, and have a diameter varying from the 900th to the 400th of a line. All these fibres are rendered transparent by acetic acid, becoming gradually pale till they disappear: occasionally, however, a few larger ones (varying from the 1000th to the 500th of a line) remain unchanged in acetic acid; these divide in an irregular manner and penetrate the tumour. These fibres insoluble in acetic acid, correspond with the nucleated fibres of areolar tissue. On the other hand, after the application of acetic acid, there appear more or less numerous groups of oval, or sometimes pointed, oat-shaped nuclei, presenting occasionally a curved appearance, similar to those which appear in the normal formation of fibrous tissue. In none but mature and perfectly formed tumours are these nuclei ever absent. We may also frequently remark between the perfect fibres, fusiform nucleated cells, apparently arrested in their development. They are found when a fresh section of the tumour has been pared off with a blunt knife, and is placed in water under the microscope.* In future for the sake of simplicity, we shall subdivide this class into *tumours of areolar tissue*, *tumours of fibrous tissue*, and *tumours of simple muscular fibre*. It is frequently, however, impossible to follow this arrangement, for fibrous tissue when morbidly reproduced, shows various degrees of inclination to one or to another of these varieties, so that after the most careful examination, it is not always possible to determine whether the fibrous tissue of a tumour most approximates to areolar tissue, normal fibrous tissue, or simple muscular tissue. But the division, if not pushed too far, will be found to be grounded on their true nature, and practically useful in relation to the genesis of the tumour.

Notwithstanding the similarity of their elements, the tumours of this group present very material differences in the histological arrangement of their fibres, and together with this they present also great variations in their physical properties. It is only in rare cases that the fibres are loosely connected with each other, easily isolated into either single fibres, or connected fasciculi with an undulating appearance, as in normal areolar tissue. In these cases, the tumour is soft, flexible, more or less elastic and coriaceous, resembling in

* See Plate VII. figs. 2, 3, and 4, and their explanation.

its physical properties the tissue of the cutis (*Desmoid tumour*). More frequently the fibres are closely compressed, separated with difficulty, and united into a solid mass. The tumour is then solid, firm, and very elastic, cannot be drawn asunder, and craunches under the knife; and the section presents a map-like appearance. This form is called *Sarcoma*, or *Fibroid*. When the union and fusion of the fibres reaches a yet higher degree, the tumour becomes very firm, almost homogenous, and of a milk white colour; it is more easily cut into thin layers than separated into fibres, and has in its physical properties the greatest similarity to cartilaginous tissue, without, however, resembling it in a histological point of view (*Chondroid tumour*). This form presents the transition to the second class of fibrous tumours, where instead of fibres, a more amorphous mass is presented.

Other differences in fibrous tumours are dependant on the manner in which the fibres are arranged. Sometimes they run irregularly in every direction, as in the normal cutis; this is usually the case in those fibrous tumours which are developed upon the external skin, or upon mucous membranes, (warts, condyloma, fibrous polypi, &c.) In other cases the fibres are arranged in a regular manner, in concentric or twisted circles, and sections of such tumours sometimes present very beautiful designs, visible to the naked eye; this is the case with the so termed fibroid of the uterus.*

Not less various are the ways in which fibrous tumours are connected with their surrounding parts, and also the forms in which they occur. Many of them are most intimately connected with, and as it were, fused into the surrounding parts, and form the transition to the hypertrophy of such organs as in the normal condition consist of fibrous tissue. Thus in the stomach, the intestinal canal, and the

* See Gluge's Atlas der pathol. Anatomie, Part IV. Tab. 4, fig. 14, 15; and Hope's Principles and Illustrations of Morbid Anatomy, fig. 215.

uterus, we frequently meet with every stage of transition from isolated fibrous tumour to local hypertrophy: and condylomata, warts, and fibrous polypi form transitions from the isolated fibrous tumour to local hypertrophy of the cutis and mucous membrane. In all these cases it must of course follow that just in proportion as the tumour is less isolated, and more connected with the surrounding parts, in such proportion its form must be undefined. Other fibrous tumours are definite circumscribed and less closely connected with the surrounding parts, usually being separated from them by a kind of cyst of areolar tissue, which, however, as we have already mentioned in our observations on fatty tumours, is more closely united to the surrounding parts than to the tumour. In these cases the external form of the tumour is more defined; it is commonly irregularly round, but occasionally presents an interlaced or ragged appearance. Sometimes the fibrous tumours are so perfectly isolated, that they show scarcely any connection with the surrounding parts, but lie free from them as it were in a sheath, and on cutting the surrounding capsule fall out. This is occasionally noticed in fibrous tumours of the uterus, which are sometimes quite detached (like a knot in a board) in the parenchyma of that organ or in its cavity, so that, in some cases even during life, they can be removed without suppuration or other process of destruction, simply by uterine contraction. In such cases, the form of the tumour is usually clearly defined, sometimes appearing perfectly round like a musket-bullet or billiard-ball, and sometimes nodulated. Doubtless the direction taken by the fibres is the most influential cause in modifying the form and properties of the surface.

All perfect fibrous tumours contain vessels; it is only in very small tumours of this kind that I have been unable to discover them. It is, however, probable that the isolated tumours just mentioned are non-vascular, and that they receive the blastema necessary to their growth from the vessels of the neighbouring parts. It appears, however, probable that some, if not all of these tumours, have in some of their stages possessed vessels, but that subsequently in proportion as the connection of the tumour with its surrounding parts became slighter, they were gradually obliterated, and at last entirely disappeared.

Usually, however, the vessels of fibrous tumours are few in number, and it is only in rare instances, or in cases where changes occur of which we shall speak presently, that such tumours are rich in vessels. But that pathological formations of fibrous tissue may be combined with vascular formation, we have already seen in our remarks on vascular tumours, (see p. 207). But these vascular tumours are essentially distinguished in their entire character from proper fibrous tumours.

We have likewise already spoken of the combination of fatty and fibrous tumours. This combination presents the most manifold varieties. Sometimes the two elements are so intimately connected, that only microscopic examination can distinguish them. In other cases, and indeed most commonly the two elements are arranged in large groups, easily discernible with the naked eye, so that the same tumour examined at one part, will sometimes appear as a fatty tumour, examined at another, as a fibrous tumour, and at a third, as a tumour composed of the combined elements.

The other principal histological variety of fibrous tumour is characterised by the fact that it contains no perfectly formed fibres, but rather presents the appearance of an amorphous mass, in which a more or less strongly expressed tendency to fibrillation is discernible. These tumours exhibit under the microscope a mass entirely amorphous, amorpho-granular, or amorpho-fibrous, in which oil-globules or fatty granules are sometimes found. By the application of acetic acid the mass becomes transparent, and more or less clearly exhibits nuclei, which resemble those of the fully developed fibrous tumours. Between this almost amorphous mass, and the perfect fibrous tumours, there is every intermediate stage. These amorphous fibrous tumours have a lardaceous appearance, and the transition-forms springing from them, are firm and similar to cartilaginous tissue, with a milk-white or yellow colour. They are never rich in vessels, and sometimes altogether devoid of them. They must be regarded as fibrous tumours, whose histological development is yet at a low stage, or whose substance is incapable of development carried to any high degree. They may, however, be known to belong to the class of fibrous tumours by the fact that, in one and the same tumour, there are found parts which are entirely amorphous, alternating with others which exhibit fibrous tissue. It is highly probable that a large number of fibrous tumours arise from an amorphous solid blastema, and that consequently most fibrous tumours at an early stage of their development, exhibit this amorphous character.

The chemical relations of fibrous tumours present many differences. The perfect fibrous tumour yields gelatin analogous to that of areolar tissue (colla), while from those consisting of simple interlaced muscular fibre, no gelatin is yielded on boiling. Neither by boiling can we obtain gelatin from the fibrous tumours which are yet undergoing development, and are amorphous. Accurate ultimate analyses of these tumours are still wanting.

Their occurrence. The various forms of fibrous tumour occur in all parts of the body which in the normal condition contain much fibrous tissue; on the external skin and the mucous membrane, as cases of hypertrophy, condylomata, warts, and polypi; in the subcutaneous cellular tissue; upon the periosteum and in the interior of the bones; on the muscular coat of the intestinal canal, in the muscular tissue of the uterus, and in the ovary; in the cavities of the thorax and abdomen, where they often reach a very considerable size; and in the cavity of the skull, where they frequently arise from the dura mater. And here the fact is exemplified, that when fibrous tumours arise in parts where areolar tissue prevails, they consist principally of more or less fully developed fibres of areolar tissue, whilst tumours consisting of simple muscular fibre, are only found in those parts which consist in the normal condition of simple muscular fibre.

Of the causes leading to the origin of these tumours, the same may be repeated as was formerly said with regard to fatty tumours. They are sometimes congenital, but more frequently appear after birth, and often, indeed, not until an advanced period of life: this is especially the case with fibrous tumours of the uterus. Their first germ is probably always dependant on the deposition of an amorphous blastema (extravasated blood and coagulated fibrin) which, in accordance with the law of analogous formation, they convert into fibrous tissue, and the occasion of this deposition is very usually a mechanical injury, as a blow, a thrust, or fall. But the cause when the mischief occurs in deep-seated parts is often beyond the power of art to trace. Experiments on animals are very well calculated to throw light on the origin of these tumours. I will here quote one case which appears to me very instructive in this point of view. I injected several ounces of an aqueous solution of hydrosulphate of ammonia into the abdominal cavity of a large dog, through a small wound in the linea alba, and then immediately closed the orifice by a suture. For the first quarter of an hour after the operation, the animal appeared to suffer violent pain; within an hour, however, he recovered and remained afterwards as well as if nothing had happened. At the expiration of twenty-four hours he was killed. There was an amorphous exudation of coagulated fibrin on several convolutions of the intestinal canal under the peritoneum, and blood was extravasated between the muscular and serous coats. On the anterior surface of the stomach there was a coagulum of blood of the size of a hazel nut, surrounded by a thick layer of coagulated fibrin, and firmly attached to the outer wall of the stomach. I am thoroughly convinced that this coagulum would, in time, have been converted into a fibrous tumour, if the animal had not been killed. I had frequent opportunities of making similar observations. This appears to illustrate the probable origin of fibrous tumours in man, at least of such as occur in the stomach, the intestinal canal, and more especially in the uterus, where there are frequent opportunities for the formation of coagula and of fibrinous exudations. In proportion to the smallness of the exudation, is the influence of the surrounding normal fibrous tissue, and the facility with which the exudation can be organized: consequently the most perfectly formed fibrous tumours are cases of hypertrophy, where the exudation is gradual and never in large quantities; and conversely, when the exudation is in large quantity, it is probable that the amorphous fibrous tumours are formed. When the tumour has once arisen, it is easy to explain its further growth. In those tumours which are provided with vessels, this growth takes place not simply at the surface, but through the entire mass. Moreover, in very large tumours we observe on making a thin section, fibres in the course of development—caudate cells.

The further progress of fibrous tumours is very similar to that of fatty tumours. They are in themselves throughout their whole course non-malignant, but they may in various ways become injurious, as by pressure on nerves, vessels, &c.; or by their size which often becomes very considerable, such tumours attaining a weight of twenty pounds or even more. They then distend the skin, cause its veins to swell, and give rise to inflammation, suppuration, and ulceration. Many fibrous tumours, especially those seated in the uterus, ossify; that is concretions are formed in them—unorganized depositions of calcareous salts, which are often falsely regarded as newly formed osseous substances. Of these we shall speak in our observations on concretions.

We shall presently notice the combinations of fibrous tumours with malignant epigeneses. Though it is impossible to divide fibrous tumours into proper species, yet the following forms and transitions may be distinguished. Perfect or fully developed fibrous tumours approach nearly to areolar tissue, to normal fibrous tissue, or to simple muscular tissue. They exhibit transitions:

1. Into the amorphous forms of fibrous tumours.

2. Into vascular tumours (rarely).

3. Into fatty tumours. All these transitions arise spontaneously from the above form.

4. Into cartilaginous and osseous tumours.

5. Into encysted tumours, through the compound *Cystoid*—in a manner to be described, when we come to encysted tumours.

6. Into malignant tumours, of which hereafter. This transition is of especial importance, but often very difficult to diagnose.

7. Of other transition-forms we shall speak in the appendix to the tumours.

In these as in fatty tumours, it is very difficult to understand the earlier classifications founded on external signs.* To this class belong, as has been already mentioned, some forms of hypertrophy of the external skin and mucous membrane—*condylomata* and *polypi*, *desmoid*, some cases of *steatoma* and of *sarcoma*, the greater number of cartilaginous tumours, (*Chondroid*), many cases of *osteo-sarcoma*, and *fibrous* tumours. Müller† distinguishes *tendinous* and *albuminoid* fibrous tumours; the former are fully formed, and on boiling yield gelatin; the latter are either not fully developed or consist of simple muscular fibre, and on boiling yield no gelatin. For information with regard to the chemical properties of these tumours, we have to thank J. Müller and Valentin for their extensive investigations. Müller has shown that we may distinguish

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* Some of the literature of the subject, (that namely referring to steatoma) has been already given in p. 213. To the works there named we may add: J. Müller in his Archiv. for 1836, Jahresber.; J. F. Meckel's Patholog. Anatomie, vol. II. Part II. p. 165, 242; Gluge's Atlas d. pathol. Anatomie, Part IV. Fasergeschwülste; G. Valentin in his Repertorium, 1837, p. 270.

Several histological delineations are given by Müller; see Plates II. and III. of Dr. West's translation. The above literature has relation chiefly to the peculiar form of fibrous tumour occurring in the uterus, and we shall return to this subject in the special department, when speaking of that organ.

† Archiv. 1836, Jahresbericht.

fibrous tumours into those which yield gelatin, and those which do not yield it. Valentin endeavoured to prove that the elementary matter of fibrous tumours in the uterus is coagulated fibrin and not albumen, but the reactions on which he founded his opinions, cannot at present be regarded as decisive.

Decisive ultimate analyses are still desiderata. It cannot be doubted but that in a chemical point of view, the laws regulating the development of these tumours, correspond with those influencing the development of the normal fibrous tissues.

FOURTH GROUP.

TUMOURS WHICH CHIEFLY CONSIST OF CARTILAGINOUS TISSUE.

Cartilaginous Tumours.

Tumours into the composition of which cartilaginous tissue enters, are of much less frequent occurrence than those hitherto described; they are, indeed, rarer than we might be led to judge from physical characters alone; since, as already stated, many swellings apparently cartilaginous belong, in reality, to fibrous tumours. Most frequently true cartilaginous tumours appear as hypertrophies and abnormal growths of bones—as callus, exostosis, &c. They then consist of true cartilaginous tissue, but only in a state of transition, since they gradually pass into osseous substance, and thus into osseous tumours in the manner described in page 198. Isolated cartilaginous tumours occur more rarely, and it is only within a few years, and chiefly by means of J. Müller's* elaborate investigations, that they have been known with any degree of accuracy and designated by the term, *enchondromata.* We must now proceed to the closer consideration of these tumours.

Enchondroma appears under three distinct forms: in the bones, either 1, in the interior; or 2, on the surface covered by the periosteum; and 3, in soft parts, as for instance, glandular

* Compare J. Müller über d. fein. Bau d. krankh. Geschwülste, p. 31, &c.; or West's translation, p. 96, &c.; Dr. Jac. Herz, de enchondromate, Erlangæ, 1843; G. Gluge, Atlas der pathol. Anatomie, Part 4.

organs. It forms a roundish, and generally smooth tumour of variable size, which on a section being made allows even the unaided eye to recognize two distinct constituents, one fibro-membranous, and the other gray, transparent, and soft, resembling firm jelly or softened cartilage. The latter element shows under the microscope roundish or elliptic cells varying from the 150th to the 50th of a line in diameter, and sometimes even larger, which enclose a granular nucleus ranging from the 200th to the 300th of a line in diameter. These sometimes occur as primary cells, and contain several nuclei, or even one, two, or three more recently formed and proportionally smaller cells in their interior.* Besides the nuclei we also occasionally observe irregular, oblong, pointed bodies which are suggestive of bone-corpuscles.† These cells resist the action of acetic acid better than most other animal cells, and, in general, are but loosely connected together, being readily isolated by slight pressure: in some more rare cases there exists between them, as in normal true cartilage, an amorphous firm intercellular substance;‡ the entire mass in this case is firmer, and in its physical characters more closely resembles true cartilage.

The fibro-membranous portion appears under the microscope as fibrous tissue, arranged into sheaths or nets, in the meshes of which is lodged the cellular substance. The latter is sometimes of irregular form, but usually globular, and then frequently protrudes upon the surface of the tumour in the form of rounded eminences.§

Hence, in the rarer cases, in which a firm, amorphous, intercellular substance exists between the cells (cartilage-corpuscles) enchondroma, viewed histologically, resembles true cartilage; in the more frequent cases, on the other hand,

* Compare J. Müller, op. cit. tab. III. fig. 4, 5, 6, 7.

† Müller, op. cit. tab. III. fig. 8.

‡ Herz, op. cit. fig. 2.

§ J. Müller, op. cit. tab. I. fig. 12; G. Gluge, op. cit. tab. I. fig. 1, 2.

in which the cartilage-corpuscles are more isolated, and have a fibrous tissue between them, it presents a greater resemblance to fibro-cartilage, with this difference, however, that in normal fibro-cartilage the cartilage-corpuscles are more isolated and scattered in a thick net of fibrous tissue, whilst in fibrous enchondroma masses of cartilage-cells lie between bundles of fibrous tissue, just as in steatoma accumulations of fat-cells are lodged between masses of fibre. We may, therefore, regard fibrous enchondroma as a combination of the cartilaginous with the fibrous tumour.

In its chemical relations enchondroma resembles ordinary cartilage before ossification, *i. e.* upon boiling, it generally yields chondrin. This was obtained by J. Müller from enchondroma of the bones and of the testicle; on the other hand a much softer enchondroma of the parotid gland yielded, upon boiling, not chondrin, but ordinary gelatin (colla). From this it would appear that chemical differences exist, upon which we require to be further enlightened.

The three above mentioned forms of enchondroma depending upon locality present, also, in their structure certain differences which deserve an especial consideration.

A. *Central enchondroma in the interior of the bones.* This form, the most frequent of all, usually appears in the metacarpal and metatarsal bones, and in the phalanges of the hand and foot, as rounded, smooth tumours of variable size, encased in a vesicular, expanded, osseous cortex. The very characteristic external form of these tumours will be best understood from illustrations.* The tumour is found, upon closer investigation, to be enclosed in a bony case, which varies in thickness in different spots, but is not unfrequently absent at some points, as if the tumour had burst through its wall. This bony covering arises less from the mechanical distension and expansion of the tumour than, doubtless,

* J. Müller, op. cit. tab. IV. fig. 1, 2, 3; Herz, op. cit. fig. 1, 3, 5, 6; Gluge, op. cit. tab. II. fig. 2.

from the circumstance that new bone is constantly formed upon its surface during growth, but that its deposition is modified in arrangement by the presence of the tumour. A section of the tumour shows the elements formerly described — portions of soft cartilaginous substance interlaced by bundles of fibres. Here and there appear also in its interior portions of bone—remains of the spongy substance of the original bone.*

B. *Peripheral enchondroma of the bones* agrees with the former variety, insomuch as it also originates in the bone: it is formed, however, not in the interior, but on its surface, and has, therefore, no bony sheath, being covered only by the periosteum. Its form is less regularly round, and its surface is rendered rugged and uneven by the separate, rounded cartilaginous formations, which protrude as distinct nodules varying from the size of a pea to that of a cherry.† The internal structure does not differ from that of the former variety, small portions of bone being, likewise, occasionally found between the fibres and the cartilage-cells. This form is principally observed in flat bones, namely, the ribs and the cranial and pelvic bones, seldom in the cylindrical bones.

C. *Enchondroma of soft parts* is much rarer, and was observed by J. Müller only four times in thirty-six cases of the disease, once in the parotid gland, once in the mamma, and twice in the testicle, thus occurring only in glandular parts. This variety is distinguished by containing no bony matter, either as an external covering or in its interior, and by the fibrous tissue intervening between the cartilage-cells, being sometimes replaced by a more amorphous intercellular substance, so that the mass closely resembles true cartilage.

The fibrous substance of enchondroma contains but few vessels. These tumours are non-malignant and unaccompanied by pain, and are so slow in their development that they

* Gluge, op. cit. tab. II. fig. 2.

† Gluge, op. cit. tab. I. fig. 1, 2.

often exist and increase for ten or twenty years, attaining a considerable size without materially incommoding the patient. Gluge describes a tumour of this kind, which, on extirpation, weighed nine pounds and a half.* They may, however, when large, like the non-malignant tumours formerly described inflame and ulcerate, and become dangerous from the quantity of the discharge.

The origin of enchondroma can often be referred to mechanical injuries, as contusions, bites, &c. which appear more capable of giving rise to this species of tumour in childhood than in adult life. Enchondroma is not, however, in all cases referrible to a local injury; sometimes it occurs in several parts of the body at the same time, resulting from a general or constitutional cause. There can be no doubt that in enchondroma of the bones, the law of analogous formation performs a determinate part in the organization of the exudation; but it should not be forgotten, that, in these cases, the cartilaginous substance of the enchondroma does not correspond altogether with true cartilage. At present we cannot even hazard a conjecture as to the originating cause of enchondroma in glandular organs.

From what has been stated, it will be seen that there exist two distinct forms of cartilaginous tumour: *cartilaginous exostosis* and *enchondroma.* They sometimes so closely resemble each other, that they can only be distinguished by a close anatomical investigation.

Enchondroma sometimes presents, in its interior, cavities filled with fluid,† and thus passes into the category of cyst formations (*Cystoid*).

In a diagnostic point of view, the transition from

* Op. cit. explanation of tab. I.

† Compare Gluge, op. cit. explanation of tab. I. It is possible that two of the cases described by Frogley (Medico-chirurg. transactions, 1843, p. 133) as osteo-sarcoma of the femur belonged to this category; in consequence, however, of there having been no microscopic examination, it is impossible to decide with certainty.

enchondroma to fibrous tumour is highly interesting. This is accomplished, in enchondroma of the bones, by the gradual increase of the fibrous part, the cartilaginous portion diminishing in the same ratio. Indeed, many tumours which, judging from the external form, might be taken for enchondromata, in reality consist entirely of more or less developed fibrous tissue, and contain no cartilaginous substance. The external form and appearance of a tumour are, therefore, not sufficient evidence of its being an enchondroma, a microscopic investigation being essential to a certain diagnosis.

Enchondroma, the most important of the forms of tumour belonging to this class, was only made known to us a few years ago by the valuable investigations of J. Müller. These tumours were previously grouped with many others occurring in the bones, and designated by the various names of *atheroma nodosum*, *spina ventosa*, *osteo-sarcoma*, and *osteo-steatoma*; it is not possible, therefore, from the name alone, to recognize the previously observed enchondromata. In the living subject before operation it is often difficult to distinguish cartilaginous exostosis from enchondroma. The diagnosis is easier on making a section of the tumour, when the internal structure—the soft cartilaginous portion with the fibrous layer—enables us to recognize the microscopical characters of enchondroma. True enchondromata do not ossify, although the ramifying corpuscles which they occasionally exhibit, are strongly suggestive of osseous particles.* The great resemblance which many fibrous tumours bear to enchondroma demands especial attention in a histological point of view, and requires great caution in the diagnosis, although the distinction between true enchondromata and fibrous tumours is of little consequence to the practical surgeon, since both forms of tumour appear to exercise an entirely similar action on the human organism. I have examined some tumours (one on the pelvis, one on the toe, and two on the hand) regarded as enchondromata and which in their external characters they perfectly resembled, especially the one figured by Herz (fig. 9); they showed no trace of cartilage-corpuscles, but consisted entirely of more or less developed fibrous tissue. These observations might lead us to judge that apparent enchondroma is almost as frequent as the true form, or at all events must induce us to exercise caution in the diagnosis, and forbid us, without minute investigation, to characterize a tumour of which the

* Müller, Plate III. fig. 8.

bony case alone remains, as true enchondroma. For further information concerning the relation of enchondroma to other tumours occurring in the bones, as well as concerning cartilaginous exostosis, I must refer to the chapter on the bones, in the special part of the work.

FIFTH GROUP.

TUMOURS CONSISTING CHIEFLY OF OSSEOUS SUBSTANCE.

Osseous Tumours.

Tumours, in which bony tissue is morbidly formed, present in individual cases such great differences in form and structure that it is impossible, as in most of the forms of tumour which have been considered, to give a general description of them. They usually appear in or upon bones, and their peculiarities can only be clearly elucidated by a comparison with other pathological changes which take place in the bones themselves. We will, therefore, leave their detailed consideration to the special part, and confine ourselves here to some of their general relations.

It is especially important to distinguish the true from the false or apparent osseous growth. The former presents in its histological and chemical relations, all the characters formerly described (see page 199) as appertaining to true bone; the latter consists of an unorganised deposition of calcareous salts between different histological elements, and belongs to the concretions, under which head it will be treated of at greater length. Most of the so termed ossifications, including those which occur in tumours, belong also to this class, and are not true bony structure.

The tumours in which true osseous substance appears, either consist entirely, or for the most part of newly formed bone; or contain it in smaller proportion, forming, according to the terminology which we have hitherto adopted, combinations of the osseous with other forms of tumour.

To the former belong the osseous formations unconnected with normal bone, which most frequently occur in fibrous membranes, especially the dura mater, in tendons, (the sesamoid bones) and occasionally in the eye (Valentin); and the osseous tumours which are connected with normal, or diseased bone, and known as *exostoses.* As they arise, like normal bone, from true cartilage, they sometimes, before their perfect ossification, consist in part of true cartilaginous substance, and are thus connected with the cartilaginous tumours.

Moreover tumours which consist only in part of true osseous substance, appear from the observations hitherto made, almost always to arise from diseased bone, but, in addition to the newly formed morbid osseous matter, there are also produced other histological elements—fibrous tissue, vessels, cartilage, fluids enclosed in cysts, and even malignant elements, as encephaloid and tubercle. The newly deposited bone forms very irregular masses, generally of a porous structure, which project in the form of plates, or spicula amongst the other elements of the tumour, or form cellular spaces enclosing these elements. The newly formed osseous substance is either connected with the original bone, which, upon the removal of the soft part by maceration, appears covered with bony excrescences, as in true exostosis;* or it lies in loose patches in the soft parts, and is lost by maceration. It sometimes forms only a small part of the whole tumour, sometimes more than half. The latter cases are connected with the exostoses.

The great variety of these compound bony tumours renders it extremely difficult to characterise and classify the individual forms; since almost every case hitherto described differs more or less from the others. We cannot, therefore, speak of distinct species or varieties of these tumours, but must follow, as well as possible, the method which we have hitherto adopted, and regard the individual forms as combinations of the bony tumour with other elements; thus it

* A very characteristic preparation of this kind is delineated by Weidmann: Annotatio de steatomatibus, tab. v.

may be combined with the fibrous tumour, the vascular tumour, the cartilaginous tumour, the fatty tumour (?), the gelatinous tumour, the encysted tumour and the cystoid, and with all the malignant forms of tumour. The subject is rendered more intricate by the circumstance that there may occur not only one of these combinations but several, indeed almost all simultaneously in the same tumour.

Causes and mode of origin of osseous tumours. From the above observations it can hardly be doubted that the formation of bony substance in tumours follows the same laws which hold good in the development of bone generally, and which have been already discussed, although this structural process has, as yet, been directly observed in only a few cases. It may, moreover, be safely assumed that the cytoblastema of the new osseous structure is a fibrinous fluid derived from the blood. The increased exudation, occurring sometimes rapidly and abundantly, sometimes more slowly but therefore continuing the longer, which gives rise to the pathological formation of bone may be occasionally ascribed to external causes—mechanical injuries as a blow, kick, fall, &c.; at other times it proceeds insidiously from constitutional or local internal causes, and is frequently only perceptible by its consequences. In the metamorphosis of the blastema into bony substance we find in many cases the law of analogous formation in operation, acting sometimes alone, at other times in opposition to a tendency to malignant formations. If we consider that normal bone itself is a very complicated structure, and, besides the proper osseous substance, contains medulla, vessels, periosteum, in short very different histological elements, it will be apparent that the law of analogous formation serves to explain many compound forms of osseous tumour. It should, however, be borne in mind, that all such laws admit of only a general application, and are frequently insufficient to the elucidation of a special case. The peculiar causes of the osseous formations which are unconnected with bone—as for instance those of the dura mater—remain entirely unknown.

Osseous tumours are invariably non-malignant : nevertheless when combined with other elements they may be destroyed by ulceration, &c. and this destructive process may proceed in the form of caries or necrosis to attack the newly formed osseous tissue itself; this is especially the case with the bony tumours combined with malignant elements.

Our knowledge of the bony tumours is still very imperfect, especially with regard to their histological relations.* The classification and nomenclature of the tumours belonging to this group are also very confusing; there belong to it the different species of *exostosis*, some of the *osteo-sarcomata, osteo-steatomata,* some cases of *spina ventosa,* the *osteo-phyte* of Gluge, and the *osteoid* of Müller. The more minute characteristics of all these tumours will be given in the special part.

SIXTH GROUP.

TUMOURS ENTIRELY OR IN PART CONSISTING OF DARK PIGMENT.

Melanotic Tumours.

In many tumours there occurs a dark pigment as a more or less prevalent constituent. This pigment appears, however, so far as the still scanty histological investigations of such tumours enable us to judge, to present very different characters.

In many cases it consists of dark (brown or black) granules enclosed in more or less distinct rounded or elongated cells, sometimes it is altered blood-pigment, and occasio-

* The special literature is given in the chapter on the morbid changes in bone. In addition to the references previously given, respecting the morbid epigenesis of osseous tissue, we may notice: G. Gluge, Atlas der patholog. Anatomie, Part II. (osteophyten); and J. Müller in his Archiv. 1843. Ueber ossificirende Schwämme oder Osteoid-Geschwülste, p. 396, &c.; in both places there is a copious bibliography of the earlier writers.

nally it is composed of granules of sulphuret of iron. The pigments of melanotic tumours admit, therefore, of distinction into the same varieties as were formerly pointed out in the pathological epigenesis of granular pigments generally, (see p. 196) namely into true and false melanosis, the latter further resolving itself into that produced by altered blood-pigment, and that consisting of deposited sulphuret of iron.

The pigment is never the sole constituent of melanotic tumours; it forms only a portion of the whole, and is scattered amongst other histological elements, such as perfectly developed or comparatively amorphous fibrous tissue, vessels (which, however, are never abundant), and malignant formations, as tubercle, encephaloid, and scirrhus. Melanotic tumours are, therefore, always compound. The pigment-molecules are sometimes equably distributed amongst the other elements, at other times accumulated at particular points: the tumour, therefore, appears sometimes equally dark throughout, sometimes spotted, and sometimes presents alternating light and dark strata. In true melanosis the colour is brown, of a bistre tint, blackish, or, if only a little pigment is present, gray; in the false variety depending upon sulphuret of iron, it is slate-gray, or greenish black: in that resulting from altered blood-pigment it is blue, violet, or brownish black. The discrimination of these three varieties is easily accomplished by means of the microscope with the aid of chemical reagents, according to the rules given in pp. 192—5. Occasionally the melanotic colour which appears in tumours in the form of spots, depends upon decomposed blood in the interior of vessels (veins).

Melanotic tumours have been observed upon almost every part of the body, in the eye, the female genital organs, the lungs, liver, &c., also upon the external surface, the skin, subcutaneous cellular tissue, &c. Sometimes they appear solitary, sometimes in great numbers; and gradually extending over the whole body, form a general disease terminating in the death of the patient. They occur more frequently in the female than in the male sex.

The progress of melanotic tumours depends upon their combinations. True melanosis is of itself non-malignant, and so is its combination with fibrous tumour; on the other hand its combination with malignant elements is naturally malignant. False melanosis is generally injurious from its very nature, since its occurrence presupposes an important decomposition of the fluids; when, however, it remains localised it is of less importance.

The causes producing them vary with the nature of the tumour: in false melanosis they are usually of a chemical nature, and can frequently be recognized, as has been already shown.

The causes of true melanosis are obscure, although the law of analogous formation appears, at least occasionally, to perform a conspicuous part; thus melanotic tumours in the eye usually arise from the choroid, and melanotic tumours of the skin in the Rete Malpighi, in which the formation of pigment is a very frequent phenomenon.

Our knowledge of melanotic tumours is still very deficient: every tumour which was entirely or in part of a dark colour, has been arranged under this division, and thus the most different structures have been promiscuously thrown together. A clear insight into the nature of these tumours can be expected only from more extended histological investigations: this is especially the case with those forms which, having spread over the entire body, have become constitutional, and which, hitherto have not been examined in a sufficiently accurate manner: and hence a more minute description of the individual forms, and a discussion on the question of their malignity or non-malignity, with a critique of the views hitherto adopted of their mode of origin, are quite unnecessary.* The chemical relations of melanotic tumours may be regarded

* The most important literature is comprised in: Carswell's Pathological anatomy. Melanoma; Schilling de Melanosi, 1831; Gluge, Atlas der pathol. Anatomie, Part III.; Cruveilhier, Anatomie pathologique, liv. XIX. and XXXII. fol. plates, Paris, 1830—42.

as still quite unknown. A portion of a melanotic tumour of the brain analysed by A. Vogel, jun. yielded :*

Carbon . .	49.885
Hydrogen . .	7.156
Nitrogen . .	23.784
Oxygen . .	19.175
	100.000

This analysis differs very considerably from that given in page 192 of the colouring matter from melanotic lungs. In that case, however, the histological examination was totally neglected, and therefore we cannot now precisely determine what was analysed, so that unfortunately it is of no value to pathological anatomy.

SEVENTH GROUP.

TUMOURS CONTAINING A GELATINOUS SUBSTANCE.

Gelatinous Tumours.

In many tumours there occurs a viscid, gelatinous substance, partly infiltrated amongst the other firm elementary tissues, and partly contained in appropriate spaces or cavities, sometimes in such abundance and so greatly exceeding the other elements, that the tumours may, with great propriety, be termed gelatinous. The elements co-existing with the gelatin in these tumours are of very various kinds, generally fibres, vessels, and sometimes even cartilaginous tissue, so that these tumours may be considered combinations of the fibrous tumour, enchondroma and encysted tumour; even cancer-cells occur conjointly with this gelatin, and the most frequent form of gelatinous tumour is the so named gelatinous cancer (colloid).

This substance is always transparent and colourless, sometimes fluid, resembling thick mucus, at other times firmer like half softened jelly. Under the microscope it appears

* Münchner gelehrte Anzeigen, 1844, No. 143, p. 108, &c.

completely amorphous and so perfectly transparent, that it is not easy to see it. In the cases which I have examined, it coagulated, on the addition of acetic acid, into a colourless, striated, amorphous mass: the same reaction was caused by sulphate of the protoxide of iron, infusion of galls and (to a less degree) by alum, alcohol, and bichloride of mercury. Nitric acid and nitrate of silver caused only a slight turbidity which was doubtless dependant on the presence of albumen. It was insoluble both in cold and boiling water. Its quantity was too small to admit of ultimate analysis; until, however, this is effected nothing certain can be determined concerning its chemical constitution.

It may be inquired whether the gelatin possesses the same properties in all tumours. In six cases, which I have now investigated, its character seemed perfectly identical, and it presented the above reactions. I consider this substance which in its chemical and physical characters is analogous to mucus and pyin (as far as its properties are known) to be non-malignant; when a tumour is composed of it, as in the gelatinous cancer (colloid), it appears to me that this results rather from mechanical causes—distension of the tissues by the deposited mass, &c. than from a specific action, as in the strictly malignant tumours. Nothing can as yet be stated with certainty concerning the origin of this substance; it arises, however, in all probability like normal mucus, from changed protein-compounds of the blood. The elucidation of these relations can only be expected when the chemistry of the metamorphosis of tissues shall be better known than it is at present.

Under the head of gelatinous tumour, J. Müller has described *Collonema*, a peculiar tumour which I myself have not yet seen and which I shall notice here,* since I do not perceive where else it can be included. According to him, it consists of " a remarkably soft gelatiniform tissue, which trembles upon touching. The organised elements form very

* Archiv. 1836, Jahresber.

scanty bundles of fibres and vessels. The chief mass consists of gray globules, some of them much larger than blood-corpuscles. Crystalline needles lie scattered in immense numbers throughout the whole tumour: they consist of a peculiar, non-fatty animal matter, and can be readily recognised by the microscope in every part of the tumour. They are insoluble in acids and alcalies; the latter by dissolving the non-crystalline portion of the tumour, isolate the needles and render them more apparent. Upon boiling a portion of the tumour in water, the crystals are destroyed; at the temperature of the body, however, they remain unchanged. They are insoluble in hot spirit, but dissolve in boiling ether. This tumour has been observed once in the brain, and once in the female breast; the crystals were similar in both cases: the uncrystallized mass, on the other hand, was different. The decoction of the tumour from the brain was not precipitated by tannin, spirit, mineral acids, acetic acid, ferro-cyanide of potassium, alum, sulphate of iron, acetate of lead, or bichloride of mercury, and, therefore, most closely corresponded with ptyalin, or the mucus of English authors; the decoction of the tumour from the breast, on the contrary, contained a very small quantity of casein, which was precipitated by a drop of acetic acid and by its other ordinary tests."

EIGHTH GROUP.

TUMOURS ENCLOSED IN A PROPER CYST.

Encysted Tumours.

These tumours are peculiarly distinguished by being enclosed in a proper membranous sac which isolates them from the surrounding parts. In the numerous differences which the individual forms of encysted tumour present, this character, however, is not always distinctly marked, and there occur many intervening forms between this and other tumours. We discriminate, therefore, between the *true*, *simple encysted tumours* (tumores cystici) and the *compound*—combinations of this with other forms of tumour (*cystoid*).

A. The true, simple encysted tumours not only possess a perfectly closed membranous sac, but it is also essential to their character, that the contents of this sac are either not at all, or only very imperfectly organized, and show no organic connection with the sac itself. This forms the distinction between encysted tumours and the enclosed fatty and fibrous tumours formerly described, in which the envelope, consisting of areolar tissue, throws out organized elongations, and processes not only into the substance of the surrounding parts, but even into that of the tumour itself; thus not so much separating the tumour from the surrounding parts, as forming a medium of connection between them.

This form of encysted tumour presents many varieties both with respect to the state of the cyst, and the nature of its contents. It admits of being grouped into two tolerably well characterized subdivisions.

The first embraces encysted tumours with aqueous or serous contents, which approximate more or less to the fluids of serous and fibrinous dropsy, and sometimes entirely correspond with them. I will call them serous cysts, lifeless hydatids. These also present different forms, most of which scarcely deserve the name of encysted tumours, and would more properly be regarded as modifications of a local true or false dropsy. Their principal forms are the following:

1. When, in a local circumscribed serous dropsy, the fluid is effused in a part consisting of lax areolar tissue, or under a thin membrane, as for instance a serous membrane, it forms a vesicle resembling the blisters so frequently observed upon the skin after burns or vesicants, in erysipelas bullosum, &c. In this case the cyst is not a new structure, but consists of normal tissue distended by the dropsical fluid; moreover, it does not form a symmetrical, perfectly closed sac; it frequently shows in its interior irregular cellular spaces communicating with each other, and has no internal epithelium, like the true encysted tumours. The fluid is precisely the same as that of serous dropsy, or of its varieties. Its essential constituent is fluid albumen which coagulates upon boiling, or exhibits the modification of this protein-compound which is not precipitated by boiling, but is readily thrown down by acids and alcohol. These misnamed hydatids are, therefore, only local œdema modified by

the histological condition of the affected part, and originate according to the same laws as œdema generally. They are observed rather frequently on many parts of the body, especially on such as consist of a lax areolar tissue, as the spermatic cord (forming hydrocele of the cord), in the choroid plexus of the brain, also beneath serous membranes, *i. e.* between the membrane and the cellular tissue which connects it with the subjacent parts, beneath the pleura pulmonalis, under the peritoneum, and on the surface of the fallopian tubes; also in the parenchyma of many organs, especially in that of the ovaries. A large proportion of the tumours known as ovarian dropsy belong to this group. These vesicles appear sometimes solitary, at other times in clusters; this seems to be dependant partly upon the anatomico-histological structure of the organ, and partly upon the extent of the disease.

I have repeatedly examined hydatids of the cord; and they always exhibited the above mentioned character. That is, they consisted of lax areolar tissue distended into membranous vesicles containing, in irregular cellular spaces, a clear, transparent, aqueous fluid, which coagulates on boiling. When the fluid was evacuated by puncture, the areolar tissue collapsed and no trace of the previous cavities could be subsequently detected. The following case may serve as an example of a hydatid in which the fluid did not coagulate by heat. In 1837 while instituting an examination of the body of a deformed woman aged fifty-six years, who had been greatly afflicted with ventral hernia and anasarca, I found under the left kidney (which was healthy) between the peritoneum and lumbar muscles, a false hydatid of the size and shape of a human kidney. It was covered over by the peritoneum, and was attached to the lumbar muscles by lax areolar tissue: its sac consisted of a very delicate transparent membrane, which was formed merely of areolar tissue, possessed no internal epithelium, and was most intimately connected with the surrounding parts. It contained about two ounces of a homogenous, transparent straw-coloured fluid, in which no solid corpuscles could be detected by the microscope. This fluid was not affected by heat, but coagulated readily and abundantly on the addition of alcohol, nitric acid, and nitrate of silver; it was, no doubt, the same which formed the œdema in the subcutaneous cellular tissue, and evidently was produced by the same cause.

Another kind of these false hydatids closely corresponds with the *false dropsy,* which was formerly described (p. 57). It originates in an obstruction of the excretory duct of a secreting part: the retained secretion accumulates and distends a certain portion of the duct or of the secreting organ itself into a tumour invested with an apparently closed sac, and containing an aqueous fluid, which, at first, chemically resembles the normal secretion, but may, subsequently, undergo changes by means of endosmosis and exosmosis. This kind of serous cyst is of less frequent occurrence than the preceding; it occurs in the kidneys, the fallopian tubes, the pancreas, and in the parenchyma of the lungs; it may easily be confounded with the first kind, from which, indeed, it cannot always be distinguished with certainty, especially after the secretion has become changed.

Through the kindness of my colleague Prof. Bergmann, I recently observed an undoubted instance of this kind in a kitten, about fourteen days old. The occluded uterus and the fallopian tubes were distended like a bladder, and upon the fimbria which were united by irregular adhesions, there were found several hydatid-like vesicles, the contents of which were clear and contained no albumen.

With respect to the hydatid-like vesicles which are not unfrequently observed upon the surface of the kidneys, it is often impossible to determine even by the most careful investigation, whether they belong to the variety under consideration, and are to be regarded as distended uriniferous tubes, or whether they should be comprehended in the first variety. Probably the *ovula nabothi* should be classed here, and may be viewed as distended uterine glands.

3. A third variety of serous cysts deserves the name of encysted tumours better than the two preceding. It consists of a perfectly closed cyst which externally is firmly connected with the surrounding parts, but internally exhibits a smooth surface resembling that of a serous membrane, and contains a clear serous fluid, devoid of regular corpuscular particles. The cyst itself consists of areolar tissue, and is soft and resembles a serous membrane, or firm, lardaceous or even apparently cartilaginous, according to the degree of development of the aforesaid tissue (see page 169). It varies in thickness in different cases, and its inner surface in general (in perfect

forms probably always) becomes coated with a delicate epithelium, which essentially resembles that of normal serous membrane. In the perfect forms, moreover, the cyst contains vessels. The fluid in the interior closely corresponds with that of serous dropsy. I believe that this form of serous cysts arises in the following manner. As the first form owed its origin to serous dropsy, so does this to fibrinous dropsy; in the first place there is formed a false hydatid (resembling our first form) whose walls are composed of expanded normal tissue. The dissolved fibrin gradually, however, becomes deposited upon the walls in the form of a closed saccular membrane, which usually consists of several layers; the fluid thus deprived of its fibrin becomes identical with that of serous dropsy. The sac, at first amorphous and consisting of coagulated fibrin, becomes partially organised, is usually converted into areolar tissue, receives vessels, and becomes invested internally with an epithelium. The encysted tumour has now become permanent, and is not capable, like the first kind, of being entirely removed by absorption; for if by the altered relations of endosmosis, the fluid originally effused, should become changed or decreased, nevertheless, on account of the internal epithelium, closure of the cavity by coalescence of its walls will not readily occur, and the cyst will maintain its independance, even through the changing relations of endosmosis, and the varying quantity of its fluid contents. These cysts can only be obliterated by means of adhesive inflammation; an illustration of this mode of formation of cysts from effused fibrinous fluids is afforded by a case described in the second part, in the chapter on the morbid anatomy of the brain, &c., where a cyst filled with fibrinous fluid had formed itself in the cerebral substance. The case figured and described in Plate v. fig. 5 and 6, also illustrates this mode of formation; at the same time it serves to elucidate the origin of a more complicated form of these serous cysts, which, up to the present time, has in general been erroneously included amongst the living hydatids. In this form, a membranous cyst consisting of areolar tissue, connected with the surrounding parts, and furnished with an internal epithelium, encloses, but is unconnected with a second shut sac of a hyaline semi-transparent character, which generally admits of separation into many very thin layers, and consists of amorphous coagulated fibrin. It is filled as in the other cases with a serous fluid. The origin of this second sac, as evidently results from the description of Plate v. fig. 5 and 6, must be explained in the following manner: from an already existing organised sac there takes place a new exudation of fibrinous fluid, which by means of the coagulation of its fibrin forms for itself a second membrane within the first. In the same way, it can be readily explained why such cysts sometimes contain altered blood, pus-corpuscles, granular cells, &c. For the means of discriminating these enclosed serous cysts from the living hydatids, we must refer to our chapter on the entozoa.

Hence it appears that this form also of serous cysts is essentially nothing more than a variety of fibrinous dropsy, and is directly connected with the encysted dropsies. It occurs partly in serous cavities, as in the pleura, pericardium, and peritoneum, and partly in the parenchyma of organs, especially in those whose texture is soft, and admits of the easy formation of a cavity by the pressure of the effused fluid—as the substance of the brain, the cellular tissue, &c.

It is little to be wondered at if any one with Bichat and his followers, regards this form of serous cysts as newly formed serous membrane, since, like this, it certainly consists of areolar tissue with an internal epithelium; nothing can, however, be gained by such a course; on the contrary, this mode of considering it possesses the disadvantage that it might easily lead us to suppose the serous membrane first formed, and the fluid in the interior only secondarily secreted from it, whereas in fact, as we have already shown, the converse process of formation takes place. The enclosed serous cysts, whose mode of origin until now has been considered inexplicable, have usually been included in the entozoa under the name *Acephalocysts*. In general, the fluid of these cysts contains no corpuscular particles; sometimes, however, there are observed in it fat-globules and minute corpuscles (elementary granules); in some rare cases it contains small organised formations, which are suggestive of the living hydatids presently to be described, and may raise a doubt with respect to the diagnosis of this form. For the particulars of the following case, I am indebted to the kindness of my friend Dr. Kohlrausch of Hanover. "In the clear aqueous fluid contained in cysts in the kidneys of a man, there swam an innumerable quantity of corpuscles which, although very different in size and appearance, were all connected by evident transitions. The smaller of these bodies were more or less regularly round, not smooth, but transparent. In their centre was observed a point which might be regarded either as a nucleus, or as an optical illusion. To this central point, which was of variable size, converged radial striæ which gave to the whole corpuscle the appearance as if its capsule was plicated from the periphery to the centre. The diameter of these corpuscles varied from the 190th to the 280th of a line; smaller ones of the 370th, and larger to the 140th of a line were less frequent. There were also observed corpuscles which, possessing a rough coarsely granular surface and little transparency, appeared, at first sight, to be very different from those just described. Their diameter varied from the 112th to the 80th of a line. On properly arranging the focus there was seen, however, within the rough surface a smooth rounded outline which, when the enveloping layer was not thick or was partially absent, showed a double border. In many of these inner cells there were also seen the central point, and the striated radiations. The external layer was granular. On causing the corpuscles to rotate, it was seen that they were round. In addition to the above, there were observed larger and more opaque bodies, varying from the 50th to the 24th of a line, with a round granulated figure. Upon being treated for twenty-four hours with concentrated acetic acid, the corpuscles underwent no change; nor were they affected within ten minutes by dilute hydrochloric acid. Upon boiling with ether they likewise remained unaltered, and no fat was extracted from them. They were insoluble in cold dilute nitric acid, but readily dissolved on the application of heat. This solution yielded on the addition of carbonate of potash a finely granular, amorphous precipitate. After evaporation of the nitric-acid solution, there remained a yellowish mass; the purple-red reaction of uric acid could not be produced. In caustic potash the corpuscles readily dissolved, in carbonate of potash less readily, but nevertheless perfectly and without the development of gas." In conclusion I will add a few words concerning another possible mode of origin of serous cysts. It may be readily imagined, for instance, that elementary cells, whose general histological mode of formation was formerly considered, might become so distended through the absorption of fluid as to form serous cysts. I am unacquainted with any case which seemed to derive its origin in this manner; indeed, all the elementary cells at present known, are far too small to permit of the supposition that even in their maximum degree of distention they could form cysts, which are always readily visible to the unaided eye. If, however, such a mode of origin is possible, it may be especially applied to the explanation of many of the so-named hydatids of the choroid plexus, since this part in the normal state already contains numerous large globular cells, which also perform a part in the concretions of this organ. This will be further discussed in the special part.

The second division of the simple encysted tumours is distinguished from serous cysts by the circumstance that the contents do not consist of an aqueous fluid, but contain peculiar corpuscular particles which render them thick and pulpy. They sometimes resemble honey, sometimes boiled groats, and occasionally they have a gelatinous appearance. In accordance with these varieties in the contents, these tumours have received different names, and been termed hygroma, meliceris, atheroma, gummy tumour, &c. Such names are, however, in the highest degree, vague and unscientific.

In this form the cyst is always perfectly closed, and firmly connected with the surrounding parts by adhesions of areolar tissue. It is organised, usually consisting of areolar tissue woven into a membrane, and containing vessels.* There usually may be distinguished upon its internal surface a decided epithelium consisting of cells,† which separates the contents from the membrane of the cyst. Thus far the membrane of these encysted tumours resembles that of true serous cysts; but frequently it is more highly organised, so that whilst in serous cysts the membrane occupies a position parallel with serous membrane, it may in these cases be compared to mucous membrane or the cutis. Sometimes, for instance, the internal surface of the cyst presents, upon certain spots, cauliflower excrescences—granulations which correspond more or less closely with the papillæ of the skin or of mucous membrane; indeed, in some cases, it contains

* See Plate IX. fig. 3. † Plate IX. fig. 2.

glands which resemble the sebaceous and spiral follicles of the integument, as they have been represented by Kohlrausch.* In these cases the epithelium is more perfect than in serous cysts; it resembles stratified pavement epithelium or thin epidermis, and consists of several layers of cells which, in complete analogy with the corresponding normal formations, show different stages of development.

The contents of these tumours, as already stated, present many varieties which are explained with tolerable sufficiency by histological and chemical examination. We find in these encysted tumours:

1. Cells of different kinds, which usually lie loosely together: sometimes they are large, irregularly rounded or oval, mostly very much flattened, and, therefore, seen laterally, appear fibrous, either with or without a distinct nucleus, resembling the external layers of pavement epithelium and of epidermis; sometimes they are small, with a distinct nucleus and nucleoli, perfectly analogous to the cells of the deeper (more recent) layers of epidermis and pavement epithelium; and more rarely they are elongated, resembling cylinder epithelium.† There can exist no doubt concerning the origin of these cells; they are epithelium rubbed from the sac. In this case as in the pavement epithelium and the epidermis, the outer layers are continually being thrown off whilst their under layers are being formed; as the free epithelial cells cannot escape externally, they accumulate in the sac; this they do the more readily as they rather strongly resist chemical influences, and being insoluble in the fluids of the body, cannot become resorbed. A gritty matter presenting a perfect resemblance to the contents of these encysted tumours, sometimes occurs as a morbid accumulation under the toe nails; it forms a white, greasy, caseous mass, and likewise consists of exfoliated, but retained epidermic scales. These cells are usually mixed with the other contents.

* Müller's Archiv. 1843, p. 365.

† Plate IX. fig. 1, 2 and 4.

When the cyst resembles a serous membrane, and throws off little or no epithelium, these cells are comparatively rare, or appear to be altogether absent. In other instances, on the contrary, the cells prevail, and sometimes, indeed, form almost the whole contents. The last described encysted tumours have, generally, a thin surrounding membrane without secreting glands.

2. Fatty matters of various kinds are almost invariably present in the contents of these tumours. They are partly the ordinary fats of the human body—olein and margarin, and oleic, margaric, and butyric acids; partly cholesterin. They occur in the most varied proportions, and consequently, although encysted tumours can be arranged into well marked groups, they are not strictly separable from each other. Sometimes the fats predominate; being either the common fats—olein and margarin—when the contents consist of irregular drops or masses, or when cells filled with fat, resembling the normal fat-cells are present: these form the transition from the encysted to the capsular fatty tumours, but are comparatively rare;—or the contents consist for the most part of cholesterin, which occurs partly in the amorphous state, and partly in the form of distinct crystalline tables.* This variety of encysted tumour frequently presents, upon the interior of the cyst, several superimposed layers of cholesterin which glisten like mother of pearl; it was, therefore, named the *laminated nacreous fatty tumour* by Cruveilhier, and *cholesteatoma* by Müller.†

These groups are, however, not strictly separated, since in different encysted tumours the individual fats are not merely mixed with each other, but also with the previously described cells in the most diversified proportions.

The source of these fats, and the causes of their secretion

* Plate IX. fig. 1 and 7.

† See Müller, op. cit. p. 50, or West's translation, p. 155.

cannot be shown with the same certainty as those of the cells. There can be no doubt that a part of the fat is secreted by the sebaceous follicles which Kohlrausch has demonstrated in the cyst, but such sebaceous glands cannot be discovered in all encysted tumours; and the production of the cholesterin, which sometimes occurs in great abundance, and often forms almost the entire contents of an encysted tumour, cannot at present be sufficiently explained.

3. Besides the substances which have been named, there are always various extractive matters, (water-extract, alcohol-extract, &c.) and salts, in the contents of encysted tumours. If the calcareous salts (phosphate and carbonate of lime) are deposited in considerable quantity, the cyst, as well as its contents, becomes entirely, or in part converted into a concretion, or, as it is usually expressed, the encysted tumour appears *ossified*. Such ossifications of encysted tumours rarely depend upon a new formation of true bony substance.

The preceding observations are sufficient to afford a general view of the structure of encysted tumours and their contents. In addition to the cases in the description of the plates to which reference has been made, we may refer for examples of the individual forms to a case of meliceris described by Valentin,* and to the description of cholesteatoma by Müller. Gluge's descriptions of the tumours belonging to this group,† are neither accurate nor come up to the present state of our knowledge; he regards the crystals of cholesterin as horny exfoliations, and describes them as rectangular crystalline leaves, which is not the case. For chemical analyses, (with the exception of the older and less accurate), see those of Berzelius,‡ Valentin, myself§ and F. Simon.‖ The quantitative analyses naturally show no great correspondence, since in every separate case the quantity of the individual elements may be

* Repertorium, vol. III. p. 307.

† Untersuchungen, Part I. &c., &c.

‡ Lehrbuch der Chemie, translated by Wöhler, 4th Edition, vol. IX. p. 726.

§ Anleitung z. Gebrauch d. Mikrosk. 1841, p. 460.

‖ Beiträge z. physiolog. u. patholog. Chemie, 1843, p. 436.

very different, as may be seen by a comparison of my analysis with that of Valentin. In 1000 parts there were contained:

		Valentin.	Myself.
Water . . .		887.15	751
Fats . . .			
Cholesterin . .	3.52		
Olein and oleate of soda.	32.16	37.90	38
Stearin (?) . .	2.22		
Fluid albumen and potash.		10.35	
Chloride of sodium. .		2.21	a trace
Lime. . . .		2.12	
Magnesia . .		1.04	
Cellular substance (which Valentin regards as coagulated albumen) .		59.23	92
Alcohol-extract with lactic acid . . .			92
Water-extract . .			27
		1000.00	1000

Fée examined a 'lardaceous tumour' from the left hypochondrium of a venereal patient who had been treated with mercury; it contained 87.5§ of cholesterin, and, therefore, was probably a cholesteatoma. This tumour enclosed in its inner layers much fluid mercury.*

Dalrymple† has given a brief description of an ossified encysted tumour (*i. e.* one impregnated with calcareous salts). The encysted tumour was situated beneath the tarsal cartilage of the upper eyelid in a middle aged man; instead of the usual caseous matter, it contained an earthy or osseous deposition. This tumour was rather larger than a pea and consisted of a hard earthy substance arranged into concentric layers, which under the microscope were seen to be entirely composed of firmly agglutinated epithelial cells; instead, however, of forming transparent, thin scales with a central nucleus, they were thick and hard, and contained granular, earthy molecules which dissolved in dilute hydrochloric acid. Between the cells there was no amorphous earthy deposit, but the whole consisted of epithelial cells which were opaque, of light brown colour, with a distinct large central nucleus. The deposition consisted, according to Gulliver, chiefly of phosphate of lime with a trace of carbonate of lime. The above cited chemical analyses very distinctly show the gradual increase of the calcareous salts as ossification progresses. In my

* Leop. Gmelin, Chemie, II. 2. p. 1373.

† London Med. Gaz. June 1843; or Medico-chirurg. Transactions, 1843, p. 238, with plates.

case the contents of the tumour contained only a trace of fixed salts; in that of Valentin, on the contrary, more than .3%; finally, Simon found in one of his cases 25.7% of fixed salts, namely 21.7% of phosphate of lime and 4% of carbonate of lime, with a trace of iron and chloride of sodium. In Dalrymple's case the salts probably existed in still greater proportions.

Similar encysted tumours occur in the inferior animals. I have observed one in the abdomen of a cat, between the skin and abdominal muscles. It contained about half an ounce of a brownish yellow, limpid, inodorous fluid, mixed with white flocculi. Its solid particles were shown by the microscope to be chiefly crystals of cholesterin; besides these, masses of flattened, irregular, non-nucleated cells, completely analogous to those of the epidermis, and numerous brownish granules were observed. The cyst consisted of a stroma of areolar tissue, from the inner surface of which there sprung, in various spots, soft, cauliflower excrescences, which resembled granulations or the irregular papillæ of the cutis and mucous membrane: glands could not be detected in the cyst, even by the most careful examination. The inner surface was furnished with a fine epithelium consisting of delicate nucleated cells which perfectly corresponded with those of the Rete Malpighii.

Although the most simple encysted tumours only enclose the elements which have been specified, others are occasionally observed, which likewise contain more highly organised tissues, as, for instance, hair, true bony substance, teeth, and horny structures.

Of these substances hair appears most frequently in the contents of encysted tumours. It is found partly loose, unconnected with the walls of the tumour, agglomerated into irregular lumps, or scattered amongst the other elements; and partly implanted and rooted in the cysts. This hair is usually light coloured, white, blond or reddish, more rarely brown or black; sometimes it is short, a few lines in length, sometimes long, and occasionally it extends to several feet, and is not inferior in length to the longest hair of a woman's head. In histological structure it perfectly resembles normal hair, exhibiting a medullary and cortical substance, having the usual squamous sheath upon its surface, and running to a point at the peripheral termination. Loose hairs commonly show a stunted bulb, like spontaneously detached normal hairs; those which are inrooted, on the other hand, possess a perfectly organised hair-root, a hair-sac presenting the normal structure, and likewise are frequently accompanied by sebaceous glands. The inrooted hairs are sometimes scattered over the entire sac, sometimes are collected in bunches upon certain spots of its surface, the rest of the sac presenting no hairs; the latter is particularly the case with the longer hairs: the sac at the points where the hairs are affixed shows precisely the same structure as the normal cranial integument.* The sac of these tumours, moreover, affords the same varieties as were described of the encysted tumours generally; it is frequently of unequal thickness and exhibits patches of earthy depositions. The contents, besides the hairs, usually consist of fatty substances, which are chiefly olein, margarin, and fatty acids: cholesterin and epithelial cells are generally very scanty, or altogether absent.

It admits of no doubt that all these hairs, like the normal hairs of the human body, originally developed themselves from hair-sacs, and were at first implanted in the cyst: the loose hairs have subsequently become detached and fallen out, and being insoluble, and therefore resisting absorption, have accumulated in the sac in precisely the same manner as was described of the epithelium in the interior of encysted tumours. It may happen that such detached hairs, at different points of their length (but *not* at their extremities), become again fastened to the sac by fibrinous exudation, calcareous depositions, cellular tissue, &c., (Cruveilhier); this, however, is only a mechanical, not an organic connection. The fat which forms the remaining contents of these tumours is, without doubt, the product of secretion of the sebaceous glands which

* A series of instructive plates and descriptions of encysted tumours containing hair are given by Cruveilhier, Anat. patholog. livr. XVIII. Plates III. IV. V.

accompany the hairs, as Cruveilhier conjectured and Kohlrausch has demonstrated.

Many encysted tumours contain only hairs and fatty substances; others, however, present, in addition to these, portions of bone and teeth. These seldom lie free in the interior of the tumour; but are most commonly between the layers of the cyst, or are enclosed in fibrous, semi-amorphous, knotty masses, so that these tumours are connected with the compound cystoids to be presently described. The bony portions consist of true osseous substance with osseous canals and bone-corpuscles (which are sometimes, however, more scanty than in normal bone) and are generally invested with a more or less perfect periosteum; with respect to size, form, and number, they present, however, the utmost diversity. Attempts have been frequently made to compare them with bones of the normal or fœtal body, and to explain them in this manner, but all such endeavours must necessarily fail.

The teeth perfectly resemble normal teeth, sometimes those of the first, sometimes of the second dentition, and like them possess a crown and root, and consist of osseous substance, dentine, and enamel. Some resemble the incisors, others the canine, and molar teeth. Occasionally, however, they differ in form from normal teeth, being bent, or crooked; and sometimes two are blended together. These teeth are usually, but not invariably connected with the above mentioned pieces of bone, and are sunk into cavities in them, as into true alveoli. Sometimes we are enabled to observe the preceding stages of development of these teeth; they appear enclosed in distinct teeth-sacs, show in their interior a tooth-germ, fragments of dentine, &c., and, in short, evince a progressive formation; whence it follows that the development of these teeth in this unusual site, proceeds in entirely the same manner as that of the normal teeth (Kohlrausch). The number of these teeth is various, sometimes only a few are observed (as from one to six) sometimes a larger number (to forty-four), indeed in one case, a single tumour of the ovary contained three hundred teeth !*

Sometimes all the teeth are arrested at one stage of development; sometimes at very different stages, so that there are found co-existing in the same tumour, teeth which correspond to the first, and to the second dentition. In all the cases hitherto observed, encysted tumours, enclosing bone and teeth, have also contained hairs.

In some more rare cases there is formed within encysted tumours a horny matter, which is connected with, or rather grows out of the sac. When such tumours are situated near the surface of the body they commonly break, and the horny substance grows out of the opening, and sometimes attains a considerable size. Home describes a case in which a horn arising in this manner acquired a length of 11 inches with a circumference of 2½ inches; generally, however, they remain much smaller. Sometimes also they are thrown off and then reappear; or they first form themselves when a common encysted tumour has become accidentally opened, and its sac thus exposed to external influences. These horns of varying form and size are usually curved like rams' horns, and sometimes spirally twisted: sometimes they are transparent like true horny substance, sometimes rough upon their surface, and opaque: they are easily cut with a knife, and in their physical characters present the greatest similarity to the malformed hypertrophied nails, which are not unfrequently observed upon the toes. The same resemblance is maintained in their histological structure. I have closely examined several horns of this kind in our pathological collection. They consisted of a horny substance which could be easily cut into shavings. Under the microscope the substance appeared entirely indefinite, and almost amorphous, like the tissue of the

* Cruveilhier, op. cit. livr. XVIII. in which will be found plates and descriptions of this class of tumour.

nails, but upon digestion for a considerable time in caustic potash, the tissue separated into small scales, perfectly resembling those which are obtained by similar treatment from callous skin, corns, &c.

The data which have been furnished preclude further doubt of the origin and signification of these horns: they are *exuberant local growths of the epidermis of the sac*, and bear the same relation to the cellular contents of the common encysted tumours, as the callous excrescences of the epidermis upon the surface of the body to the furfuraceous separation of the cuticle in pityriasis.

Further particulars and descriptions of such horns may be found in E. Home, Philosoph. transact. 1791; J. F. Meckel, Handbuch der pathol. Anatomie, II. 2. p. 276; A. Cooper in A. Cooper's and Traver's Surgical Essays, p. 2, 1820, p. 233 et seq. with illustrations. These horns are similar in every respect to those which occur upon the external surface of the body, several of which have been described and figured by Cruveilhier, livr. XXIV. Plate III. Encysted tumours with hairs are also found in the inferior animals; in these cases the hair always resembles the normal hair of the animal: in sheep, encysted tumours contain wool; and in birds, tumours which enclosed feathers are found.

Occurrence and further progress of the simple encysted tumours belonging to the second division.

Simple encysted tumours containing fat and epithelial cells, occur in almost every part of the body, most frequently in the sub-cutaneous cellular tissue, particularly upon the cranium and the eyelids, but also in the face, upon the shoulders and the back; more rarely they exist in the internal organs and of these most frequently in the ovaries. They appear sometimes solitary, sometimes simultaneously upon many parts of the body; there have been observed, not unfrequently, four, five, six, and even nine upon one person. A. Cooper saw sixteen upon the head. They vary from the size of a pea to that of the fist, or even of a cocoa nut; their diameter, however, seldom exceeds one or two inches. They occur at every age and in both sexes, and are sometimes congenital, although they usually arise later in life. In some cases they appear to be hereditary, and not very unfrequently are observed in several members of the same family.

The forms which contain hairs are most frequently situated in the neighbourhood of hairy parts, on the temples, near the eyebrows, &c.; these which, besides hairs, also enclose teeth and bone, have been hitherto met with only in the ovaries; those which contain horn, most frequently exist upon the upper part of the head.

All these encysted tumours are perfectly non-malignant: although, like all non-malignant tumours, they may either from exciting causes, or, spontaneously, if they have attained a considerable size, become inflamed and break. Frequently, however, they exist throughout a whole life without injurious results. They can be removed without again forming: if, however, the extirpation has not been complete, and a part of the sac remains behind, this, on account of its epithelial investment, cannot become united to the adjacent parts: it continues to secrete, and the encysted tumour reappears in its former condition.

Causes and origin. Some of the encysted tumours which enclose cells and fat, most probably arise from sebaceous glands of the skin, which, owing to some obstruction in their excretory duct, become distended with their accumulating secretion. This mode of origin is, however, certainly not so frequent as A. Cooper believed,* and, at all events, can only apply to such as exist in or immediately beneath the skin: it cannot take place in encysted tumours of the internal parts, nor in those which contain hairs, bone, and teeth. Certainly in very many, if not in most instances, they are new organs formed by morbid processes, and we can readily suppose that their development is similar to that of serous cysts. If any pathological exudation, which is incapable of further organization, as for instance pus, becomes deposited in the body,

* Surgical Essays, vol. II. p. 236.

in such a manner, that it cannot escape, but irritates the surrounding parts, and gives rise to exudation, it becomes surrounded by a capsule of coagulated fibrin, which gradually organises itself in granulations, and at length is converted into a membrane resembling mucous membrane or cutis, and becomes furnished with an epithelium—a proceeding frequently observed in fistulæ, &c. At first the original contents are still present; they are, however, gradually resorbed, and give place to the secreted product of the newly formed sac-membrane, which always becomes further organised. In this way probably extravasations of blood, accumulations of pus, &c., which have no tendency to external rejection, may become the cause of encysted tumours. The origin of such tumours can frequently be attributed to external influences, contusions, &c., but more especially, continued pressure upon one spot: they may also arise, however, from constitutional, and internal causes acting in an insensible manner. The following example appears to me to contribute to the confirmation of this view of their mode of origin. A parrot in confinement died with a scrofulous deposit which had destroyed the skin by ulceration, and had caused caries of the cranial bones, &c. Upon dissection, the cavity of the abdomen appeared almost completely filled with a clear reddish fluid, which upon evacuation, spontaneously coagulated and characterized itself as fibrinous dropsy. In the neck were found after the removal of the skin two tumours of the size of walnuts, which from external appearance must have been regarded as glandular enlargements, but upon dissection presented peculiar characters. They both formed imperfect encysted tumours: their rather thick sac was formed of the substance of the hypertrophied distended gland, and upon its inner surface were numerous highly vascular granulations, covered with epithelium; the contents formed a soft mass, which presented some irregular pus-corpuscles, but for the most part consisted of cells, perfectly similar to the epithelial cells, and the cells in the contents of encysted tumours, and which, therefore, no doubt had become separated from the walls of the cyst.

The encysted tumours which contain hairs, bone, and teeth, are also undoubtedly formed in a similar manner, and it is not necessary to assume, with Cruveilhier (op. cit.) and Bricheteau,* that these are the enclosed remains of a partially absorbed fœtus. Nevertheless we are far from clearly understanding why, in these cases, there are developed in the sac-membrane such complicated formations as hair-sacs with hairs, sebaceous glands, bony substance, and tooth-sacs with teeth.

The above opinion of A. Cooper, that superficial encysted tumours are occluded and distended sebaceous glands, is founded chiefly upon the observation frequently made by him, that by the introduction of a probe, the excretory duct can be again opened, and in this way the contents of the tumour may be evacuated without any special operation. Ph. von Walther,† with a view to weaken this theory even for the superficial encysted tumours, alleges that, notwithstanding frequent endeavours, he has never been able to perceive the sac-mouth, nor express any portion of the contents. The decision of this question is difficult, and in individual cases it is often impossible to say whether the encysted tumour has arisen in one or the other manner. The opinion of Cruveilhier and Bricheteau that encysted tumours which enclose hairs, teeth, and bones are the enclosed remains of a partially absorbed fœtus, is liable to such weighty objections, that it must be totally abandoned. Cruveilhier himself admits that the tumours containing hair, which so frequently occur upon the scalp and eye-lids, and vary from the size of a pea to that of a walnut, are not in every case to be regarded as the remains of a fœtus, or as an enclosed embryo; the more so, as such tumours, in many instances, obviously originate after birth. Moreover, the perfectly analogous encysted tumours containing feathers, which are observed in birds, cannot be explained in this manner, since the egg is developed externally to the body. Nor is any such admission required to account for bony structures in the interior of encysted tumours, since a pathological formation of new osseous matter not unfrequently takes place in other localities. Again, there exists no reason

* Diction. des Sciences médic. t. XXVII. Kyste.

† Gräfe u. v. Walther, Journ. d. Chirurg. vol. IV. part III. p. 384.

why, through the agency of local influences, the pathological formation of tooth-sacs and teeth in them, should be less readily effected than that of hairs, glands, and bones. In the inferior animals, teeth are not unfrequently observed in abnormal situations when intrafœtation is out of the question; as for instance upon the temporal bone. Even admitting the possibility of the mode of origin assumed by Cruveilhier, its application to the cases in question, presents far greater difficulties than that of the other explanation. How does it happen, for instance, that every part of a fœtus becomes completely resorbed with the exception of one solitary tooth, which remains perfectly unacted upon? Cruveilhier himself has collected a number of cases where, in extra-uterine pregnancy a fœtus was retained and became petrified by the deposition of calcareous salts,* but not one of the cases which he has described, presents the slightest resemblance to an encysted tumour containing bones and teeth. Moreover, how can it be accounted for that the teeth resemble not merely the milk-teeth, but frequently also those of the second dentition? A fœtus dead and undergoing absorption for seven years is stated, in some unknown manner, to cast its milk-teeth and get a new set! Also the number of the teeth sometimes met with, militates against this view: in one case, which Cruveilhier certainly terms doubtful (but upon what grounds?) there were found in a single tumour three hundred teeth, a mass which we must suppose to be furnished by the accumulated remains of at least ten fœtuses!

To the more simple encysted tumours which have been hitherto considered are allied

B. More compound and less regular forms presenting transitions between these and other kinds of tumours; to distinguish them from the simple, true encysted tumours (cysts), I shall, after J. Müller, call them *cyst-like* tumours (*cystoids*), premising, however, that they no more form a strictly separated group than the other forms of tumour. They resolve themselves into many sub-species or varieties which likewise cannot be strictly bounded, and result from combinations with other forms of tumour. As such varieties, we may distinguish:

1. Foreign bodies which have penetrated into the organisation from without, as bullets, &c. also parasites, and entozoa; and unorganised epigeneses formed in the organism, as calculi and concretions, which sometimes invest themselves with sacs

* Anat. Patholog. livr. XVIII. Plate VI.

and become encased as in a capsule. In this case the foreign body is the primary cause, and the sac a secondary structure which arises in this manner: the irritation of the foreign body causes an exudation whose fibrin organises itself, and usually passes into a vascular cellular tissue, which assumes a membranous form, and becomes furnished with an epithelium upon its internal surface. Somewhat similar phenomena ensue after extravasations of blood (apoplectic clots): but in this case the sac-membrane is generally more or less blended with its contents.

2. *Compound cysts.* It has been formerly stated that from the same cause several (true or false) independent serous cysts may be formed in the same vicinity. These formations are not to be regarded as compound, but as accumulations of simple cysts. It sometimes happens, however, as has been shown by Hodgkin,* that new, secondary cysts are formed out of the wall of the original cyst. These compound cyst-formations may present a double type; for the secondary cysts develop themselves either:

a. By the side of the primary cyst, chiefly towards its external surface, and there thus arise locular cystic structures whose separate cysts vary in form and size; or,

b. The secondary cysts develop themselves on the interior of the wall of the parent-cyst in its cavity, and appear either pedunculated, or sessile with a broad base. They form clustered aggregations of cysts, which are filled with a serous or mucous fluid.† Such pedunculated or sessile growths from the wall into the interior of the cyst, do not, however, always form secondary cysts, but are often much more solid, and consist of various kinds of tissue. They are then to be considered as a more extended development of the above-mentioned granulations, which are frequently formed upon the inner surface of the wall of simple cysts.

* Medico-chirurg. Transactions, vol. xv. p. 265, &c., with plates.
† See Hodgkin, op. cit. fig. 1—6.

3. *Combinations of cysts with other forms of tumour.* It not unfrequently happens that tumours which, in their histological structure, belong to the amorphous or organized fibrous tumour, to enchondroma, &c., contain in their interior cavities of various kinds, which are furnished with more or less smooth walls, and enclose a serous, mucous, fatty, or gelatinous fluid. These are the combined cysts and cystoids: on account of their fleshy stroma, J. Müller* comprehends them under the common name of *Cystosarcoma*. He distinguishes three separate forms of them:

a. Cystosarcoma simplex, in which the cysts, enclosed in a fibrous sarcoma, have each their distinct membrane, the inner wall of which is simple, smooth, or at most beset with a few vascular nodules. This form may be described as the cystic formation combined with the simple cyst.

b. Cystosarcoma proliferum, in which the cysts enclosed in the sarcomatous mass, contain younger cysts in their interior, which are attached to their walls by pedicles;—cystic structure combined with compound cysts.

c. Cystosarcoma phyllodes, in which the cysts, included in a sarcomatous substance, are ill-defined, form several cavities and chambers without a distinct proper membrane, and are filled more or less completely with solid, foliaceous, cauliflower growths from the floor and walls of the cavity. This form corresponds with the cystic formations where solid granulations spring exuberantly from the walls of the cyst.

The forms already described may serve to afford an idea of the complicated relations of the compound and combined cyst-formations. The subject is as yet very insufficiently worked out, and there still exists great obscurity concerning it, especially with respect to the relations and causes of their development. Although, perhaps, in individual cases the origin may be sufficiently explained, general laws of formation cannot, at present, be laid down. The most important

* J. Müller über den feineren Bau der Geschwülste, p. 56, or West's translation, p. 170.

literature is to be found in the works referred to in the text, by Hodgkin and J. Müller: descriptions and illustrations of some forms are given by Gluge in his Atlas d. Patholog. Anatomie, Part IV. under Cyst-formations; also by Andral in his Patholog. Anatomie. Hodgkin includes malignant tumours amongst the compound cyst-formations; a view which will be presently criticised.

MALIGNANT HETEROLOGOUS TUMOURS.

Pseudoplasmata.

The nature of non-malignant tumours consists essentially in this, that they are formed of the persistent elements of the body, and as such maintain their existence and participate in the general metamorphosis of the tissues. They may indeed be destroyed by softening and ulceration, but this is effected through the agency of causes which are not inherent in their nature, but are only accidental and exoteric.

Malignant tumours, on the other hand, proceed of necessity to softening from esoteric causes; the softening being a necessary consequence of their development.*

This circumstance sufficiently distinguishes the two classes of tumours. But other pathological formations also soften without being, on this account, malignant. Thus, for instance, softening takes place in all suppurations in which the pus is developed from a solid cytoblastema. In this case, however, the morbid epigenesis alone softens, the original tissues taking no part in it; if the pus is evacuated externally or becomes resorbed, they return to their original condition, and re-assume their previous functions; the affected part, with the exception of some trivial changes which occasionally remain, is restored *in integrum*. The case is far different with malignant tumours. In these the softening is not confined to the morbid epigenesis amongst the original histolo-

* It certainly happens that tumours, which at their commencement we should regard as malignant, occasionally do not soften, but this is dependant on accidental or external causes, much like those which induce softening in non-malignant tumours.

gical elements, but the latter become themselves involved in the process of softening, and are also destroyed, so that the expulsion of the mass from its place of formation is attended with a loss of substance. The softening of the pseudoplasmata, therefore, is not innoxious, but malignant and ulcerative; it consists not in a healthy suppuration, but in a process of ulceration.

The difference between non-malignant and malignant softening is not confined to the above points; it extends even to the morphological formation of the product of the softening. In the non-malignant softening this consists of the normal pus-corpuscles formerly described; in the malignant, on the other hand, of very irregular molecules, which show scarcely a trace of organization, and resemble the products of the putrefaction of organic bodies, mixed with fragments of the destroyed tissues.

This statement perfectly corresponds with that which was formerly advanced as the distinction between *non-malignant* and *malignant suppuration.* In fact no strict line of demarcation can be interposed between malignant or ulcerative suppuration (ulceration) and the malignant tumours; some kinds of the latter—the typhous, the scrophulous, and some of the tubercular depositions—form a debateable territory, which may be as justly annexed to the former as to the latter. This, however, holds good only for some forms; others, as encephaloid and scirrhus, are histologically distinct from common ulceration. The view maintained by C. Wenzel,* that pseudoplasmata (carcinoma) and ulceration are identical, is therefore, with certain restrictions, perfectly correct: it does not, however, hold good in all cases, and may be more accurately expressed by stating that the two are connected by a neutral ground.

Besides the morphological distinction between ulcerations

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* Ueber die Induration und das Geschwür in indurirten Theilen, Mainz, 1815.

and pseudoplasmata, there is another which has relation to *the extent of the malignancy.* In ulcerations the malignancy is usually local, the destruction of the tissues, and the entire pathological process continuing, for the most part, topically circumscribed. In the pseudoplasmata, on the contrary, the epigenesis, and with it the destructive process is frequently propagated from the spot originally affected to other parts, and this propagation and extension attain such a degree that the death of the patient ensues. These different degrees of malignancy can be discriminated as *local*, and as *general.* Upon further consideration it will be perceived, however, that even this distinction is untenable. There are ulcerations which do not remain locally circumscribed, but spread extensively and attack different and often widely separated parts of the body, and finally, by an exalted influence upon the whole organism, induce death ; in these, therefore, we perceive not merely a *local* but a *general malignancy.* On the other side, there exist tumours absolutely corresponding in all other points with the malignant, but in which the destruction is merely local, and the loss of substance even becomes repaired without its exerting an influence upon the organism sufficiently exalted to occasion death. This is observed to be frequently the case with tubercles, and sometimes with scirrhus. For although some surgeons maintain that every scirrhus after its removal by operation again returns, other experienced practitioners, amongst them Travers,* maintain the contrary; and it can be no longer doubted that pulmonary tubercles may heal without recurring. Hence in this point of view ulcerations and malignant tumours are not strictly separated.

After this preliminary consideration of the relations in which the pseudoplasmata stand to the other pathological epigeneses, we shall proceed to examine more attentively those points which the different pseudoplasmata possess in common.

* Medico-chirurg. Transactions, vol. xv. p. 219.

These tumours do not arise, as was formerly supposed, from a transmutation of the normal tissues; they are, rather, new formations which penetrate amongst the previously existing histological elements of the body. Their cytoblastema is always originally fluid and only subsequently becomes solid: it generally fills up the interstices of the tissues amongst which it is deposited, as completely as mortar the spaces between the stones of a wall. This may be directly observed in pulmonary tubercle and in scirrhus, and it results from these observations that the cystoblastema is secreted in a fluid state, even in the cases where we find it solid: for this perfect impletion of all, even of the smallest spaces between the elements of the tissues can only be effected by a fluid.

The cytoblastema is undoubtedly derived from the vessels, and is probably effused through the agency of the same causes which give rise to fibrinous dropsy.

We possess no accurate knowledge respecting the chemical composition of the cytoblastema: although all observations hitherto made, tend to show that it contains the same elements as fibrinous dropsy, and that its coagulability depends upon dissolved fibrin. It may be possible that the cytoblastema of the different pseudoplasmata contains specific chemical principles—peculiar modifications of the protein-compounds: the present state of animal chemistry does not, however, allow of a positive affirmation or denial of this question.

The effused cytoblastema undergoes changes which are very dissimilar in different pseudoplasmata: in some forms it becomes organized, and is converted into cells, amongst which, in certain cases, fibres and blood-vessels are formed: in others, scarcely a trace of organization can be detected, the cytoblastema remaining amorphous, or showing only very feeble indications of cellular structure.

In all cases, however, the new formation finally softens, and becomes disintegrated, and in the disintegration there are involved not merely the permanently amorphous, but also the organised parts. The product of the softening is not, as in normal pus, an emulsion of organised corpuscles, but a fluid with irregular broken up organic molecules,—an organic detritus, which, only in the highly organised pseudoplasmata, contains a few integral or broken cells.

The softened pseudoplasmata are thus also morphologically distinguished in an essential point from normal pus, and correspond more nearly with the unhealthy pus of ulceration. The fluid resulting from the softening of the pseudoplasmata, is not bland and innocuous, on the contrary, it is usually ichorous, corrodes the surrounding parts, and has a putrid odour. Upon what substances these injurious properties depend, has not been chemically determined, but the fact itself is undoubted.

The period which elapses between the deposition of the cytoblastema and the softening is various in different cases, but is always longer than that which is requisite to develop normal pus from a cytoblastema; here, again, the softening of the pseudoplasmata coincides with ulceration.

As in suppuration, so also in the pseudoplasmata, the softening is not confined to the newly formed products; the normal tissues amongst which the cytoblastema was deposited are also involved in the destruction, and simultaneously soften.

These facts enable us to explain in a sufficient manner the *local* malignancy of the pseudoplasmata. It is determined by entirely the same causes which we formerly recognized as conditions of ulceration. There exist, however, two causes of which, no doubt, either may be efficient, or both may co-operate. In the first place, from the long incarceration of the coagulated cytoblastema the tissues become injuriously compressed, and since they are in some measure isolated, their nutrition is impaired and their death thus occasioned. Secondly, the corrosive property of ichor, which frequently resembles a putrid fluid, exerts its action upon them, and likewise contributes to their death.

Allowing that these causes account for the local malignancy of the pseudoplasmata, we have still to seek for an explanation of their extension, and of their pernicious influence upon the whole organism.

It has been mentioned that these consequences do not always ensue, that for instance, tubercles sometimes continue local, and the destruction caused by them may, as in other instances where loss of substance has occurred, heal by cicatrization. This, however, is not usually the case; in general, the pseudoplasmata progressively extend until they terminate in death. As the non-malignant tumours grow by the conversion (conformably to the law of analogous formation) of the nutritive fluid secreted in their surrounding parts into a structure resembling themselves, also so may malignant tumours be propagated according to the same law. Since, in this manner, the increased extent of the tumour is accompanied by an extension of the softening, the loss of substance and the destruction are constantly increasing.

The softening of malignant tumours usually commences not upon their surface, but in their interior; the product of the softening, therefore, not being immediately discharged, the ichorous pus continues for some time in contact with the walls of the vessels, and, by endosmosis, its fluid parts are taken up into the lymph and blood; exerting a morbific influence, in a manner at present but little understood, upon these fluids, and thus gradually inducing a general cachexia. Moreover, the vessels which intersect the tumour become involved in the process of destruction, some indeed, becoming obliterated by it, whilst others are opened, and into the gaping mouths of such veins and lymphatics, not only the fluid but the solid particles of the softened mass enter, and proceeding further into them, excite phlebitis and inflammation of the lymphatics, with their consequences.

These evil effects of their increase and of their general morbific influence upon the collective organism are shared by the pseudoplasmata and by ichorous suppurations; the former, however, commonly possess them in a higher degree, being mostly deeper seated, and, therefore, retaining the ichor for a longer period, and moreover increasing with greater energy. These consequences may be obviated by the removal of the pseudoplasma by operation previous to its softening, and upon this rests the advantage to be derived from the employment of the knife in the malignant epigeneses. In order to be useful, such an operation must be radical, *i. e.* no part of the pseudoplasma should be left behind.

But the general malignancy of the pseudoplasmata is not confined to this; there commonly arise also on other spots of the body in the vicinity of the original pseudoplasma, or distant from it, simultaneously with the first or subsequently, other pseudoplasmata of the same kind. Upon what this depends we know not, and pathological anatomy has thrown no more light upon this point, than respecting the causes which give rise to pseudoplasmata generally.

That the pseudoplasmata are not produced by metamorphosis of the normal tissues, but that like all other pathological formations, they take their origin from an amorphous cytoblastema, is indubitable: observations which establish this will be adduced in our observations on the individual pseudoplasmata. It is no less indisputable that this cytoblastema is furnished from the vascular system, especially from the capillaries. It is possible that the cytoblastemata of the pseudoplasmata from their earliest stages differ from those of the other pathological epigeneses. I have had repeated opportunities of examining such cytoblastemata, but have never been able to detect any peculiarity in them. Our knowledge of the different modifications of the protein-compounds is, however, still very imperfect, and we possess no means of recognising mere microscopic quantities. This question must, therefore, for the present remain unanswered. Our knowledge is not more definite regarding the causes which lead to the formation of the pseudoplasmata. The present state of this subject may be thus briefly summed up: firstly, it may be assumed that the formative cause consists in a depraved condition of the fluids, *i. e.* certain elements of the blood become changed, or there occur in it new and peculiar substances which after their deposition in the parenchyma of organs, necessarily become converted into pseudoplasmata. According to this view, therefore, there already exists in the blood, previous to the formation of any pseudoplasma, a cancerous or tubercular matter whose deposition upon a definite spot may determine the localization of the disease, or its propagation to several organs may result from the first deposition not removing the whole of this matter from the blood. Through the continual production of this matter, and its deposition in various parts of the body, the disease becomes constitutional. Against such a view, which attempts to explain the disease solely on the principles of humeral pathology, there may be urged weighty objections. In the first place such specific morbid principles have not as yet been demonstrated; indeed, the failure of every attempt to trace them, renders their existence very improbable, and if, nevertheless, in modern times, certain physicians speak of such matters, (stating for instance, that tubercles consist of casein), this only shows the deficiency of their knowledge of organic chemistry. Moreover, it cannot be conceived why such a principle circulating in the blood throughout the system, becomes deposited only in certain spots, and does not, with the nutritive fluid, exude every where from the capillary vessels; and consequently, why pseudoplasmata do not arise simultaneously in every part of the body. We are, then, compelled to assume that certain parts of the body possess a peculiar attractive power for these principles, something similar, we must suppose, to that by which the parenchyma of the kidneys especially separates urea: for this separation cannot be ascribed to peculiarities of the vascular system, since pseudoplasmata may arise in nearly every part of the body. This could not be an original, innate, attractive force, because for the reason last mentioned, all parts of the body would then possess it, and thus the local occurrence of pseudoplasmata would remain unexplained. It must be first acquired by a change in the constituents of the body, which may be either direct or mediately transferred from the nervous centres. With this admission, however, the morbific cause becomes, partly at least, transferred from the province of humoral pathology to that of nervous pathology, or solidism.

A second view, which is closely allied to the first, seeks the cause of the pseudoplasma in a *contagium animatum:* for instance, it ascribes to the specific cells of cancer the power, like that of the spores of cryptogamic plants, of propagating the disease by the expulsion of new cells or by the genesis of such cells in their interior. Two distinct modifications of this view may be exhibited. According to one, all pseudoplasmata in every case spring from such a germ: according to the other, this is but *one* of the modes of propagation, and is especially adapted to explain the formation of new pseudoplasmata in an organism already infected. There are very weighty objections to both opinions, which I shall state at length in speaking of cancer, where this view can be supported with greater plausibility than for the other pseudoplasmata. It may in this place be provisionally remarked, that by the assumption of a contagium animatum, neither the origin of the pseudoplasmata, nor even their propagation in an organism already infected, is sufficiently explained. The other theories which have been advanced are still less tenable. I deem it, therefore, right that we should candidly avow our ignorance of any thing certain, respecting the general formative causes of the pseudoplasmata. In the consideration of the individual forms we shall frequently revert to this subject.

The malignant epigeneses are as little capable of precise classification as the non-malignant tumours. They may, however, according to the higher or lower degree of organisation which they attain before their disintegration, be reduced into certain groups, but these are still less strictly separable than in the case of the non-malignant formations; transitions between the individual forms are of common occurrence, and indeed, the same tumour not unfrequently shows totally dissimilar elements; the reduction of these formations into numerous species with a multiplicity of names is, therefore, quite unjustifiable. We discriminate, firstly, pseudoplasmata which are slightly or not at all organised; and secondly, such as attain a higher grade of organization. As representatives of the former class may be pointed out the depositions in typhus, and in scrophulous tumours; of the second, encephaloid and scirrhus. Many varieties of tubercle form a connecting link between these leading divisions.

In the classification of the pseudoplasmata there has hitherto prevailed and still, to some extent, prevails a very great confusion. In fact, there is scarcely a part of medicine where more obscurity and prejudice prevail than here. In the following pages I shall consider the pseudoplasmata mainly in a histological point of view: the question whether the commonly received distinctions between the morbid processes which generally accompany the different pseudoplasmata are positively established, does not properly belong to our subject; it will, however, be borne in mind, although we shall not permit it to carry us too far from our especial subject.

FIRST CLASS.

PSEUDOPLASMATA SLIGHTLY OR NOT AT ALL ORGANIZED.

The tumours belonging to this class are characterized by the circumstance, that during the whole process of their development, from their first appearance to their softening, they show a very low degree of organization. The mass forming them appears either entirely indeterminate and amorpho-granular, or it attains, in the most highly developed cases, to a very imperfect cellular structure: the product of their softening is an indeterminate granular detritus.

Morphologically, as well as pathologically, (that is to say in relation to the concomitant local morbid phenomena), these new formations are most closely allied to ulceration, from which indeed they cannot be strictly separated. In general, however, they do not remain local, but appear simultaneously on several parts of the body. But this propagation does not, as in the more highly organised pseudoplasmata, depend upon the conversion (in conformity with the law of analogous formation) of the nutritive fluid in their vicinity into a mass resembling them, but is rather due to the same cause which gave rise to the first pseudoplasma becoming repeated in its vicinity or in a distant part of the body. The cavities and ulcers produced by the softening of these depositions can, therefore, spontaneously heal with much greater facility, than those which ensue from the softening of the more highly organised pseudoplasmata.

From the second class—the more highly organised pseudoplasmata—they are histologically distinct, although even here transition forms are not wanting.

They appear absolutely non-vascular, and if vessels are found in them, these are not of recent development, but belong to the normal tissues, amongst which the epigenesis was deposited.

Their common termination is the softening of the deposited mass. The period which elapses between the deposition and softening is very different in individual cases; it may vary from a few days or weeks to several months. In general the softening extends to the enclosed normal tissues, and the united product opens for itself a passage, and is discharged externally. An ulcer is thus formed: this either spreads by continuance of the original process (new deposition with softening) in the surrounding parts, until it terminates in death; or the ulcer heals by cicatrization, whilst the loss of substance is repaired by permanently organised epigeneses.

In other cases the softened mass does not become discharged but is gradually resorbed, and the loss of substance is repaired by a similar cicatrization to that which occurs in the preceding case. Sometimes the reparation is interrupted by the deposition, instead of softening, becoming converted into an earthy or cretaceous mass, and thus forming a concretion.

The separate forms of these epigeneses have generally been distinguished less by histological and anatomical characters than according to the true or pretended peculiarities of the morbid processes with which they are usually associated. I shall follow this classification as it has the most special relation to practical medicine.

DEPOSITIONS IN TYPHUS.

In the majority of the cases of typhus, pathological epigeneses occur in different parts of the body, most frequently in the intestinal canal between the mucous membrane and the muscular coat, in Peyer's glands, (especially at the termination of the small intestines) and in the mesenteric glands: less frequently in the spleen and lungs, and in and under the mucous membrane of the trachea. These formations usually appear as a more or less firm lardaceous mass of a yellowish or whitish colour, which is deposited in greater or less abundance, amongst the normal tissues, gradually softens, and as the normal elements of the region become also involved in this process, forms ulcers which either heal by cicatrization, or continue until the death of the patient. In many cases death takes place before the commencement of softening. Of the phenomena which attend the softening and cicatrization in the different organs we shall treat in the special part: in this place our attention will be directed to the mass alone.

This must, in every case, be deposited in the fluid state, and subsequently assume the solid form by coagulation: otherwise it could not so completely fill up all the interstices of the tissues. Upon examination, however, it is invariably found coagulated: at least, I am acquainted with no instance where it has been observed still fluid.

Under the microscope the following constituents are recognized in the mass.

1. An amorphous, semi-transparent stroma.

2. Molecular granules from a size too minute to estimate, to the 800th of a line in diameter; sometimes interspersed with larger fat globules.

3. Larger corpuscles (imperfect cells and cytoblasts) from the 800th to the 300th of a line in diameter, rarely larger. Some of these enclose smaller corpuscles (elementary granules and nucleoli) which are wanting in others.*

By acetic acid the amorphous substance is rendered more transparent, and at length invisible; the granules as well as the cytoblasts and nucleoli remaining unchanged, whilst the cells become paler and gradually disappear. By alkalies, on the contrary, the entire mass is rendered diaphanous, and there remain visible only a greater or smaller number of granules: this reaction is produced more rapidly by potash, than by ammonia.

These three elements, in different cases, are present in very varying quantities, the amorphous matter seldom predomi-

* See Plate VI. fig. 12, 13, 14, 15.

nates; most commonly the granules are in excess, and in this case the mass has, in refracted light, a grayish brown appearance. The cells and cytoblasts are sometimes so thinly scattered that they are with difficulty perceived; in other cases they are more frequent, but it is very seldom that they are the predominating element. When softening takes place, the amorphous matter disappears; the granules, however, and the cells and cytoblasts appear suspended in a fluid, as in an emulsion. The softened mass frequently contains unsoftened particles of considerable size which, by the solution of the surrounding parts, become isolated, and are thus discharged as agglomerate masses.

The softening of typhous matter usually proceeds rapidly, following the deposition in the course of a week or only a few days; it is but seldom that several weeks intervene. The typhous matter cannot be histologically distinguished from the deposits which occur in scrofulosis and tuberculosis: distinctions may, indeed, be sometimes perceived between these different deposits but these are not greater than are observable between the varieties of typhous matter. Neither can it be distinguished with precision from many forms of inflammatory exudation in the early stages of development, nor from the product of many malignant suppurations, from exudations in gangrenous parts, and similar processes, whilst its differences from normal pus, and from the more highly organized pseudoplasmata are very obvious.

The question of the origin and signification of this typhous matter can be only partially answered by pathological anatomy. It appears to be ascertained that this matter is secreted in a fluid state from the capillary vessels. Moreover, the cause of this separation is, doubtless, a local hyperæmia of these vessels; as, indeed, in typhus may be readily proved by direct observation. The secreted matter is, therefore, a part of the blood which, shortly after its separation, coagulates. But we are acquainted with only one principle in the human body, which is capable of spontaneous coagulation, namely, fibrin. Of this, therefore, the typhous matter chiefly consists: it is, however, as in all similar cases pervaded by the other elements of the blood. The question here suggests itself: Is this fibrin normal or has it, whilst still in the blood, undergone a specific change? The possibility of such a change cannot be denied, since we know that fibrin is very transmutable: but the assumption of such a change without a demonstration of its nature by organic chemistry, is of no advantage in a scientific point of view. By such a hypothetical transmutation of the fibrin, we may endeavour to explain why the typhous exudation is not converted into normal pus, but breaks up without any distinct organization. This view, however, may be opposed by another equally plausible: it is very probable that in typhus the normal properties of the tissues are deprived of their ordinary energy, and that their formative power is impaired. In this diminished energy of the original tissues may, likewise, be sought the reason why the exudation does not become organized, but undergoes disintegration. Probably, however, neither the one nor the other view alone is correct, and doubtless there are a multiplicity of concurrent causes in action, whose manifold intricacies cannot be at present unravelled. With this brief view of the subject, I wish to express myself as opposed to the opinion, that there exists in the blood a specific typhous matter, with the deposition of which, in certain parts of the body, the disease localizes itself and terminates. At the same time the local importance of this deposit cannot be questioned. A great number of cases of typhus proceed to a fatal termination from the effects of these depositions, from ulceration, perforation of the intestine, &c.

With respect to the histological arrangement of typhous matter, it remains to be observed that foreign ingredients are frequently intermingled with it—as epithelial cells, chyle-corpuscles, &c., which must not be confounded with the histological elements of the matter itself.

SCROFULOUS DEPOSITS.

In scrofulosis, as in typhus, depositions occur in various parts of the body—most commonly in the lymphatic glands and their vicinity, but also in other glands, and other organs. In an anatomical and histological point of view, the scrofulous matter bears so great a resemblance to the typhous, that here we shall only notice their distinguishing characters.

The essential difference is, that here the whole proceeding is accomplished much more slowly—the deposit and the softening generally lasting as many weeks, or even months, as in the other case days.

The matter also exhibits in different cases great anatomical variations; it is sometimes dense and firm, so that thin sections can be made; sometimes it is lardaceous, sometimes soft and crumbling like new curds. It is likewise sometimes colourless and semi-transparent, sometimes whitish, sometimes of a yellow tint. Histologically, it is perfectly similar to typhous matter, and consists essentially of the same elements: it presents an amorphous stroma, molecular granules, and undefined cells and cytoblasts, varying in diameter from the 600th to the 300th of a line, occurring in very different proportions and mixed with fat-globules. The granules are partly protein-compounds, partly fat, and in part calcareous salts: the latter disappear with effervescence on the addition of nitric acid.

After its softening, the matter consists of the same indeterminate granular 'detritus' as the typhoid deposit. Softening and ulceration do not, however, always ensue: in many cases the above mentioned calcareous deposition becomes predominant, and the mass is converted into a concretion.

Scrofulous matter cannot be with certainty distinguished histologically from typhoid or tubercular matter. There occurs every intermediate grade between it and ordinary suppuration.

The statements formerly made respecting the mode of origin and the signification of typhous matter hold good equally here. Further observations concerning the conditions of the lymphatic glands infiltrated by scrofulous matter, follow in the special part. The reader will find a histological and chemical investigation of these tumours by Valentin in his 'Repertorium,' vol. II. p. 282.

TUBERCLE.*

Tubercles form the most frequent and therefore the most important of this class of deposits. They have especially

* The literature of tubercle is remarkably copious; in addition to the various works on pathological anatomy and pathology generally, we may mention; Laennec, de l'Auscultation médiate; Carswell's Pathological Anat. Tubercle. fasc. 1, 1833; Schröder van der Kolk, Observationes anat.-patholog. fasc. 1, 1826; Clark, on Consumption; Sebastian, de

attracted the attention of physicians, and for this reason merit an attentive consideration.

Originally the name 'tubercle' was a very general one; in accordance with its proper signification, it expressed all nodular tumours, and even at the commencement of the present century, Baillie applied the term to fibrous tumours of the uterus. At the present day, however, its meaning is much more limited, and by tubercles we now understand those pathological epigeneses which are engendered in consequence of a specific disease or morbid tendency—*tuberculosis*.

In establishing this definition, however, sufficient care has not been taken to point out, firstly, that all tumours which are regarded as effects of tuberculosis, invariably show the same anatomical and histological constitution, and can be distinguished with certainty from all other pathological epigeneses; secondly, that, on the other hand, the appearance and course of tumours which, from their anatomical structure, must be regarded as tubercles, are always attended

origine, incremento et exitu phthiseos pulmon. obs. anat. Groningæ, 1837; Louis, Recherches sur la phthisie, 2nd edition, Paris, 1843; or Walsh's translation, London, 1844; Boudet, recherches sur la guérison naturelle ou spontanée de la phthisie pulmonaire, Paris, 1843; Zehetmayer, über die Lungentuberculose, Zeitschrift der Gesellschaft der Aerzte in Wien, Jahrg. 1, No. II.; Engel, die Tuberculose, ditto, 1, 1844, No. V.

Further references are given in the special department. A very perfect view of the literature of the subject is given by Cerutti, Collectanea quædam de phthisi pulmon. tuberculosa, Lipsiæ, 1839, 4.

For information on the histology of tubercle we may especially refer to: Gerber, Handbuch der allgemeine Anatomie, 1840, p. 187, &c., or Gulliver's English edition, p. 305, &c.; Gluge, Untersuchungen, No. II., p. 182, &c.; Klencke, Untersuchungen und Erfahrungen, vol. II. p. 12, &c.; Lebert in Müller's Archiv. 1844, p. 190, and in his Physiologie pathologique, 1845, vol. I. p. 351, &c.; Günburg, die Pathologische Gewebelehre, 1845, vol. I. p. 100, &c.; Addison in the Transactions of the Provincial Medical and Surgical Association, vol. II. 1843, p. 287, &c.

with the morbid phenomena which are pointed out as characteristic of tuberculosis; and thirdly, that tuberculosis is positively always the *cause* and not merely the *effect* of local tubercles; on the contrary, it was conceived that enough had been done when this correspondence was rendered probable for only *one* organ—the lungs, where they certainly appear most frequently. It is, however, certain that physicians frequently regard tumours in the brain, under the peritoneum, and even in the lungs to be tubercles, when their histological structure shows that this is not the case; moreover, as was stated generally of the pseudoplasmata belonging to this class, true tubercular matter cannot be distinguished with certainty from other epigeneses, namely from the scrofulous and typhous, and from many other ulcerative processes. In a pathologico-anatomical view, therefore, the definition of tubercle is by no means strictly limited; whether or not this is the case with the morbid process which is named tuberculosis cannot in this place be investigated.*

I will now endeavour to consider the general relations of this pathological epigenesis: its peculiar relations in individual organs will be considered in the special part.

With respect to the origin of tubercle, there can be no doubt that its formative substance is secreted from the capillary vessels in a fluid form, in perfectly the same manner as was stated of typhoid matter. It afterwards fills up all the interstices of the tissues in a manner too perfect to be accomplished by any substance that was not originally fluid. Probably this secretion results from the same causes as that of fibrinous dropsy generally, and is preceded by a local hyperæmia of the participating capillaries. Whether or not this proceeding should be termed inflammation, is a question which will be subsequently considered. Pathological anatomy fails to demonstrate an especial cause for this secretion from

* See Engel, op. cit.

the blood into the parenchyma, in the formation of tubercle. Whether or not this secreted fluid contains other elements than in the normal state, and whether there exists ready formed in the blood a specific tubercular matter which, on this occasion, becomes separated, can be answered with as little certainty for this, as for the typhous and scrofulous depositions. Hitherto all attempts to demonstrate such a specific principle in the blood have failed: this speaks certainly against its existence, although we cannot deny that with our present means, we are unable to demonstrate every modification of the protein-compounds, and this would be the point to be considered.

This fluid condition of the tubercular matter cannot be directly observed. Some, indeed, assert that they have seen it, but the difficulties of satisfying ourselves of the presence of a specific cytoblastema of this kind, differing from the normal nutritive fluid are so great, that the correctness of such observations may reasonably be called in question. Whenever tubercles are observed in what may be presumed to be their earliest stages, they appear solid, form a more or less dense mass, and fill up all the interstices of the elementary tissues in which they are deposited. The tissues are usually neither displaced nor altered by the tubercular matter; on the contrary, they in general retain their normal position; they are, however, as closely and perfectly invested by it, as the stones of a wall by the solidified mortar which has been applied between them. We can most readily convince ourselves of this condition by treating fine sections of tubercular deposit from the lung with acetic acid or caustic ammonia. By means of these reagents the opaque tubercular matter is rendered transparent, and under the microscope, the enclosed portions of lung (the intersecting fibres) are perceived to be arranged amongst the tubercular matter just as in the normal state. This experiment, however, does not always succeed, for sometimes the tubercular matter contains numerous molecular granules which are not rendered transparent by these reagents; in this case the preparation, even after the above treatment, remains opaque or at least turbid.

On microscopical examination, tubercular matter is found to be composed of different elements, whose proportions are extremely various in separate cases, but which essentially correspond with the elements of the typhoid and scrofulous matters formerly described. There are:—

Firstly, a transparent, amorphous, vitreous stroma, occurring in large masses, which perfectly resembles coagulated fibrin and micro-chemically reacts like it: that is to say, acetic acid and alkalies render it pale, and finally cause its disappearance;*

Secondly, minute granules (molecular granules) varying from the 800th of a line in diameter to inappreciable minuteness, chiefly of a roundish form, and occurring in large masses of a brownish colour. These granules do not always exhibit the same chemical reactions; they seem, therefore, to be differently constituted. Some of them appear modified protein-compounds, such as we have formerly had occasion to notice: they are insoluble in acids and alkalies, and in ether, and are little or not at all attacked by other reagents. Others consist of fat, and dissolve in boiling ether. Amongst them we frequently notice larger fat-globules presenting the same chemical character. Finally, a third kind of these granules are calcareous salts (phosphate and carbonate of lime): they dissolve in acids with partial effervescence.†

Thirdly, imperfectly developed cells and cytoblasts, with or without nucleoli: the former are partly soluble in acetic acid; the latter are insoluble: both disappear on the addition of caustic ammonia or potash. The cells are generally very

* This substance does not admit of expressive delineation; it is intended to be shown in Plate VI. fig. 1. A. B.; fig. 2, A.; fig. 3, A.; fig. 5, B. a.

† These granules are most obvious in softened tubercles, being set free by the solution of the amorphous stroma enclosing them. See Plate VI. fig. 6.

imperfectly developed, and a distinct nucleus can seldom be recognized. Their size usually varies between the 400th and the 300th of a line, their diameter rarely attaining to the 200th of a line.* With these more or less fully developed cell-formations in tubercular matter, we must not confound other structures, presently (p. 283) to be described, which are frequently found in the vicinity of tubercle.

These three elements occur in individual cases in very different proportions. The amorphous stroma seldom predominates; the granules more frequently—sometimes, indeed, almost the entire mass of tubercle appearing to consist of them; of these, the protein-granules are generally predominant; the fatty granules are less frequently in excess; and there are cases in which the calcareous granules prevail. The cellular formations are sometimes entirely absent, so that it is often impossible to discover even traces of them in tubercular matter: in other cases almost the whole mass of the tubercle appears to consist of cells and cytoblasts. The degree of organization of the tubercle depends on the prevalence or deficiency of these cell-structures.

The naked eye is itself sufficient to reveal differences in different cases of tubercle. As the extremes of these differences, we may notice two which have been characterized as distinct varieties of tubercle. In one variety the tubercular matter is of a gray or whitish colour, semi-transparent and homogeneous: this has been named *gray infiltration.* In the second variety the matter is yellowish, opaque, dense, lardaceous or mellow, like some sorts of cheese (*yellow tubercular matter*). Between the two varieties, however, there is presented every gradation. These two varieties present histological differences; in the former we have an amorphous mass and cellular structures; in the second, the granular elements prevail. The absence of these granules is a suffi-

* See Plate VI. fig. 1; fig. 3, a, b; fig. 4, a; fig. 5, a.

cient explanation of the greater transparency, the grayish white colour, and smooth section of the former; while their occurrence accounts for the opacity, yellow colour, and irregular, granular section of the second variety. These varieties of tubercular matter have been regarded as the same substance in different stages of development, and in many cases this view is undoubtedly well-founded; thus gray tubercle in the process of its development, as it approaches to softening, usually assumes a granular appearance, and may be converted into the yellow variety. But on the other hand we also meet with tubercles of the yellow variety in apparently the very earliest stages of development. Hence there can be no doubt that this variety can exist primarily, since, from the very commencement, granules are separated from this tubercular mass as from gray tubercle.

Further changes of tubercular matter: softening. Of the above constituents of tubercular matter, the amorphous substance is present from the commencement, as soon as the tubercle becomes firm: it is, without doubt, the product of the coagulation of fibrin; moreover, the greater part of the granules are frequently present from the first. The imperfect cells and the cytoblasts make their appearance gradually; their development is the only trace of the process of organization of which tubercle is capable. Other organized structures such as we have learned to recognize as products of formative activity, and such as occur in the more highly organized pseudoplasmata, are here absent. In tubercle there are formed neither fibres nor vessels, and in fact, even the normal vessels of the part in which the deposition occurs, become compressed, emptied, and impervious; none but a few of the larger vessels with thick walls remaining uninjured. Hence, if, in examining tubercle, vessels capable of being injected are found in it, they must not be regarded as epigeneses, but merely as the remains of the original vessels.

The ordinary course of tubercular matter is to soften, and this occurs in the following manner. In the first place the amorphous stroma liquefies; the elementary granules then separate and the cells and cytoblasts become liberated, in part break up, and form a sort of emulsion either with a pre-existing or a newly secreted fluid. In this process of softening most of the tissues, between which the tubercular matter has been deposited, take a share; they also break up, the more delicate first, the firmer resisting the destructive action for a longer period, and the product of their disintegration mixes with the softened tubercle, presenting the appearance of a thick, quasi-purulent fluid, which therefore forms an organic detritus saturated with fluid (serum), and under the microscope exhibiting very indefinite characters. It appears as an aggregation of elementary granules with cytoblasts and cells in various states of preservation.* Sometimes crystals of cholesterin or of ammoniaco-magnesian phosphate, or certain organized structures originating from the textures surrounding the tubercle are present. In the fluid of the softened tubercle we usually find a viscid (pyin-like) substance which coagulates on the addition of acetic acid. The softened mass usually exhibits a tendency to external rejection, in this point of view resembling the pus of an abscess. In some few cases it becomes gradually resorbed, disappears, and the cavity formed by the destruction of the tissues is filled by the formation of a cicatrix, or else a portion of the tubercular matter remains as a compact and sometimes even as a quasi-cartilaginous mass, or undergoes a species of fatty degeneration.

In other cases the development of the tubercular matter proceeds in a different manner. A copious deposition of calcareous granules occurs in the tubercular matter, and continues to increase, while the other constituents are removed by resorption. In this manner tubercle becomes converted into a white pulverulent, or chalky mass, or else into a dense stony substance. This modification of tubercle is usually surrounded by

* See Plate VI. fig. 6.

a kind of cicatrix formed of thickened fibrous tissue, and may remain for years in the organism without undergoing further change, or becoming incrusted on its surface. We shall return to this subject in our remarks on concretions.

Its relation to the surrounding parts. — Tubercular deposits form either nodules of very varying size, or are continuously distributed through a whole organ, or its greater part. We consequently make a distinction between *tubercular nodules* and *tubercular infiltration;* when the former are very minute, not exceeding a millet-seed in size, but yet visible to the naked eye, we name them miliary tubercles. These two forms of tubercular deposit are not separated by any definite limit; there are, however, the following distinctions whose establishment frequently varies in accordance with the subjective opinion of the observer. Neither form of deposit has got a well-defined limit, each usually extending almost imperceptibly into the surrounding healthy tissues, unless in certain cases arrested by some peculiar anatomical arrangement, as in the case of glands. Sometimes, however, a secondary limitation of tubercular deposition is brought about by other pathological epigeneses appearing in the surrounding parts; this may arise either from the influence of the surrounding tissues on its metamorphosis, being stronger at the margin where the amount of deposit is small, than in the centre, and, in this way, other products being formed at the periphery of the mass; or from the deposited tubercle exciting irritation in the surrounding parts, and thus giving rise to a cytoblastema distinct from that of tubercle, and becoming converted into pus and granular cells. Hence at the margin we frequently find histological elements distinct from those in the centre of tubercle—namely pus-corpuscles and granular cells; we may also expect to see epithelial cells, and other elements of the original normal tissues, which on making a microscopic examination, must not be confounded with the elements of tubercle. After the process of softening these elements mix with the liquefied tubercular mass, and thus increase the number of the constituents of the detritus deposited by it.

Whether the cytoblastema of these peripheral formations is identical with, or distinct from that of the tubercular matter itself, this much is certain, that the latter can exert no great influence on it, and that its generative power is very small. This is an essential difference between tubercular matter and the more highly organized pseudo-plasmata. We shall see that they possess this capacity in a high degree, and that the cytoblastema separated in their neighbourhood, is excited to analogous development; while in tubercles this is not the case, or at most only occurs occasionally to a slight degree. The extension of the tubercular deposit is dependant only on the unknown cause which, in the first instance gave rise to it (the tuberculous diathesis).

For this reason tubercles frequently heal without any artificial aid, when this tendency, and, at the same time, the occurrence of the deposition terminate. The cure is effected, either by the cavity becoming filled by the formation of a cicatrix, by its being invested by newly formed membrane (mucous membrane with epithelium), by the tubercular mass becoming resorbed, or finally by its becoming converted into a concretion by the deposition of calcareous salts. The details of these processes are different in the various organs, and we shall enter with more minuteness into the subject in the special part, in the chapter on the morbid anatomy of the lungs.

This deposition occurs most frequently in the lungs and the lymphatic glands, but likewise in the kidneys, liver, spleen, mucous membranes, external skin, bones, and almost every part of the body.

The period intervening between deposition and softening, varies extremely in different cases; in some it does not exceed a week or two, whilst it may extend to many months.

The diagnosis of tubercle is sufficiently explained by the preceding observations. To determine the presence of tubercle with accuracy, the microscope is generally requisite, and with the aid of that instrument, it may be distinguished with certainty from most other pathological epigeneses It is difficult, indeed frequently, quite impossible to distinguish it from typhous and scrofulous matter, and from certain forms of unhealthy suppuration. In the softened condition, it is much more difficult to recognize than in the unsoftened state, since, as we have already mentioned, other elements are then mixed with it.

Respecting the chemical composition of tubercle, nothing is at present definitely known.

Such statements as those of Preuss,* in which he asserts that tubercle consists in part of casein, are founded on investigations which do not at all correspond with the present state of our chemical knowledge, and any one expressing his belief at the present time, that tubercles consist of casein, would show that his ideas of zoo-chemistry were extremely lax and unsatisfactory. At present all that we can say is, that tubercular matter consists principally of a protein-compound, as has been shown by Lehmann,† and has been repeatedly confirmed by myself. There can, however, be no doubt that during the progress of softening, the tubercles undergo chemical changes; Lehmann has shown that during this process the phosphorus and sulphur in the protein-compounds diminish, and that ultimately they altogether disappear. Scherer‡ has submitted to ultimate analysis the tubercular matter from various organs. The very interesting results which he has obtained, appear to show that tubercle in different cases, presents a different composition, and is not always identical with protein. We must, however, be cautious in drawing general conclusions from such isolated analyses, valuable though they be, for as it is hardly possible to obtain tubercle perfectly free from enclosed tissue, or other foreign admixtures, elemen-

* Tuberculorum pulmonis crudorum anal. chemica, Berol. 1835.

† Physiologische Chemie, vol. I. p. 197.

‡ Untersuchungen zur Pathologie, p. 212, &c., or Simon's Animal Chemistry, vol. II. p. 478, &c.

tary analyses do not in this case give such certain results, as in cases where the substance to be analysed can be exhibited in a state of chemical purity. In addition to the protein-compounds, there naturally also exist fat, extractive matters, a substance resembling pyin, and various salts, as constituents of tubercle. When the tubercles become converted into concretions, the calcareous salts predominate over the organic constituents; thus in cretaceous tubercles of this nature, Thenard found only 3% of organic matter, and 96% of salts. Lebert's* opinion that cretaceous tubercles consist chiefly of chloride of sodium, and sulphate of soda, and that the salts of lime are present only to a small amount is incorrect. The analysis of Boudet on which he founds his opinion, does not bear on the question, for a tubercle containing in 1000 parts only 0.697 of inorganic matter is not calcareous, and other analyses of tubercles actually calcareous, show that the salts of lime occur to a very large amount. Most calcareous tubercles, although only slightly soluble in water, dissolve almost entirely on the addition of an acid. There is, moreover, a chemical impossibility in Lebert's opinion: salts which dissolve as readily in all the fluids of the body as these soda-salts, cannot exist in the body in a solid form, and produce concretions which remain exposed to the action of those fluids for months and even years: they would dissolve and be carried away in a few hours, or at any rate in a day or two. The preceding view of the structure of tubercle is based on hundreds of original observations made during a series of years, and coincides in all its principal points with the statements of most unbiassed observers, as for instance, with the valuable Memoir of Lebert in Müller's Archiv, which unquestionably contains the best histological account of tubercle yet published. We shall only notice a few of the numerous opinions that have been promulgated on this subject. Gerber† whose opinion on the formation of tubercle in general corresponds with mine, draws a distinction between *albuminous* and *fibrinous tubercle*, regarding the former as unorganized, the latter as organizable. A distinction of this nature is certainly possible theoretically, but can be of no practical value, since the capability that tubercles possesss for organization is very small, and no definite limit can be drawn between those that possess it to a greater or lesser degree. This bears on the long controverted point, whether tubercle is or is not organizable: it is unnecessary, however, to say any thing further on this point. But that unorganizable tubercle consists of albumen, and organized tubercle of fibrin is a hypothesis whose admissibility I might be inclined to question. Gerber further distinguishes the organizable fibrinous tubercles,

* Müller's Archiv. 1844, p. 289.

† General Anatomy of Man and the Mammalia, English edition, p 305.

according to the degree of their organization, into *hyaline tubercle, cytoblast tubercle, cell tubercle, cellulo-fibrous tubercle,* and *filamentous tubercle.* These distinctions are not altogether unfounded, but they have relation to the deposition rather as it occurs in the domestic animals than in man. Addison* regards tubercles as a deposition and accumulation of abnormal epithelial cells, and the evil consequences of this deposition in the lungs and other internal organs are dependant according to him, on the epithelial cells not being removed (as occurs on normal free surfaces,) but remaining and exerting an injurious effect on the surrounding parts. These abnormal epithelial cells consist, according to Addison, of colourless blood-corpuscles which stagnate in the pulmonary capillaries, and afterwards become converted into these cells. Addison regards many tissues, for instance, epithelial cells and pus-corpuscles, as formed from the colourless blood-corpuscles. Here then there is an elementary view of the structure of morbid tissues differing essentially from mine. As, however, it is shown in numerous parts of this work, that these structures are formed from an amorphous cytoblastema, a special refutation of Addison's views appears unnecessary. A few other points belonging to this subject may be elucidated by a statement of the views which have been laid down by J. Engel, in his very interesting essay on tuberculosis.† Engel distinguishes between interstitial tubercle (miliary tubercle) and infiltrated tubercle. The former is the result of a peculiar condition of the blood, closely approximating to its state in typhus; the latter is in all cases an inflammatory product. The conversion of the inflammatory exudation into tubercular matter, and not into other structures, depends, according to Engel, on various conditions:—in the first place on the exudation itself, under which head we may consider: *a.* Too large a quantity of the coagulated fibrinous exudation, by which the complete infiltration of the whole mass with moisture is prevented. *b.* Deficiency of the fluid of organization generally, and, in this way, too great a dryness of the exudation. *c.* Foreign admixtures, namely blood-corpuscles. *d.* Preexisting tubercular matter, acting in accordance with the law of analogous formation already laid down. A second series of conditions depends on the part affected, and the whole organism. Under this head we may arrange: *a.* The activity of the metamorphosis of tissue—in proportion to the inertness of the metamorphosis, is the tendency to the formation of tubercle. *b.* And what is essentially the same thing, contiguity with vascular organs—the greater this is, so much the less is the tendency to tuberculization; and *c,* The condition of the vital powers—in proportion

* Transactions of the Provincial Medical and Surgical Association. vol. II. p. 287, &c.

† Zeitschrift d. Gesellsch. d. Aerzte in Wien, Jahrg. 1, p. 353.

to their weakness, the facility for tubercular deposition is increased. There is a third series of exoteric conditions, amongst which we must mention pressure, and very likely cold.

Engel likewise attempts to elucidate the further changes of tubercle and their consequences. As soon as the tubercular deposit has assumed the solid condition, it begins to act on the tissues, and to destroy them. It afterwards softens, and this softening is, according to Engel, a kind of putrefactive process depending on a chemical alteration in the exuded fibrin. Sometimes, however, this softening does not proceed from a primary decomposition of the tubercular matter itself, but is induced by exoteric influences, as for instance, by imbibition of the deposit with water from adjacent œdematous parts, or by inflammatory products deposited in the vicinity of the tubercle. The softened tubercular matter reacts on the blood, in which it (or at least the fluid portion taken up by resorption) may induce modifications. The softened tubercular matter may also be converted into an ichorous fluid, if there is a sufficient quantity of it, (for minute depositions do not undergo this change), if there is a due amount of moisture, if it is far removed from highly vascular organs and there is consequently little metamorphosis of tissue, if the vital powers of the organism are depressed, if it is in contact with extraneous matter, as atmospheric air, fragments of food, bile, fæces, urine, &c., and finally, if there is an undue excess of warmth. Other changes may accompany, or may occur in place of the above alteration; thus a portion may liquefy and be resorbed; the conditions for this change are, that there shall not be too large a mass of exudation, that it shall be in a position to be freely infiltrated with fluid, and that the age of the patient shall be advanced. When the amount of water contained in tubercle is reduced by absorption to a minimum, the tubercular matter shrinks and becomes indurated. The conditions for this change are a densely compressed mass of exudation, and generally speaking, advanced age. In all essential points, this is the same as what is meant by the tubercles becoming *obsolete*. These changes relate to the still unsoftened tubercle. The changes occurring after softening are: *a*, *cicatrization*, the conditions of which are that there must not be too great a destruction of tissue, that there should be a healthy condition of the surrounding parts and no induration, and that the age of the patient be not very far advanced. *b*. Entire or partial *resorption*, which occurs the more readily in proportion as the deposit is small, and the surrounding parenchyma healthy. *c*. The admixture of the softened tubercle with *pus*, &c.; and *d*, the conversion of tubercle into *atheroma* or *calcareous concretions*. All these terminations of tubercle are usually associated with the curative process. In order, however, that a perfect cure may ensue, it is necessary, that the fresh formation of tubercular matter should cease, and on this point, Engel gives it as his opinion, that in a certain condition of the blood, these depositions do not occur. I have entered thus fully into Engel's views, because I regard his attempt to explain the formation of tubercle as very important and praiseworthy.

In the leading points I agree with Engel, and if there is much in his Essay that is not very strictly defined, as for instance, the term "inflammation," which without further explanation, he puts down as the cause of infiltrated tubercle, and if also his views regarding the peculiar condition of the blood are not based, as they ought to be, on accurate chemical analysis, still he appears to have adopted the only true mode by which we can hope to arrive at accurate conclusions regarding the nature of tuberculosis and similar processes. The formation of tubercle by a *contagium animatum*—by semi-individual cells as Klencke* supposes—appears to me perfectly untenable, and I do not consider that we have sufficient evidence of the accuracy of his inoculation-experiments. Moreover, how can tubercles, not consisting of cells, propagate in this way? I shall, in a subsequent page, return to the consideration of this point. Another opinion has also been put forward, namely, that tubercles consist of hydatids; this is based on the observation that occasionally quasi-tubercular deposits are found in encysted tumours (as we have already seen), and in hydatids and the cysts of certain entozoa (as will be shown in a future page). These facts show, at all events, that from the above-mentioned structures a quasi-tubercular mass can be produced, but they do not conversely show that tubercles must always arise from these structures.

Respecting the causes of softening I entirely agree with Engel in thinking that they may be referred partly to influences residing within the tubercular mass, and partly to external influences, as extreme moisture, suppuration of the surrounding tissues, &c. The investigation of the conditions in individual cases, which alone can be serviceable to practical medicine, must remain to be undertaken by our successors.

SECOND CLASS.

EPIGENESES OF A MORE HIGHLY ORGANIZED CHARACTER.†

The forms of tumour belonging to this class are extremely

* Untersuchungen und Erfahrungen, vol. I. p. 121.

† The literature of this class of tumours is very abundant. We may especially notice the chapters devoted to the subject in the treatises of J. F. Meckel, Andral, and Lobstein, on Pathological Anatomy. Their appearances as presented to the naked eye, are to be seen in Carswell's

various, and exhibit in their anatomical and histological relations, in their progress, and in their duration, very great differences; and hence we find that many members of this group have received distinct names. But in these tumours it is just as impossible as in the non-malignant, to have genera and species such as we have in descriptive zoology and botany. Such a fine distinction and separation of species, based on unimportant points, would from the very first lead to each individual tumour being regarded as a distinct species, and we should thus have millions of names. I shall, therefore, endeavour to group and consider these forms in accordance with their essential common points, and shall only describe the most prominent ones as peculiar varieties. As familiar illustrations of this class we may notice the terms, *cancer* and *carcinoma*, which in the following pages must always be regarded as synonymous.

Carcinomatous structures are distinguished from the preceding class—the slightly organized epigeneses—by a higher degree of organization; they not only show a more highly developed cellular structure, but frequently also fibres, vessels, and granulations enter into their composition. They are not, however, strictly limited from the former class, for although the tumour as a whole can be easily distinguished from one of the former class, it frequently contains particular portions which cannot be distinguished with certainty from tubercular deposition. Neither is there any strict limit between these and certain forms of non-malignant tumour, namely fibrous

Pathological Anatomy, Carcinoma, fasc. 2, 3; and Cruveilhier's Anatomie pathologique. For the microscopical appearances we may especially refer to J. Müller über den feineren Bau der krankhaften Geschwülste, or West's translation; A. Hannover, Svar paa Sporgsmaalet, Hvad er Cancer? Kjobenhavn, 1843; Gluge's Atlas der patholog. Anatomie, Parts 1 and 4, and his Anatomisch-mikroskop. Untersuchungen, Parts 1 and 2; and Klencke's Untersuchungen und Erfahrungen, vol. II.

tumour, and cases frequently occur in which it cannot with certainty be determined whether a tumour belongs to the carcinomatous or fibrous group, that is to say, whether it be malignant or non-malignant. The malignancy depends here, as in the former class, on softening and a disintegration of the elements, commencing with the cellular structures, but gradually proceeding to the fibrous parts and the elementary tissues of the affected organ.

The anatomical and histological relations of carcinomatous tumour exhibit the greatest variety; indeed, even in the same tumour, different parts often present very different characters. Their characters further vary with their stage of development. These tumours are sometimes soft, resembling cerebral substance; sometimes firm, like lard; and sometimes hard, like cartilage; sometimes they are highly vascular, and of a reddish tint; sometimes pale; sometimes they are distinctly separated from the adjacent parts, whilst in other cases there is no line of demarcation between them and the surrounding tissues. Hence in a general consideration of the subject, these relations are of no value.

Moreover the histological elements of individual carcinomatous tumours are very different, and arranged in various ways. I shall therefore notice them separately. In carcinomatous tumours there occur:

1. A firm, dense, amorphous substance, bearing a close resemblance to, and probably identical with coagulated fibrin. It is rendered transparent by acetic acid, and by ammonia and other caustic alkalies, and sometimes incloses molecular granules consisting of modified protein or fat. This substance is doubtless to be regarded as the solid cytoblastema of cancer, and is subsequently converted into cells or fibres, which may sometimes be very clearly detected.* It is characteristic of a definite stage of the development of cancer, and is conse-

* See Plate VIII. fig. 9, A, B.

quently often entirely absent in perfectly developed specimens. Indeed, it appears that in some cases, cancer arises only from a fluid cytoblastema, so that during its whole course this substance does not present itself. In rare cases it occurs as the preponderating constituent; and then the nature of the cancer can only be recognized in more highly developed portions of the tumour; or, indeed, the diagnosis may be altogether impossible. This firm amorphous substance is in itself not characteristic of cancer; in fact it closely resembles and appears to be identical with the ordinary solid cytoblastema of all other epigeneses, namely coagulated fibrin.

2. Molecular granules which appear to consist partly of a modified protein-compound, and partly of fat, and which we have already had occasion to notice as constituents of morbid epigeneses, occur also in cancer,* and along with them we frequently meet with large fat-globules and fatty granules.† Elementary granules consisting of calcareous salts appear but rarely in cancer. These molecular granules are sometimes entirely absent; in other cases, namely in softened parts, they are very numerous, and sometimes unite into large masses, forming aggregate corpuscles. These structures are, however, not characteristic of cancer.

3. Cellular structures form a very important class of elements, which are never absent in perfectly developed forms of cancer. They sometimes predominate to such an extent, as to form nearly the whole tumour, as in cases of encephaloid, but are only of secondary importance in hard cancer (scirrhus). The cellular structures occurring in cancer are of two kinds: *a.* Such as during its whole process of development can never exceed the cellular form. These cells—transitory cells according to our scheme in p. 125—are the *characteristic cancer-cells.* *b.* Such as are capable of development into

* See Plate vi. fig. 8, 11; Plate viii. fig. 1, 4, 6.

† See Plate viii. fig. 4, b.

other structures, namely into fibres, and therefore only to be regarded as cells in a transition state — developmental or fibre-cells.

A. The characteristic cancer-cells present extreme variations, from the simple cytoblast through every modification of which a simple cell is capable, up to highly developed cellular forms—varieties which in every case depend for the most part on the degree of development of the primary cells, and are sometimes transitory, and sometimes persistent stages of development. The primary forms of these cells present no peculiarity. The nuclei vary from the 450th to the 250th of a line in diameter, are insoluble in acetic acid, and often contain nucleoli;* the cells are nucleated and round, or oval, vary from the 300th to the 100th of a line in diameter,† entirely dissolve on the addition of the caustic alkalies, and disappear, with the exception of their nuclei, on the addition of acetic acid.

Still more characteristic of carcinomatous tumours are the cellular forms, which frequently, but not invariably are associated with the above primary forms, and only rarely occur independently of them. To this class belong:

α. Peculiarly formed, caudate, ramifying cells.‡

β. Cells containing a large number of nuclei (from two to twenty or thirty) or enclosing in their interior perfect young cells.‖ They are usually of considerable size, varying from the 100th to the 30th, or even 20th of a line in diameter.

γ. Cells with a very thick wall, exhibiting a double contour.§

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* See Plate VI. fig. 8 b, 9 b; Plate VIII. 1 d, 4 D, 6 D, 8 A.

† See Plate VI. fig. 7, 9, 11; Plate VIII. fig. 1 a, 4 D, 6 A, a, b, 8 b.

‡ See Plate I. fig. 11; Plate VI. fig. 7, 8 a.

‖ See Plate I. fig. 5, 6, 7; Plate VI. fig. 7, 8.

§ See Plate I. fig. 2 A; Plate VIII. fig. 6 B, 9 B.

δ. Double cells formed either by the division of one, or the fusion of two cells.

ε. Cells filled with granules (granular cells) and others in which granules appear to be scattered over the surface.*

In some forms of cancer there also occur:

ζ. Cells of various forms and sizes inclosing dark (generally black) granular pigment (pigment-cells).†

Between these different forms of cells, there occur innumerable transitions, and they are all doubtless to be regarded as primary cells in different stages of development. Some of these forms occur principally in certain varieties of cancer, of which they may be deemed characteristic, as we shall presently see. Hence it follows, that of all the above forms, there is none that can be deemed as solely pertaining to cancer; in fact that there is no such thing as a distinctive cancer-cell; and consequently that from observing a single cell under the microscope, it is impossible to decide with certainty whether it is cancerous or not. On examining a mass of these cells we can often decide with certainty on their being cancer-cells, from the varieties which they present, and from the occurrence of the above forms.

B. The transitory cells occurring in cancer are chiefly fibre-cells, that is to say, they are fusiform cells prolonged in the same axis in both directions, such as occur in the development of areolar tissue, and of simple muscular fibre.‡ They occur for the most part in the firm, rarely in the soft forms of cancer.

In the numerous forms of cancer which I have examined, I have always found these fibre-cells playing only a secondary part, and Hannover's experience coincides with mine. J. Müller appears to have found them as the sole, or at all events as the predominating ingredient

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* See Plate VI. fig. 11; Plate VIII. fig. 6.

† These cells are precisely similar to the pigment-cells from a melanotic lung, depicted in Plate IX. fig. 7.

‡ See Plate VI. fig. 9; Plate VIII. fig. 7 c, fig. 9 c.

in many cancerous tumours.* I think, however, that the cases in which they predominate belong more to non-malignant (fibrous) tumours than to actual cancer.

4. Fibres of various kinds form a further histological element of cancerous tumours. Some are perfectly identical with those of fibrous tumours; these either resemble the fibres of areolar tissue, are very delicate, and vary in diameter from the 2000th to the 800th of a line, or else they resemble the fibres of simple, non-striated muscular fibre, being thicker than the former, and varying in diameter from the 800th to the 300th of a line. Sometimes both these kinds of fibres are seen perfectly developed; in other cases the formation of the fibres is less distinct, the whole mass having an almost amorphous appearance, as if the fibres were blended into one another—just as we have already seen in the amorphous variety of fibrous tumour. As in the case of fibrous tumour, the fibres arise sometimes from undoubted cells, and sometimes from an amorphous cytoblastema independently of any regular cell-formation. These kinds of fibres may be distinguished by their becoming pale on the addition of acetic acid, and frequently entirely disappearing, at least nothing but elongated oval nuclei remaining in their place.†

The second kind of fibres occurring in cancer are identical with Henle's nucleated fibres,‡ and with the fibres of elastic tissue. They frequently present a ramifying, sometimes a dichotomic arrangement, and are chiefly to be distinguished from the preceding group by their behaviour with acetic acid—instead of disappearing, their outline becomes more clear and distinct.

In some forms of cancer, as for instance, in encephaloid,

* Ueber den feineren Bau, &c., p. 21, Plate II. fig. 11; or West's translation, p. 64, Plate IV. fig. 11.

† These fibres are shown in Plate VIII. fig. 2, 3, 5, 7.

‡ Allgemeine Anatomie, p. 194.

these fibrous structures are altogether absent; in other forms as for instance, scirrhus or fibrous cancer, they predominate. By the predominance of these fibrous structures, of which the former is by far the more common, cancerous tumours connect themselves with the formerly described fibrous tumours, and indeed it is sometimes impossible to distinguish whether a cancerous or a fibrous tumour had first existed.

The arrangement of these fibres and their relations to the cells is also extremely variable. Sometimes the cells and fibres are so arranged, that on making a microscopic examination, some parts are found to consist only of fibres, and others only of cells. Usually the fibres form the groundwork or stroma in whose interstices the cells are deposited. Sometimes the fibres assume a radiating arrangement, proceeding from the centre to the periphery of the tumour, as for instance, in cancer of the liver.* In other cases a tissue with roundish meshes is formed, in which the cellular masses are deposited†—an arrangement very similar to that of the elastic tissue in the healthy human lung. In certain forms of cancer we observe the fibres and cells in very peculiar relations to each other; the fibres form roundish capsules, of which the interior is filled with cells‡—a formation similar to that which occurs in certain ganglia, where also cells (ganglionic corpuscles) are found enclosed in capsules composed of fibres. These fibrous capsules are sometimes isolated,‖ and are sometimes connected by fibres issuing from them with similar tissue in their vicinity.

The formation of these singular capsules appears to proceed in the following manner: in the first place, there is formed a cell with a thick cell-wall, exhibiting a double contour.§ In this, as in a parent cell,

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* See Carswell's Pathological Anatomy, Carcinoma, fasc. 2, Pl. IV. fig. 1.

† See Plate VIII. fig. 10.

‡ See Plate VIII. fig. 3 A, B.

‖ See Plate VIII. fig. 3 B.

§ See Plate VIII. fig. 9 B.

there is a new cell-formation, while the thick cell-wall assumes a fibrous character. This peculiar metamorphosis of a cell is analogous to nothing hitherto observed; I have, however, so frequently made the observations leading to this view of the case, that I regard it as beyond a doubt.

This structure is chiefly formed of the fibres soluble in acetic acid; those which are insoluble in that re-agent—the elastic fibres—occur much more rarely in cancer, and never in large masses. They appear also regularly arranged in a reticulated form, and cross-barred, or else in irregular meshes.

5. Blood-vessels also form an element (although not an essential one) of cancerous tumours. In some forms they are altogether absent, in others they are present, but appear to belong to the normal tissue, within which the cancerous matter has been deposited; as for instance, in the soft forms of cancer, where the newly formed cancerous matter is not sufficiently firm to compress the vessels of the tissues infiltrated by it. Some forms of cancer, on the other hand, undoubtedly contain new vessels which appear for the most part between the fibrous elements; rarely, if ever, between the cells. In open cancer (cancerous sores) granulations are formed which are remarkably vascular; of these, however, we shall speak presently. The cases of cancer which are furnished with very numerous new vessels, form a distinct variety to which the name *Fungus hæmatodes* has been given; but many cases which have been described by different authors as fungus hæmatodes, do not in reality belong to cancer.

In cancer as in other forms of tumour, it often becomes a disputed point, whether or not there are blood-vessels present. It appears to me that the whole question of dispute is made clear by the preceding observations, and indeed, after all, it is a point of no great importance. Some, after injections, have found only arteries, and no veins; we may understand this, if we remember how much more easily the veins may be compressed and obliterated by the pressure of the cancerous matter, and likewise how much more easily they may become filled with it, than the arteries. Whether lymphatics and nerves occur in cancer is doubtful; if they are present, they are undoubtedly not newly formed, but belong to the parent tissue.

6. Another element which enters into the composition of cancerous tumours—which indeed, is seldom altogether absent, and often occurs in very large quantity—is a viscid fluid perfectly analogous to the essential constituent of the gelatinous tumours described in p. 236. This viscid fluid is characterised by the presence of a substance resembling mucin or pyin, which on the addition of acetic acid, sulphate of iron, or infusion of galls, coagulates into a colourless, streaky, amorphous mass, as may be observed under the microscope; a similar but less marked effect is produced by alum, alcohol, and corrosive sublimate. The ultimate composition of this substance, its mode of origin, and its uses are unknown.

The above elements are the essential constituents of cancer. In the process of softening they undergo changes which in all essential points are identical with those observed in the softening of tubercle. Of these we shall speak presently. According as one or other of these elements predominates, and according to the various modes in which they are associated and arranged, we have the different forms and varieties of cancer, which, however, cannot be strictly separated from one another, but exhibit every possible transition-stage. The most important of these forms will be presently noticed.

In addition to the above elements, we sometimes meet with others which, however, do not belong to the cancer itself, but to the parent-tissue in which it was deposited; as for instance, striated muscular fibre, fatty tissue, glands, &c. As many of the above mentioned elements of cancer occur also as normal constituents of the body—as areolar tissue, simple muscular fibre, elastic tissue, and vessels—it is not always easy to distinguish whether such elements, when they occur in a cancerous tumour are newly formed or belong to the parent-tissue.

Causes, formation, development, distribution, further course, and consequences of cancer.

Pathological anatomy has not yet succeeded in throwing any very great light on the causes giving rise to the formation of carcinomatous tumours. It is probable that here, as in the formation of other morbid epigeneses, a whole series of causes are in simultaneous action, and mutually checking one another; these causes lying partly in the property of the cytoblastema, and partly in that of the organ or of the whole organism in which the cancer becomes developed.

The cytoblastema of cancer, as of all other morbid epigeneses, arises doubtless from the blood, is originally fluid, and identical with the liquor sanguinis. Sometimes an increased quantity of blood-plasma is separated in consequence of a local capillary hyperæmia,* arising from some mechanical cause—as compression, a blow, &c. In other cases, namely when the formation of the cancer is very gradual and imperceptible, no signs of local hyperæmia can be detected, and it is possible that then the ordinary nutrient fluid (not increased in quantity, and either changed or unchanged) may by local influences be converted into cancer. In some cases the cytoblastema appears to remain fluid, and in this fluid condition to undergo development; in other cases it coagulates before the commencement of development, and the cancerous matter is formed, either wholly or in part, from a solid cytoblastema.†

The circumstance of the coagulation shows that the cytoblastema consists, in a great measure, of fibrin. The solidification of the cytoblastema yields one of the histological elements of cancer, namely the solid amorphous substance. But since there is nothing characteristic in this mass—for, indeed, it is perfectly identical with the coagulated exudation of fibrinous dropsy—it is impossible from it alone,

* As in the case illustrative of Plate VIII. fig. 9; and I have met with many similar cases.

† See Plate VIII. fig. 9.

to diagnose the presence of cancer; indeed, this is only possible when other parts of the tumour are in a more advanced stage of development.

Moreover, the molecular granules described as a second constituent of cancer, are formed (in part, at least) at a very early period, and probably in a fluid as well as in a solid cytoblastema. Their formation is undoubtedly dependant on some (still unknown) chemical peculiarity of the cytoblastema, as on its containing a superabundance of fat, or some peculiar modification of one of the protein-compounds. When these conditions are not fulfilled, the molecular granules are altogether absent, or are only very sparingly present.* These primary molecular granules must not be confounded with those which make their appearance during the process of softening, and of which we shall discourse presently.

The further development of cancer consists in the organization of the cytoblastema, and in its conversion into the cells and fibres, which we have already described.† In this early stage, the formation of vessels is probably extremely rare. It is not easy to trace the development of the cells, for, in general, from the very first we observe them of very different forms, and apparently in various stages of development. Sometimes, in the examination of a cancerous tumour, we observed very large knotty masses, varying in diameter from the 30th to the 10th of a line, or even larger, containing irregular cells, and exhibiting a tolerably distinct outline. They probably have the same signification as the large cells already described, in whose interior young cells are formed, while the cell-wall becomes converted into fibrous tissue. The fibres soluble in acetic acid, arise partly from undoubted fibre-cells, and partly from the amorphous blastema without any definite cell-formation. No certain observations have yet

* See Plate VIII. fig. 9.

† We have attempted to depict this early stage of development from a solid, amorphous cytoblastema, in Plate VIII. fig. 9.

been made regarding the formation of elastic fibres; they appear, however, in some cases to arise from a channelled or reticulated thickening of the solid, membranous cytoblastema. Regarding the chemical metamorphosis of the blastemal fluid, by which the viscid substance of which we have made mention, and which is of such frequent occurrence in cancer, arises, we cannot offer even a probable conjecture.

Hence it follows that cancer is a thoroughly morbid epigenesis, and is not in the smallest degree produced by a metamorphosis of the tissues between which it is developed. Another question to be considered is: What influence do the surrounding parts exercise on the development of cancer? I mean by this, not the altogether unknown influence which the modified energies of the tissues doubtless exhibit in the formation of cancer, but simply the influence which the parent-tissue exerts on epigeneses in accordance with the law of analogous formation. An influence of this nature can have no weight in the formation of cancer-cells, since they are heterogeneous tissues, and their first appearance can be as little explained by that law, as the appearance of pus-corpuscles. On the other hand, the fibrous structures and the vessels of cancer may very possibly be formed by the influence of the surrounding parts, in accordance with the law of analogous formation—at least in those parts which in their normal state contain vessels. According to this view, those kinds of cancer which contain fibres must be regarded as a combination of malignant tumour containing cells, with non-malignant fibrous tumour, and we shall show, in a future part of this work, the importance of it, for the more the fibres predominate in a cancerous tumour, so much the more innocuous and less malignant do we generally find it.

The cancerous matter occurs between original elementary parts of the parent-tissue, and occupies, more or less perfectly, all the interstices. A slight infiltration of cancer in a tissue, frequently escapes the observation of the unaided eye, and can only be detected by careful microscopic examination—as for instance, in fatty tissues.* When the interstices are not thoroughly filled, and the cancerous deposit is soft, the parent-tissue, at least in the first stage, is comparatively little injured. If, on the other hand, the infiltration is complete and the cancerous deposit very firm and solid, then the elements of the tissue become compressed, appearing to be blended with the deposit into a homogeneous mass, and gradually become atrophied and disappear. This disappearance of the elements of the tissues by atrophy and resorption, which is peculiar to the first stage of cancer, previous to softening, must be clearly distinguished from the destruction of the entangled tissue, which is dependant on the softening of cancer, and of which we shall speak presently. It is beyond all doubt that by the gradual increase of a cancerous tumour, the parts in its vicinity must be displaced; this applies, however, more to whole organs than to the elements of tissues, and is much rarer than is usually supposed. Thus, for instance, in cancer of the liver the hepatic cells do not become displaced, but get enclosed in the cancerous deposit, and thus gradually become atrophied.

Finally, after its full development, the cancer proceeds to soften; the process being essentially identical with that occurring in tubercle, and which we have already described. It proceeds in cancer, even independently of cell-formations. It is only in those cases where other processes—as gangrene, tubercle, or typhous deposit—are combined with cancer, that the amorphous blastema around and in the cancerous tumour breaks up directly, without the previous formation of cells. These separate from one another, break up, and form a quasi-purulent fluid, which sometimes contains decided (although partially injured) cancer-cells, and sometimes a mere detritus, consisting of molecular granules, crystals of cholesterin, &c., perfectly similar to softened tubercle. On what this disinte-

* See the description of Plate VIII. fig. 6, 7.

gration depends, is unknown; it appears to be dependant on the nature of the process itself*—as in the formation of pus from a solid cytoblastema—for although it can be hastened or retarded by external influences, it cannot be entirely arrested. As a general rule the softening proceeds very gradually, commencing at individual points of the tumour, often at several simultaneously. A section of the tumour at this stage, shows at one or several spots collections of purulent fluid, consisting of softened cancer-cells. I think it is not improbable that these points at which the softening commences, when they are very minute, and at the same time very few, gradually disappear by resorption, the slight loss of substance healing by cicatrization, and the injurious progress of the cancerous tumour, being thus prevented; this, however, only occurs in those forms of cancer which consist for the most part of fibres, and contain only a few cells. The ordinary course of a cancerous tumour is very different; the softening continuing to progress, and thus gradually extending to the whole cellular structure within the tumour. In this manner the minute and isolated specks of pus enlarge, and by uniting, form large masses, (such as occur in the formation of abscesses,) till finally the collected fluid forms for itself an external outlet, thus converting occult into open cancer. But further, another change occurs in the softened cancerous matter; it undergoes chemical modifications, becomes decomposed, acrid, fetid, and of an unhealthy appearance; in short, the softened cancerous matter becomes converted into an ichorous discharge, the chemical properties of which are not accurately known, and probably vary in different cases. These changes, like those of an analogous character occurring in tubercle, are dependant on a species of

* Vegetable physiology furnishes us with an analogous proceeding in the normal softening of many fruits (as for instance, that of solanum nigrum) which depends on a separation and solution of the (merenchyma) cells forming their tissue.

putrefaction, of which the conditions have not yet been accurately investigated; but—as in that case—probably are a large quantity of the product of the softening, impeded metamorphosis in the surrounding parts, and an admixture of matter inducing putrefaction—namely blood. Until the commencement of the ichorous discharge, the softening is usually restricted to the cellular portions; at the same time the solid parts, namely the fibres and blood-vessels, which in themselves have no tendency to soften, undergo putrefaction and disintegration through the influence of the ichor; their destruction is, however, usually very gradual. In this stage, a section of those forms of cancer which contain fibres presents a very peculiar appearance. It exhibits irregular cavities filled with ichor, whose walls are very tough, often as hard as cartilage, and are composed of fibres, presenting, as it were, a corroded appearance. Isolated fibrous bundles frequently softened and half destroyed at their superficies project into the cavities, or extend across them in the form of rafters or arches. We sometimes discover the open mouths of corroded blood-vessels; in these cases effused blood, coagulated in clots or mixed with ichor, fills the cavities.

The above series of processes occurring in the development of cancer, occupy very different periods of time in different cases; they always require several weeks or months, and sometimes several years. In proportion to the extent of cellular structure in a case of cancer, so much the more quickly does the process of development attain its termination, and it has long been remarked that the forms of cancer, in which cells predominate, (encephaloid) usually run their course and terminate fatally in about as many months as those forms in which fibres predominate (scirrhus) require years.

Simultaneously with the process of development the cancerous tumour undergoes other changes; it increases to such a degree, that from a very limited origin it often becomes distributed over a large space, occupying one or even several organs. This enlargement is undoubtedly dependant on the cellular structure of the cancer, and probably also on the fibres acting upon the nutrient fluid in the neighbouring parts, in accordance with the law of analogous formation. The increase of the cancerous cells is forwarded by the circumstance that many of them act the part of parent-cells, and contain in their interior young cells, which in all probability are capable of a similar mode of increase. Moreover, the numerous cytoblasts frequently observed in a cell, probably all become themselves developed into distinct cells. With these facts before us, there is clearly no limit to the increase of cancer-cells, neither is there any necessity for regarding them as distinct organisms similar to the lowest fungi and algæ. It is clear, however, that the fibres and the vessels (if any are present) cannot be increased by means of the cancer-cells; in all probability the increase of the fibres—and in fibrous cancer such an increase undoubtedly occurs—is dependant upon the influence of the pre-existing fibres, just as is the case in the growth of pure fibrous tumours. The innate capacity for augmentation possessed by cancer, is very energetic, and forms an essential distinction between cancerous tumours and scrofulous depositions; for in the latter this capacity is either altogether absent, or only present to a very slight degree. Hence the growth of cancer is most rapid when an increased cytoblastema is yielded to it from any source, as for instance, from inflammatory exudation, especially from fibrinous dropsy in the adjacent parts. It always increases on the supervention of softening and ichorous discharge, in consequence of the irritation to which these processes give rise in the surrounding parts. The exudation thus yielded by the neighbouring hyperæmic parts is converted into cancerous matter, and hence cancer is not, as is frequently the case with tubercle, separated from the surrounding parts by granular cells or pus, nor is it retarded in its growth by a line of demarcation. The newly-formed cancerous matter goes through precisely the same course of development as the original; proceeding of necessity to softening. In some cases, we find the peripheral portion of the cancerous matter, and the surrounding parts contending, as it were, for the cytoblastema, and sharing it between them. There are formed, as may be observed in cancerous ulceration, fungoid and extremely vascular granulations; but these are always so infiltrated with cancerous matter, that, after a very brief existence, they soften and become disintegrated, never contributing to the formation of persistent tissues.

Distinct from this local enlargement of cancerous tumours, there is another mode of increase, which usually occurs in the latter stage as softening commences, or sometimes earlier. There are formed other cancerous tumours distinct from the original tumour, often many in number, some being situated in close proximity with the original seat of the disease, namely in the adjacent lymphatic glands, whilst others occur in remote parts of the organism. The causes of this distribution of cancer are still very obscure —an obscurity which is increased by the circumstance that we are in a great measure ignorant of the causes of the primary deposition. Doubtless the same cause which gave rise to the first tumour, influences the formation of the others. This cause appears to be in operation when, long after the removal of a cancerous tumour—often years after, and when the wound caused by the operation had long healed—a new cancerous tumour becomes developed in another part of the body. To this cause we usually apply the term *cancerous diathesis*, a phrase against which no objection can be raised, since it is merely the expression of an unknown fact, just as x represents the unknown quantity in an unsolved equation.

Another mode in which a cancerous tumour may increase, has been noticed by B. Langenbeck.* When cancer-cells make their way into the veins and lymphatics opened by the

* Schmidt's Jahrbücher, vol. xxv. p. 99, &c.

softening of the cancer, and thus enter the circulation, which is by no means a rare occurrence, they become retained in the smaller capillaries, in consequence of their size, and thus becoming further developed at these points, give rise to secondary cancerous tumours. Langenbeck succeeded in inducing secondary cancerous tumours in the lungs of a dog, by injecting into its blood-vessels fresh cancer-cells from a tumour while still warm, which had been removed two hours and a half previously from the humerus of a man. A cancerous tumour being once formed, its distribution in this manner, into different parts of the same individual, is by no means unlikely; but it is undoubtedly not the only way in which it can be extended, and it admits of several very serious objections.

After this notice of the development and extension of cancer, we are now prepared to consider its *consequences* to the organism. These vary in accordance with the stage of progression of the tumour. In the first place, previously to the commencement of softening, they are purely local, and frequently barely perceptible. The cancerous matter is injurious to the adjacent elementary textures simply by its pressure and by its checking their nutrition, and these symptoms are the more urgent in proportion to the firmness of the tumour, and to the closeness with which it includes the elements of the parent-tissue; these causes frequently leading to the atrophy, and occasionally to the disappearance of these elements. Sometimes we observe especial phenomena from the pressure exercised on a neighbouring organ, on a nerve, or on a canal; these are, however, simply mechanical effects, and not to be distinguished from those to which non-malignant tumours might give rise.

On the supervention of softening, the consequences become more serious; we now usually observe an (inflammatory?) reaction of the surrounding parts, and the tumour commences to be painful. Still more injurious are the effects of the unhealthy suppuration which ensues; the surrounding parts being affected by the ichorous discharge; the blood-vessels and lymphatics in the tumour and in its vicinity becoming destroyed; and the veins, unless they had previously been obliterated, often giving rise to such very serious hæmorrhage, as to threaten life itself.

The softened cancerous matter may enter the veins and lymphatics, and give rise to inflammation of those vessels, and its consequences. Cancer-cells may, also, as we have already mentioned, enter into the circulation, and becoming deposited in the capillaries, give rise to secondary cancerous tumours. But independently of any laceration of the vessels, the fluid portion of the ichorous discharge may enter into the blood by endosmosis, and induce changes in it, in a manner not at present understood. To this passage of the ichorous discharge into the blood, there are usually ascribed a series of general symptoms, which are frequently noticed in the later stages of cancer, and known collectively as *cancerous cachexia;* the chief of these are a peculiar, yellowish grey colour of the skin, disturbances in the nutritive process, and in the functions of the nervous system. It need scarcely be mentioned that the degree to which these symptoms are developed is proportional to the amount and the malignancy of the ichorous fluid which enters the blood. Hence it follows that in encephaloid, which softens rapidly, yields a large amount of ichor, and is tolerably vascular, the course of events is much more rapid and severe than in scirrhus. That under these circumstances, the vital powers must become exhausted, and death sooner or later occur, appears to be perfectly self-evident.

Such being the course and the consequences of cancer, we can readily understand the advantages to be gained by the surgical removal of the tumour, or its destruction by means of caustics; in fact its pathological anatomy indicates the mode of treatment. Since, as we have seen, every true cancerous tumour is continuously increasing, and nature has not adopted any means of limiting its growth, as we observe in tubercular and some other tumours, we see a theoretical indication of the necessity of an operation—a view confirmed by practical experience. It likewise follows that every extirpation or destruction by caustic must be radical, for otherwise the remaining cancerous matter enlarges after the operation, and, in consequence of the more abundant secretion of cytoblastema, grows more rapidly than before. It is only after the entire removal of the cancerous matter, that the influence of the surrounding healthy parts can induce normal granulations, and lead to cicatrization. If the surrounding parts are not in a healthy condition, or the original cancerous diathesis not eradicated, then even after a perfect operation, a cure will not result. The accurate determination of these cases must be left to the judgment of the surgeon. Since the most injurious consequences are dependant on the occurrence of softening and unhealthy suppuration, it is expedient that the operation should be performed, if possible, before these changes ensue. It is very true that previously to these changes taking place, the diagnosis of a cancerous tumour in the living body is very uncertain; but still it is far better that we should run the risk of occasionally extirpating a harmless tumour, than that, by delaying the operation, the patient be subjected to the risk of certain destruction.

Cancerous matter appears to be sometimes deposited in other tumours originally of a non-malignant character; these subsequently become converted into cancerous tumours, or form combinations of cancer with the preceding groups.

I have hitherto avoided entering minutely into the question regarding the causes of cancer, in order that I might not interfere with the continuity of the subjects discussed in the preceding pages. The *parasite-theory* appears to afford an obvious and intelligible mode of accounting for the formation of this adventitious product. According to this view, the cancer-cells are *independent organisms*, (or according to Klencke's nomenclature *semi-individual cells*,) in all cases possessing the property, when conveyed into the interior of the living body, of there further developing themselves, and forming cancerous tumours. We may, therefore, explain the primary formation of cancer by assuming that a cancer-cell accidentally getting into the body, gives rise to the development of a tumour of this description. This view is principally supported by experiments with inoculation, in which local cancer has been produced by transmitting recent cancer-cells into the organism, as in the experiment of B. Langenbeck to which we have already alluded. But on close consideration, it appears that very weighty doubts suggest themselves against our acceptation of the view, that all primary cancers arise in this manner, even if we allow that in every inoculation-experiment actual cancer is produced, and not merely a tumour of some other kind, such as we frequently meet with in the examination of the dead body after injuries. Although I have no reason to doubt the accuracy of Langenbeck's experiment, yet in other cases, the necessary microscopic examinations are wanting. If, further, cancer-cells can serve to transmit cancer from one individual to another, when they have got into the interior of the organs (that is, within their parenchyma), the question then suggests itself—how can they, under ordinary conditions, get there? Even if we assume that they can be distributed into the surrounding atmosphere from open cancer, in the same manner as the spores of algæ and fungi (which, however, is very improbable, since the cancer-cells, are for the most part, tolerably large, and exceed the 100th of a line in diameter), and are deposited on the outer or inner surfaces of the body, still they are not in the parenchyma of the organs, and they can only enter, if there are wounds or lacerations, which as a general rule do not precede the formation of cancer. Moreover, in this system of propagation we must assume that the cancer-cells retain their vitality for a considerable period after their removal from the organism, and that they remain unaffected by external influences, such as a lowered temperature, dessiccation, &c.

I will mention one experiment which appears to bear strongly on this point. From the body of a man who died from encephaloid of the testicle, which had extended itself along the vertebral column as far as the diaphragm, and formed a very large tumour, I took, about thirty hours after death, a portion which contained an immense number of uninjured cancer-cells, expressed from the soft mass some of these cells, mixed them with luke-warm water, and filtered the fluid through a piece of linen, in order to remove any large clots which might mechanically tend to close the capillaries. The fluid thus prepared, contained millions of perfectly integral cancer-cells, averaging the 100th of a line in diameter, together with numerous molecular granules, besides fluid albumen and fat; from its odour there was not the slightest indication of putrefaction. This fluid was injected into the jugular vein of an adult healthy dog, so that I am convinced that at least thousands, very probably millions of cancer-cells were thrown into the circulation of this animal. With the exception of the respiration being disturbed for the first few minutes after the operation, the dog exhibited no morbid symptoms, and when killed eight months afterwards, not the slightest change could be detected in any organ, although a single cell might, according to this view, have given rise to the development of cancer. This experiment (like others undertaken by Valentin, Dupuytren,* &c., with similar results) shows that cancer-cells lose their capacity for development very shortly after their removal from the body or after death, and tends to render it extremely improbable, that cancer should often be propagated in the above manner. But many other experiments are opposed to the production of cancer by contagion, as for instance, the cases in which it arises from mechanical influences, as a blow or a fall. On these grounds, the view that cancer is formed by the transference of cancer-cells, appears to the unprejudiced investigator, to be very improbable; at least this mode of formation can at most only occur in a very restricted class of cases. But on the other hand, this view seems better adapted to explain the further distribution of cancer in an individual already suffering from it. And yet on close examination doubts arise regarding even this limited application, as may be seen by a reference to the explanation of fig. 9 in Plate VIII. In this case cancer of the lungs succeeded the primary affection of the testicle.

Here the recent cancer consisted of a solid cytoblastema, which was partly amorphous and partly becoming cellular, there being only a few spots in which perfect cancer-cells could be discovered. If I allow that here one or several cancer-cells became impacted in the same capillary vessels, and gave rise to exudation, it still remains problematical how a few cells could exert so strong an influence on a proportionally large mass of exudation as to convert it entirely into cancerous matter, whilst, in other cases, the plastic force of an organic cell is limited to its most immediate vicinity. And here arises a second doubt. Many cancers consist not merely of cells, but also contain fibres. How do these fibres arise? We may, indeed, assume that in certain cases the cancer-cells are converted into fibres; but, from numerous experiments, I am induced to believe that such an assumption is altogether false, since it is the peculiar nature of cancer-cells not to enter into other forms, but to undergo disintegration. Langenbeck,† however, asserts that he has observed that after transmitting cancerous matter into the circulation of a dog, cancer consisting not merely of carcinomatous cells, but also of "very strong, clear, juicy fibres" has formed in the lungs. But how can he explain their production as due alone to the influence of the cancer-cells? These remarks afford a sufficient refuta-

* Compare Hannover, Hvad er Cancer? p. 91.

† Op. cit. p. 104.

tion of a hypothesis respecting the formation of cancer, which has recently been regarded by many, without sufficient examination, as based on indubitable evidence. In opposition to this view, there is nothing to hinder us from assuming that cancer-cells are originally formed in the body, like other cells which occur in morbid epigeneses, as, for instance, pus-corpuscles.

But the conditions giving rise to one or other form of cell are still for the most part unknown; and I deem it unnecessary to submit to a similar examination the other opinions which have been promulgated regarding the causes of cancer, since they would lead us too far from our subject, and afford no valuable results.

Attempts of this kind finally lead to the subject of miasm, contagion, &c.—points which belong rather to general pathology than to pathological anatomy. The preceding observations respecting its propagation, lead to the belief that cancer proceeds chiefly from the vascular system, namely, from the veins—a view supported by certain anatomists, and, amongst others, by Cruveilhier. The cancerous matter observed in the veins is certainly very rarely formed there as a primary product, but is usually secondary, depending on a propagation of the cancerous matter in the blood. Indeed, in many cases no cancerous matter is observed in them, but merely pale coagula of fibrin, similar to those which occur in phlebitis: this has been shewn by Hannover.* The assertion, that cancer can only form in certain organs, as, for instance, in cellular tissue, is negatived by direct observations. For other views on the subject of cancer, and for the literature with which they are supported, we must refer to J. Müller's original work, or to Dr. West's translation. I must here revert to the opinion maintained for many years by Hodgkin, and still again recently† brought forward by him in opposition to the view that cancer is formed from the cells.

It consists essentially in this—that all cancerous tumours both in man, and in the lower animals, arise from the compound cysts already described.

The following considerations may serve as a clue to the correct estimation of this view, which appears to me to contain much truth, although not to admit of the general application that Hodgkin supposes. We have already seen that cysts may arise from morbid blastemata under very different relations, when the surrounding parts or the peripheral portion of the blastema become organized. The same may happen in certain cases when the greater part of the blastema is converted into a pseudoplasma; the cancer may then be associated with a more or less complicated cyst-formation. Moreover, those forms

* Op. cit. p. 86.

† Medico-Chirurg. Transactions, 1843, p. 242.

in which masses of cancer-cells appear to be enclosed in fibrous capsules, indicate the possibility of such processes. In this sense, Hodgkin's opinion appears, at all events, as established, and deserving of the consideration of future investigators. But, on the other hand, we must not conclude with Hodgkin, that all pseudoplasmata proceed essentially from compound cysts. We can certainly never succeed in recognizing this structure in the infiltrated forms of tubercle, encephaloid, and scirrhus. Again, when cysts occur together with the pseudoplasmata, the latter do not arise from the former, but both are formed simultaneously. The cysts render the pseudoplasmata more complicated, and exert an influence on their form, but have nothing to do with their production. It is on this point that the objection is based which Professor Grose of Cincinnati, has urged against Hodgkin, namely, that there is an essential difference whether or not the contents are produced by the wall of the cyst. If it is assumed that the membrane of the cyst gives rise to the pseudoplasma, such an opinion is just as false as that all tubercles arise from hydatids.

In the explanation of these points we must not refer to cystoid of the ovary; for, in consequence of the structure of the graafian vesicle, peculiar conditions are there present; in fact, these vesicles may be regarded as normal cysts, differing, however, in character, from those of any other part of the body. In an excellent memoir recently published by Engel,* the very praiseworthy attempt to explain, on physico-chemical principles, the formation and development of cancer, has been made in the same manner as was formerly done in the case of tubercle. I believe that here, as in that case, this is the path the exact investigator must follow; but the difficulties in this case are greater even than in the former, because cancerous tumours are generally much more highly organized than tubercle, and the modification of the blood, which is assumed by Engel to be the basis of the formation of cancer, not merely requires confirmation, but an accurate chemical examination. Our chemical knowledge of cancer is very slight; the older observations, as, for instance, those of Lobstein, are at present of little value. More recently, J. Müller† and Scherer‡ have occupied themselves with its chemical investigation, but their results have not thrown any great light on the subject. In the chemical analysis of cancer, as in that of all other organic structures, the most essential point to attend to is, that the chemical and histological investigations should

* Zeitschr. d. Gesellschaft d. Aerzte zu Wien. Jahrg. I. p. 267, &c.

† Op. cit. p. 24, or West's Translation, p. 73, where the analyses of the earlier chemists are quoted and criticized.

‡ Untersuch, p. 220.

proceed hand-in-hand, and that we should endeavour to give a suitable account of the seat, form, and signification of each substance recognized by the chemical analysis. Cancer, however, consists of solid portions infiltrated with fluids: these solid portions are an amorphous blastema (probably fibrin), elementary granules (whose chemical composition has been already considered), fibres, and cells. In chemical composition the fibres are probably identical with those that occur in fibrous tumours, and must be regarded as forming an intermediate link between the protein-compounds and gelatigenous tissues. The composition of the cancer-cells is still unknown; it doubtless varies with their development. The fluid constituents of cancer are, undoubtedly, extremely various, according as the tumour is crude, softened, or discharging. Hence, to complete our knowledge of the subject, a large number of analyses is requisite, and we proceed on a very false principle, in attempting to deduce general conclusions from isolated investigations. We shall return to this subject in our remarks on the different forms of cancer. For statistical information relative to cancer, we must refer to Herrick and Popp,* and Leroy d'Etiolles.†

The *diagnosis* of cancer in a pathologico-anatomical point of view, is in many cases very easy, whilst in others it is extremely difficult, and, indeed, almost impossible. Even after its extirpation, or in the dead body, when we can examine it at our leisure, and with all our aids to diagnosis, we cannot always decide with certainty on its nature. In this case, as with the former tumours, our diagnosis must be based not so much on the coarser physical characters which in cancer are liable to extreme variations, as on the histological relations as viewed through the microscope. The diagnosis must be based:

1. On the peculiarity of the development of the tumour, namely, on its softening. But softening may also occur in other tumours, as in tubercular tumours, and in cases of unhealthy, malignant suppuration, accompanied by loss of tissue and induration of the surrounding parts. Here we must adopt the second of our means for diagnosing cancers: we must search for the cancer-cells which are characterized by

* Ueber bösartige Fremdbildungen. Regensburg, 1841.

† Gazette Méd. de Paris. Mars, 1843.

their form and size, and by the number of cytoblasts and young cells, and may be readily distinguished from pus-corpuscles, as well as from the indefinite cellular structure of tubercular swellings. In most cases the softened cancerous matter exhibits these cells, or fragments of them; but when these are absent, and when the cancer-cells generally are not perfectly formed, then a certain diagnosis is impossible; and the difficulty is, if possible, increased in those cases where a tumour approximates equally to cancer, tubercle, and unhealthy suppuration. Hence it is sometimes impossible to distinguish whether we are examining an open cancer, or some other foul ulcer. It is not in accordance with the principles of human reason to erect an arbitrary and constrained distinction, where nature herself has fixed no definite limit.

2. Before the commencement of softening, the diagnosis is exclusively founded on the presence of cancer-cells; and it is certain, in proportion to their abundance, preponderance, and perfect condition, and to the facility with which they admit of being distinguished from other primary or developmental cells. The irregular caudate cells* are especially characteristic, as also are the large cells with many cytoblasts and young cells,† the cells with a thick wall,‡ and the accumulations of cells in fibrous capsules.§ The other forms of cells are very slightly or not at all characteristic, since they occur in the development of other tumours; thus, for instance, the elongated fusiform cells‖ occur also in the strictly fibrous tumours. Hence, when a cancerous tumour is met with at a very early stage, and the amorphous cytoblastema predominates, or the cells assume a primary form, and present no marked characteristics, the diagnosis is very problematical. Another circumstance, rendering the diagnosis uncertain, presents itself when the cells are secondary in quantity to

* See Plate I. fig. 11.
† See Plate VI. fig. 7, 8.
‡ See Plate VIII. fig. 6. B.
§ See Plate VIII. fig. 3. B.
‖ See Plate VIII. fig. 9. C.

fibres or other structures. In this case, however, the uncertainty of a true diagnosis is only apparent; for such tumours lie in reality between cancer and non-malignant fibrous tumour; they are a combination of the two forms, and become innocuous as the latter predominates. The relations are very similar with the combinations of cancer with melanosis and vascular tumour.

Several cases illustrative of the diagnostic value of the microscope in relation to cancer in its various stages, are given in the description of the plates to the second volume. Further observations on the diagnosis of cancer will be found in our remarks on the individual varieties. With respect to its surgical diagnosis, and the detection of cancer of the internal organs during life, we shall add nothing further in the present place, since they are based on many phenomena which are not included in the domain of pathological anatomy.

FORMS AND VARIETIES OF CANCER.

Cancerous tumours, although they all exhibit the essential characters of carcinoma, yet in their physical properties and in the arrangement of their histological elements, present the greatest varieties, which are, however, dependant on two causes: 1, on the organ in which the tumour is developed—a point to which we shall return in the second volume; and, 2, on a difference in the arrangement of the histological elements entering into the formation of the tumour. These differences we shall consider at some length. In the examination of a cancerous tumour we sometimes find cancer-cells, and sometimes fibrous tissue predominating, and the degree of development of these tissues also varies in different cases; sometimes the principal constituent is a firm, amorphous cytoblastema, and occasionally the most abundant ingredient is a viscid tenacious fluid. This is the case not merely with different cancerous tumours, but it is even observed in different parts of one and the same tumour; so that frequently, indeed most commonly, on taking two neighbouring sections, we find that they present very different physical properties, and a perfectly distinct histological arrangement. Attempts have been made to regard these differences as different species of cancer; but here, as we have already shewn in the case of the other tumours, a division into species, such as is adopted in natural history, is impracticable: like many minerals, cancer presents a group of forms merging into one another without any fixed line of demarcation, the individual constituents being, to a certain degree, vicarious, and reciprocally displacing one another. The following are the chief of these forms:

FIRST FORM.

CELLULAR CANCER—ENCEPHALOID.*

Synon. Medullary sarcoma; fungus medullaris; cancer medullaris; carcinoma medullare; milk-like tumour.

Encephaloid is that variety of cancer in which the cancer-cells predominate over the remaining histological elements of the tumour. It appears to be generally developed from a fluid cytoblastema, and hence in examining it during its early stages of development, we rarely find the firm, amorphous cytoblastema, which is usually met with in other forms of cancer. The fibrous tissue is never so prominent an ingredient as the cancer-cells; indeed, in some cases it appears to be altogether absent, so that the cancer-cells are directly deposited between the normal histological elements of the affected organ; more frequently, however, it occurs in a subordinate degree, forming a stroma in which the cancer-cells lie. When the fibres predominate, encephaloid merges into fibrous cancer, and we sometimes observe that while one portion of a tumour resembles encephaloid, another more closely approximates to fibrous cancer. The viscid fluid likewise occurs almost constantly in encephaloid after soften-

* Compare J. Müller, über den feineren Bau, &c., p. 19; or West's translation, p. 58; Hannover, Hvad er Cancer? p. 9; G. Gluge, Atlas der pathologischen Anatomie, Part 1; Valentin, Repertor. vol. II. p. 277. The three first works give a tolerably perfect sketch of the previous literature of the subject.

ing; it is, however, rarely the leading constituent; in these cases encephaloid approximates to gelatinous cancer. In consequence of the extreme softness of its elements, encephaloid compresses the parent-tissues in a less degree than solid cancer. It admits of the passage of blood-vessels through its structure, and as they do not become obliterated so frequently as in fibrous cancer, its appearance is usually vascular. In some cases newly-formed vessels occur in it. When, during the softening of encephaloid, the vessels become opened, the effused blood more readily enters the soft tissue, and mixes with it, than in the harder sorts of cancer; the whole mass assumes a sanguineous appearance, and in this way encephaloid merges into fungus hæmatodes; it must, however, be observed, that the term fungus hæmatodes is applied to many tumours which have no connexion with encephaloid, as for instance, telangiectases and other non-malignant vascular tumours.

Black granular pigment may likewise enter into the composition of encephaloid, forming melanotic cancer (carcinoma melanodes).

There are certain forms of cancer-cells which are characteristic of encephaloid, for instance, parent-cells with young cells in their interior, cells with numerous cytoblasts,* and the irregular caudate and ramifying cells.† My own experience leads me to assert that these forms are not often found in other forms of cancer; but, on the other hand, they do not occur in all cases of encephaloid.

Encephaloid grows more quickly, distributes itself more rapidly, and attains a more considerable bulk than any other form of cancer; tumours of this nature often being as large as a man's head, or even exceeding that size. It also softens more rapidly than the other forms of cancer, because the cells which are the element on which softening especially depends, are here the predominating ingredient; and for the

* See Plate VI. fig. 7 a, 8 d. † See Plate I. fig. 11.

same reason it is the most likely to form a discharging ulcer, and the most rapid in assuming that condition. Hence of all forms of cancer encephaloid runs the quickest course, is the most malignant, and causes death in by far the shortest time. It often destroys life in a few weeks, or at furthest in a few months after its first appearance, unless it has been removed by an operation at an early stage.

Encephaloid appears to occur primarily or secondarily in nearly every organ and portion of the body, at every age, and in both sexes.

From the above observations it may be easily imagined that the coarser anatomical and physical relations of encephaloid are extremely variable; and this view is supported by experience. The colour of encephaloid tumours varies considerably; they are sometimes whitish, sometimes of a yellow tint, sometimes almost gray, so that in the same case there are some parts that may very fairly be compared to the white, and others to the gray substance of the brain. In other cases, when the tumour is penetrated by numerous minute vessels, we have a reddish, flesh-coloured, or pink tint. When blood extravasated from the injured vessels has become mixed with the substance of the tumour, as usually happens at the commencement of softening, the whole mass, or certain portions of it appear of a dark red colour, or if the hæmatin of the extravasated blood has begun to change, the tumour may present a brownish-red or mahogany tint.

These tumours likewise differ in their consistence; before softening they are firm, varying lrom the consistence of solid lard to that of the brain; after opening they sometimes become more granular or fibrous, and sometimes as they soften, they cease to discharge, but on pressure are converted for the most part into a milky and apparently purulent fluid. In those cases, in which from the very first the consistence has been slight, if the tumour is deposited near the external surface, as under the skin, or in certain muscles, it frequently communicates a deceptive feeling of fluctuation, before the commencement of softening.

With regard to its anatomical arrangement in the mass, encephaloid sometimes forms only a single tumour, and sometimes many; and varies from the size of a hemp seed to that of a man's head. These tumours are usually blended with the surrounding parts (infiltrated encephaloid), but occasionally they are perfectly separated from the adjacent tissues, being enclosed in an indefinite capsule of areolar tissue, which sometimes exhibits the characters of cartilage (the combination with fibrous cancer) just as is generally observed in newly formed areolar tissue. Sometimes encephaloid occurs in small patches enclosed in fibrous partitions, presenting a certain resemblance to the normal structure of the pancreas (pancreatic tumour). There are other varieties which are less striking to the eye, and which from the absence of any thing with which to compare them, have received no special names; they all, however, serve to elucidate the histological arrangement of encephaloid, and its relations to the parent-tissue. The latter is usually so concealed by the morbid deposit, that frequently even the most careful examination fails in detecting its elements.

When encephaloid is developed in external parts of the body, as in the bones of the extremities, or the subcutaneous cellular tissue, it gradually becomes blended with the skin, which is thus rendered distended and œdematous, the superficial veins standing forth like blue cords. It finally ulcerates, and there are formed fungoid growths, irregular leafy and cauliflower granulations, which are usually extremely vascular, and bleed on the slightest provocation (fungus hæmatodes); these granulations are not inclined to become organized; they unite, and discharge to such a degree, as rapidly to induce death by colliquation.

The *diagnosis* of encephaloid is essentially characterized by the same signs as those of cancer generally. From scirrhus it is distinguished by its greater softness, by its more rapid course, and by its small amount of fibrous tissue. There is, however, no strict line of demarcation between them ; and many very characteristic cases have been at first sight regarded as encephaloid, which after a more careful examination seemed doubtful, or to occupy a transition-form between the two. The accurate limitation of encephaloid, is rendered more difficult by its combining with other forms of tumour, as with melanosis (cancer melanodes) or with telangiectasis.* This combination may probably occur in several ways; the melanosis and the vascular structure may be superadded to the encephaloid, or conversely the encephaloid may be the last formed, or finally the two epigeneses may be simultaneous.

There is also a species of *false encephaloid*, a morbid epigenesis which in its physical properties appears identical with true encephaloid, but in its histological and physiological relations is essentially different from it. I once observed a tumour of this nature in a lung; it was of the size of a walnut, of a reddish-white tint, about as soft as brain, and was declared to be encephaloid by all the physicians who were present. When examined under the microscope it was found to be merely a deposition of oil-globules (fat) in the normal tissue of the lung, and hence there remained no doubt of its non-malignant nature.† This example may serve to show the possibility of such mistakes; future carefully conducted histological investigations will probably lead to the discovery of other forms of tumour which may be mistaken for encephaloid.

As instances of the coarser anatomical and physical, as well as of the histological relations of encephaloid, I may refer to the description of Plate VI. fig. 7—11. An instance of the transition-form merging into fibrous cancer, is given in the description of the case of cancer of the knee-joint represented in Plate VIII. fig. 6—7. The following case will

* See R. Froriep in the Encyclop. Wörterbuch der medic. Wissenschaft, vol. XIII. Berlin, 1835, art. Fungus.

† See Plate VI. fig. 10, A, B.

serve to give a good idea of the mode in which encephaloid extends itself. A joiner about forty years of age, had for three years a swelling of the testicle which gradually enlarged. There was subsequently formed a tumour in the abdomen which was perfectly visible on a mere ocular examination. He died after having experienced paralysis of the lower extremities and the bladder. The left side of the scrotum was much enlarged, and on piercing its walls a considerable amount of a clear yellow fluid spirted out. A large portion of the tunica vagin. propria testis was attached to the albuginea by fresh adhesions, which admitted of ready separation by the finger. The testicle and epididymis of the left side were much enlarged, weighing fourteen ounces. They, however, retained their normal shape and exhibited, independently of the recent exudation, a smooth surface. They were both of a tolerably firm consistence, and their section exhibited a yellowish tint. Internally the mass was coarsely granular, resembling fresh curds. The cord traced from the testicle, exhibited minute knotty swellings before entering the abdominal ring. In the abdominal cavity these increased in frequency and size, and finally became fused together into a large encephaloid mass, the size of a child's head, covering the whole of the left side of the vertebral column as far as the diaphragm, enclosing the aorta and the left kidney, but not extending into the right side of the abdominal cavity. It was of a white colour, resembling brain, was soft, and when pressed between the fingers, was easily reduced to a pulpy consistence. Histologically the soft encephaloid in the abdomen consisted of minute cells of the most varying forms, between which were very numerous fat-granules and oil-globules. In the testicle these cells were likewise found, but they were deposited in a firm amorpho-granular mass.

The chemistry of encephaloid is in much the same condition as that of cancer generally. The analyses which have been hitherto published are either far behind the present state of science, or must be regarded merely as starting points for future chemists, and in their present state do not admit of the deduction of any general conclusions. In the first category we may place the analyses communicated by Lobstein,* and those of Hauser,† and Baudrimont;‡ in the latter those of Brande,§ Valentin,‖ J. Müller, and Scherer.¶ Of the chemical nature of the principal ingredient of encephaloid—the cancer-

* Lobstein, Anatomie pathologique, vol. I.

† Oesterreichische medic. Jahrb. März, 1841, p. 317.

‡ L. Gmelin, Chemie, vol. II. p. 1373.

§ Berzelius, Lehrbuch der Chemie, 4th Ed. vol. IX. p. 729.

‖ Repertorium, vol. II. p. 277.

¶ Untersuchungen, p. 220, 221.

cells—we are altogether ignorant; the other constituents are not so essential, and to a certain degree vicarious. As a general rule encephaloid contains much more fat than fibrous cancer. Cholesterin is often present, frequently occurring in softened encephaloid in the form of crystals. Whether the phosphorized fats discovered in encephaloid by some chemists (Brande, Beaudrimont) are of any especial importance, must be determined by future investigation. J. Müller distinguishes three varieties of encephaloid:

1. Encephaloid abounding in roundish cells, though intersected by a delicate fibrous net work.

2. Encephaloid with an exceedingly soft cerebriform base, composed of pale elliptic corpuscles devoid of caudate appendages.

3. Encephaloid with caudate or fusiform corpuscles. The latter he regards as cells in the process of conversion into fibres; it seems to me, however, to be very doubtful, whether tumours consisting merely of fibre-cells should be regarded as encephaloid. Moreover, it is not always easy to determine whether the caudate cells must be regarded as always progressing into fibres,* or whether they should be viewed as peculiar encephaloid-cells incapable of further development. Gluge† regards the caudate bodies described by Müller as an artificial product arising from the action of spirit. It is certainly true that encephaloid preserved in spirit is no longer fit for histological examination, and that albumen coagulated by alcohol may sometimes assume forms, which under the microscope present a remote similarity to elongated cells; however, none who are used to microscopic investigations could mistake such artificial products for actual, unaltered cells, and Müller's experience in this department, as well as the figures of these cells, which he has depicted, utterly overthrow Gluge's supposition. Respecting the causes, mode of formation, and importance of encephaloid, we can merely apply the same observations as were previously made in relation to cancer generally. Some writers have endeavoured to establish an especial connexion between encephaloid and nervous tissue, regarding the former as merely an abnormal development of the latter structure. Such opinions have not even a shade of probability: they are based on an accidental similarity existing between the two, in colour, consistence, and certain chemical constituents. The microscope at once reveals the essential difference between these structures.

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* See Plate VIII. fig. 9.

† Atlas der pathologischen Anatomie, Part 1, p. 19.

SECOND FORM.

FIBROUS CANCER—SCIRRHUS.

Synon. Cancer scirrhosus; carcinomatous sarcoma; hard cancer; carcinoma simplex; carcinoma fibrosum.*

Under the term scirrhus we include those forms of cancer in which the fibrous tissue predominates, and which are consequently firmer and harder than encephaloid: hence its name.† In its early stages we find more frequently than in encephaloid, a firm, amorphous blastema; hence scirrhus does not invariably exhibit decided and perfectly formed fibres, for here as in the genuine fibrous tumours, the blastema does not always, even in the more advanced stages, undergo transformation into distinct fibres admitting of isolation, but sometimes permanently remains as an indefinite fibrous mass, holding a position both morphologically and chemically between coagulated fibrin and the gelatigenous fibrous tissue. The fibrous portions of scirrhus coincide in every point of view with those of non-malignant fibrous tumours, and hence, as we have already mentioned, scirrhus must be regarded as a combination of encephaloid with fibrous tumour. There are thus an endless number of transition-forms, the extremes of the series being on the one hand encephaloid, and on the other fibrous tumour. The mutual relations between the fibres and the cancer-cells vary extremely in scirrhus; sometimes both elements occur with a certain degree of regularity, the fibres forming net-work or capsules, whose interstices and cavities are filled with cells, or else radiating from certain points; sometimes on the other

* See Müller, op. cit. or West's translation; Hannover, op. cit. p. 22, &c.; Lobstein, Anatomie pathol. vol. I.; and G. Gluge, Untersuchungen, Part 1, p. 139, Part 2, p. 138.

† σκιῤῥός, hard, firm.

hand the fibres and cells are separated from each other. When, in the latter case, the tumour is divided into several portions, it is frequently impossible to distinguish some of these parts from encephaloid, and others from fibrous tumour. In scirrhus we frequently find the cellular structure less developed than in encephaloid; we rarely observe in it either large parent-cells, or cells with numerous cytoblasts; more frequently the cells are small, roundish or oval, and granular. Elementary granules are common after softening has commenced. Moreover, the viscid fluid is, as a general rule, present in scirrhus; when it occurs in excess, it forms the transition to gelatinous cancer. Since scirrhus is slower in its development, and more solid than encephaloid, so also is its action on the parent-tissues previously to softening more strongly marked; the elements of these tissues being more firmly compressed, become more readily atrophied. Hence, unsoftened scirrhus exhibits fewer and smaller vessels than encephaloid; if they are not altogether absent, they are at all events very small, and may be easily overlooked by a careless observer. Large vessels in scirrhus are, however, not rare, and we frequently find the milk-ducts pervious in mammary scirrhus of long standing.

Corresponding with these histological differences between scirrhus and encephaloid, there are also variations in their development, growth, and consequences. The growth of scirrhus is much the slower, for the cells on whose propagative power the enlargement of encephaloid is chiefly dependant, are here of mere secondary importance; hence scirrhus rarely attains to the same magnitude as encephaloid. On the other hand, the mechanical consequences of the tumour arising from pressure on nerves and vessels, contraction of canals, &c., are sooner and more energetically manifested than in encephaloid.

Conversely the process of softening is slower in scirrhus, the cells forming minute radiating islets of pus, which do not become so easily converted into ichorous discharge, but are more liable to resorption; hence the softening is less likely to extend to the adjacent tissues. Consequently scirrhus is much slower in conducing to a fatal result than encephaloid, and must be regarded as far less dangerous. While the latter often causes death in a few months, scirrhus usually continues for years. When the softening of scirrhus has progressed to a certain degree, there occur in it cavities, such as have been previously described, partially filled with a red ichorous fluid, and having fibrous or semi-cartilaginous walls united by irregular bands and arches. The granulations of scirrhous tumours resemble in all essential points those of encephaloid; and in the later stages when open ulcers are once formed, the progress of scirrhus becomes more rapid, and more closely approximates to that of encephaloid.

Scirrhus occurs as a secondary product in nearly every organ of the body, but its appearance as a primary affection is much rarer than that of encephaloid, and it seems for the most part to attack glandular organs. It appears most frequently during the latter half of life—from the fortieth year; and does not attack children. Finally it is more common in the female than in the male sex, in consequence of the female breast being the most common seat of the affection.

As there are great differences in the histological arrangement of scirrhus, so likewise are there extreme variations in the coarser anatomical relations of this form of tumour. Scirrhus usually forms a roundish tumour with a more or less nodulated surface. Its consistence is generally very firm; the tumour in this respect resembling cartilage or even stone (cancer eburneus); this hardness depends on its fibrous structure, and (as in the case of fibrous tumour) varies with the toughness, compactness, and amorphous character of the fibres. Its nodules, in cases where the tumour is superficial, are frequently observed, on the application of the hand, to be of a lower temperature than the surrounding parts. This is probably dependant on the circumstance, that in consequence of the limited supply of blood to these parts, the metamorphosis of tissue is much checked; however, I do not regard this hypothesis as a conclusive answer to the question. On passing a knife through them, scirrhous tumours craunch in just the same manner as fibrous tumours.

A section of one of these tumours sometimes appears of a bluish-white or milky colour, transparent, opalescent and shining—characters dependant on the fibrous portion, and exhibited in like manner by fibrous tumours; sometimes it presents a more opaque appearance, and is of a white or gray colour, with a shade of yellow—a character depending on the cells; and occasionally it presents a reddish tint if many blood-vessels are present. In most cases the unaided eye will detect difference of structure at different points; some parts being fibrous or transparent; while others are opaque, yellow, or green; when softening has commenced, a caseous appearance is sometimes presented. By scraping a tumour of this nature, we usually obtain a whitish creamy fluid. Specks of blood are rarely observed, and coagula never unless softening has advanced, and the blood-vessels are injured. As a general rule, scirrhus is intimately blended with the surrounding parts, not being enclosed in a capsule or presenting a definite border.

In regard to the diagnosis, and pathologico-anatomical appearance of fully developed scirrhus, we have nothing further to add; but even the most experienced observer, with every aid to diagnosis at his command, will frequently be in doubt, whether or not he is examining true scirrhus, since this form of cancer presents so many transitions into other sorts of tumours. These are, as we have already had occasion to mention.

First, the transition into encephaloid. It often appears to be a point of indifference whether a tumour should be referred to encephaloid or to scirrhus; the cancer-cells, and the fibrous structures being so equally balanced, that neither element predominates. Sometimes again, one portion of a cancerous tumour resembles encephaloid, whilst another more closely resembles scirrhus. These are cases belonging strictly to neither encephaloid nor scirrhus, but embraced in one of the numerous forms of cancerous tumour, which do not find a place in our artificial arrangements, however much we may extend them.

A second transition-form is that into gelatinous cancer, of which we shall speak presently.

The third series of transition-forms are those into non-malignant fibrous tumours. These are of the highest pathological importance, and are more likely to occur in proportion as the scirrhus is removed from encephaloid. In tumours previous to softening, it is often impossible to distinguish whether the few cells observable amongst the fibres are cancer-cells, or whether they are the developmental cells of other tissues, and this is a point on which microscopic examination can throw little light. Even after the establishment of softening, the diagnosis is sometimes uncertain, since non-malignant fibrous tumours may also undergo that change. It is a question which must be answered by future observers, whether in such cases cancer-cells are superadded as secondary formations to a fibrous tumour, originally non-malignant. I regard this secondary formation as not improbable, for we frequently observe that tumours which have existed for years without giving rise to more than mechanical annoyance, rapidly soften and become converted into cancer; I have, in several cases, observed this to occur in fibrous tumours of the uterus and mammary gland. Hence many forms of scirrhus should be regarded as combinations of encephaloid with fibrous tumour, and I must express my conviction, that many cases which from their pathology and morbid anatomy have been termed scirrhus, have been merely epigeneses of fibrous tissue. Although Andral first called attention to it, yet almost daily we observe simple hypertrophy of the muscular or cellular coat of the intestinal canal, mistaken for scirrhus,—an error I have myself repeatedly witnessed.

A further difficulty in the diagnosis arises when a cancerous tumour consists for the most part of an amorphous solid cytoblastema. There are no means of distinguishing this from the solid cytoblastema of a non-malignant tumour, and a certain diagnosis can only be established when a portion of the tumour becomes characterized as more perfectly developed scirrhus.

Hence it follows that the determination, whether a tumour is, or is not of a scirrhous nature, is sometimes, even with the best aids to diagnosis, merely presumptive, and occasionally the opposing characters are so equally balanced, that not even a conjectural opinion can be hazarded.

A very characteristic form of scirrhus is exhibited in Plate VIII. fig. 1, 2 and 3; fig. 4 and 5 illustrate a case of cancer of the liver, which may be regarded as pertaining either to scirrhus or encephaloid; fig. 6 and 7, exhibit soft cancer of the knee-joint, belonging more correctly to encephaloid than to scirrhus. Fig. 9, illustrates the formation of scirrhus from an amorphous cytoblastema. Other cases of scirrhus are illustrated in the second volume.

Under the term *carcinoma reticulare*, J. Müller* describes a peculiar variety of cancer which must be here noticed. It embraces those forms in which accumulations of cancer-cells are deposited on the meshes of a fibrous stroma, so that a section of the tumour exhibits a more or less regular appearance of net-work.† The fibrous masses occur in the form of thin transparent bands; the accumulated cells are whitish; but present a dark appearance when examined under the microscope by refracted light. The individual cells sometimes resemble the ordinary granular cells. Like the preceding forms of cancer; it is not strictly defined, and hence it is not to be regarded as a peculiar species.

Another form of cancer described by J. Müller,‡ under the term *carcinoma fasciculatum seu hyalinum*, appears histologically to be referable to this class, since it consists of very delicate fibres. It is, however, not firm like true fibrous cancer, but as soft as encephaloid, and highly vascular; according to Müller, it contains no cancer-cells. Notwithstanding the great number of cancerous tumours which I have examined, I have never yet met with this variety; hence my opinion with regard to the correctness of placing it in the above category must be considered only provisional. All that is known in relation to the chemistry and causes of scirrhus has been already given in our remarks on cancer generally.

* Op. cit. p. 15, or West's translation, p. 44.

† See Plate VIII. fig. 10; also Müller, op. cit. Plate I. fig. 1—9.

‡ Op. cit. p. 23, or West's translation, p. 66.

THIRD FORM.

COMBINATION OF MELANOSIS AND CANCER.

Melanotic Cancer.

Synon. Cancer melanodes ; carcinoma melanodes.*

We have already had occasion to mention that dark granular pigment may occur as an incidental constituent of cancerous tumours. This pigment is either enclosed in cells, which are only slightly, or not at all different externally from the ordinary cancer-cells (true melanosis), or it occurs in the form of free granules, and then sometimes consists of sulphuret of iron. Hence we have here the same differences as we formerly noticed in our remarks on melanosis.

The characters of melanotic cancer vary with the quantity and arrangement of the black pigment. When a small number of pigment-elements (cells or granules) are equally distributed over a large amount of cancerous structure, the tumour presents a gray colour. If an excess of pigment is deposited at special points, the cancer presents a dark speckled or marbled appearance. Finally if the amount of pigment is very excessive, the cancer presents throughout a blackish brown colour, and resembles in its appearance a true melanotic tumour. Melanosis is associated both with encephaloid and scirrhus; the former, according to my own experience, being combined with true, the latter with false melanosis. In its progress and relations melanotic cancer presents no especial peculiarities.

FOURTH FORM.

GELATINOUS CANCER, OR COLLOID.

Synon. Cancer alveolaris; carcinoma alveolare ; cancer aréolaire ; cancer gelatiniforme.†

We have previously described the viscid fluid, which forms

* See Müller, op. cit. p. 18, or West's translation, p. 55 ; Hannover, op. cit. p. 32.

† See Müller, op. cit. p. 16, or West's translation, p. 50 ; Hanno-

a tolerably constant, and, therefore probably essential ingredient of cancerous tumours. This gelatinous fluid is so increased in certain forms of soft cancer, as to give the tumour a very peculiar appearance. In some cases this jelly-like matter is enclosed in cellular cavities, varying from the size of a pin's head, to that of a wall-nut, or even of an egg: the cancerous tumour then presents a very characteristic appearance, and receives the name of *gelatinous cancer*, or *colloid*. The stroma of these tumours is invariably fibrous, being sometimes a delicate net-work, and in other cases being very thick, tough and apparently cartilaginous, such as occurs in fibrous cancer. In the interstices between these fibres, there lies this colourless, transparent jelly, which, when examined under the microscope, is found either to retain its transparent and amorphous appearance, or else to enclose very pale cells,* differing, however, from true cancer-cells, being generally speaking, larger and more delicate, and the walls not being so thick. Occasionally, we observe crystals of ammoniaco-magnesian phosphate enclosed in the gelatinous matter. No true softening or suppuration occurs in this form of cancer; in the intestinal canal where it is most frequent, the surrounding tissues become gradually infiltrated by the jelly; strictures are thus formed in the gut, and the contents of the canal being pressed on the soft gelatinous mass, give rise to perforation of the walls. Hence gelatinous cancer is in some degree different in its progress from the other forms of carcinoma.

Regarding the causes of this variety of cancer nothing cer-

ver, op. cit. p. 29; Otto's seltene Beobachtungen zur Anatomie, Physiologie, und Pathologie, Plate I. fig. 4; Cruveilhier's Anatom. patholog. liv. 10, tab. 4; copied in Hope's Principles and Illustrations of Morbid Anatomy, fig. 180, 181; Carswell's Pathological Anatomy, fasc. 3, tab. 1, fig. 8; Broers, Observationes anat. patholog. Lugd. 1839, c. 4, tab.; G. Gluge's Untersuchungen, Part 1, p. 132.

* See Plate VIII. fig. 11.

tain is known. Müller believes that its gradual enlargement is dependant on a further development and increase of the cells containing the jelly; young cells being formed within the parent-cells.

Colloid, in its characteristic form, most commonly occurs in the intestinal canal between the stomach and the rectum, from whence it proceeds to the peritoneum—especially the omentum; it more rarely occurs in other organs—in the breast bones, &c.

The external characters of this form of cancer are so very striking, that no one who has once seen a case, or even a good plate of it, can well err in his diagnosis. The peculiar interstices formed by the fibrous meshes and filled with jelly, present no variation, at least in cases of fully developed colloid. When colloid presents transitions into other forms of cancer, as, for instance, when the jelly is not enclosed in its proper interstices, but is deposited free between the fibrous structures and the cells, the diagnosis can only be established by microchemical examination, and there is a difficulty in assigning to the tumour its proper place in the scale of cancerous formations.

The reader will find a description of several cases of colloid, with plates, in the chapter on the morbid anatomy of the stomach and intestinal canal, in the second volume.

Many forms of tumour which have received special names from morbid anatomists and surgeons, do not, in a histological point of view, merit such a distinction. To this class belong polypi and fungoid growths. The former have only this in common—that they arise from, or are invested with mucous membrane. But if every epigenesis invested with mucous membrane, and developed in or under such a membrane, be termed a polypus, it is obvious that there may be great differences in the histological arrangement of such a class.* The nucleus of a polypus may, however, be formed by almost any form of tumour, either by a non-malignant structure—as lipoma, fibrous tumour, or encysted tumour; or by a malignant structure—as carcinoma. The same is the case with fungoid growths, which may arise from any discharging tumour, ulcer, &c. We shall have more to say in relation to these tumours in the second volume.

SPECIAL RELATIONS

OF

UNORGANIZED PATHOLOGICAL EPIGENESES.

The unorganized epigeneses occurring in the human body are very numerous, and present many varieties. In the following pages, devoted to their special consideration, we shall commence with certain general considerations, beginning with their *elementary relations.*

All these forms arise from fluids—mother-liquids, holding the matter of which the future deposit is composed, in a state of chemical solution. Nearly every fluid in the body may act as a mother-liquid, since they all contain matter which, under certain conditions, may be separated in a solid form. The conditions for this separation are in all respects identical with those which chemistry teaches us to recognize in relation to the separation of solid bodies from their solutions, that is to say, the deposits invariably follow chemical laws.

As a general rule, the separation of a substance from a

* Regarding the histological relations of *polypi,* consult the treatise of Frerichs, de Polyporum Structura Penitiori. Leeræ, 1843; and regarding the coarser relations, see Meissner über die Polypen in verschiedenen Höhlen des menschlichen Körpers. Leipz. 1820.

fluid takes place when the conditions on which its solution depends, are checked. The causes which may hinder it from remaining dissolved are various; they may, however, for convenience, be arranged in the two following classes:

1. The dissolved substance may undergo a chemical change so as to become altogether, or in a great measure, insoluble in the fluid in which it was previously dissolved. Cases of this nature are remarkably numerous, and occur under a variety of circumstances. Thus, for instance, bicarbonate of lime dissolves in water, but if it becomes converted into the neutral carbonate it is no longer soluble, and becomes deposited. At the temperature of the human body, urate of ammonia and the other uric-acid salts are soluble to a certain extent in water; if, however, they are decomposed by the addition of an acid, the uric acid becomes liberated, and being much more insoluble than the majority of its salts, forms a deposit in the fluid. If oxalic acid is mixed with an aqueous fluid containing a soluble salt of lime, oxalate of lime is formed, which, being insoluble in water, separates as a deposit.

Another cause, closely allied to the preceding, is a change in the solvent fluid. Phosphate of lime, for instance, is soluble in acid, but not in alkaline fluids; hence, if an acid solution of this salt should in any way become alkaline, a precipitation takes place. Another view may, however, be taken of this process; it may be supposed that phosphate of lime in an acid fluid becomes converted into a superphosphate—the free acid taking up a part of the base from the neutral salt of lime—and that the super-salt is soluble in water: and that the alkaline fluid, on the other hand, removes a portion of the acid from the lime and forms a basic salt insoluble in water. Hence, taking this view of the question, the two causes are in reality identical.

2. All substances soluble in aqueous fluids are merely so to a certain extent, that is to say, a certain amount of water is

requisite in order to retain a certain amount of the substance in solution. The solution is then saturated. If a portion of water is removed, a corresponding amount of the substance must separate in an undissolved form.

Both of the above cases occur in the human body, and give rise to numerous separations of matters no longer soluble —*precipitates*. The former cause is frequently in operation, and acts under very different conditions, as we shall perceive when speaking of the different forms of precipitate. The second cause is comparatively rarer, and depends for the most part on evaporation and endosmosis.

By evaporation, a concentrated fluid occurring in a part of the body exposed to such an influence, may lose so much water that a part of the matter dissolved in it (or, indeed, the whole amount) may separate in a more or less solid form. This cause is very frequently in operation in the nasal cavity, more rarely in the mouth, the cutaneous glands, the vagina, behind the glans penis, and possibly also (although very rarely) in the lungs and bronchial glands. It is probably never effectual in parts more remote from an exposed evaporating surface.

Endosmosis, as is well known, occurs when two fluids of unequal concentration are separated from each other by a thin animal membrane; an interchange of their constituents taking place under these circumstances, and the thinner fluid becoming more concentrated. When a thin fluid of this sort is saturated with substances requiring a large amount of water for their solution—as, for instance, the urates—then if endosmosis comes in play, they no longer remain entirely dissolved, but a portion becomes separated. This view is, however, rather founded on general theoretical considerations than on special experiments, and requires further proof.

Precipitates separated by either of the above causes may, as can be readily conceived, disappear, if conditions arise which render them again soluble.

Precipitates are the commencement of all unorganized pathological epigeneses. They bear the same relation to perfectly formed concretions as the elements of the tissues to tumours. They frequently occur in such small quantities as entirely to escape detection by the naked eye; the microscope is then requisite to detect their presence, and to elucidate their formative relations.

From microscopic investigation we learn that precipitates occur in three different forms—the amorphous, the indefinitely granular, and the crystalline.

Amorphous precipitates form a transparent, gelatinous mass, difficult to observe under the microscope—as, for instance, basic phosphate of lime, or silica in the gelatinous state.

Granular precipitates consist of very minute granules of indefinite size and form (generally roundish), in all respects identical with the elementary or molecular granules already described. Minute accumulations of them are generally colourless; in large patches they appear dark when viewed by refracted, and white by reflected light; we may instance albumen precipitated by an acid, or granular depositions of fat. In some few cases they present a coloured appearance; thus the finely-granular deposits of urate of ammonia frequently present a brownish red, and sometimes a beautiful pink colour.

Crystalline precipitates consist of more or less perfectly formed crystals, which, however, are usually only microscopic. Many of the forms occurring in these precipitates are very characteristic, as, for instance, those of uric acid, ammoniaco-magnesian phosphate, cholesterin, and margarin. Others are less perfect, or so minute that their crystalline form cannot be recognized under the highest powers.

These three forms of precipitates are, however, not strictly separated from one another; and it frequently depends upon accidental circumstances whether a precipitate assume one or other of them. The amorphous is generally the primary condition of the precipitate; it subsequently assumes the granular or crystalline state. In just the same manner as an amorphous cytoblastema becomes metamorphosed into a cell, which again undergoes a higher transformation and becomes converted into an integral constituent of tissue, so can an amorphous precipitate become converted into one of a granular character, and this again assume a crystalline form. This progressive metamorphosis does not, however, always occur. Many precipitates, as for instance, the protein-compounds, are incapable of crystallization, never being able to advance beyond the finely-granular state. On the other hand, crystals may be formed directly from a fluid, without previously assuming the amorphous or granular state. Chemistry teaches us that precipitates assume the crystalline form with a facility proportional to the slowness of their formation, and, on the other hand, that in proportion to the rapidity with which they are formed, they assume the amorphous or granular state. This law holds good in the same manner in relation to analogous morbid formations.

Hence, as a general rule, it matters little whether a precipitate be amorphous, finely-granular, or crystalline; and the occurrence of crystals in the human organism is usually not of that importance which many have attributed to it. With the exception of some few cases, as, for instance, the crystals in the inner ear (otolithes) it is only of importance in indicating the pre-existence of certain formative processes, or in enabling us to recognize, from the form of the crystal, the chemical composition of the substance composing it.

We shall now consider the individual substances which occur as constituents of the precipitates in the human organism, their form, chemical relations, and mode of formation.

1. *Protein-compounds.* We have nothing to add to the observations already made (see page 64) regarding fibrin coagulating in the amorphous state. It cannot be doubted that the protein-compounds often separate in a granular form,

and constitute the elementary granules which have been so frequently mentioned. But the special relations of the individual protein-compounds, their metamorphoses, and the different degrees of solubility of their modifications are still imperfectly known, and must be left for future investigators to work out.

As a general rule, precipitates formed from protein may be recognized by the following characteristics: they are never crystalline, usually finely-granular, occasionally amorphous; when treated with an aqueous solution of iodine, they assume a yellow colour; they are insoluble in ether and mineral acids; acetic acid renders them transparent without entirely dissolving them; by prolonged action they dissolve in caustic potash; when they can be isolated and obtained in large quantity, they dissolve by prolonged ebullition in concentrated hydrochloric acid, yielding a lilac-coloured fluid. When a finely-granular precipitate simultaneously presents all these reactions, it may be declared with certainty to be a protein-compound. If only a few of these reactions are exhibited, the diagnosis becomes comparatively less certain.

The causes of the formation of these precipitates are still very obscure. We do not know, whether in individual cases, they consist of fibrin, albumen, or globulin, if we except those instances in which the fibrin coagulates in an amorphous state; and we are equally ignorant regarding the causes giving rise to the precipitation. Albumen, as is well known, is precipitated by the mineral acids, by heat, by alcohol, and by metallic salts—as, for instance, corrosive sublimate: the precipitates caused by these influences are likewise amorpho-granular: but it is extremely seldom that albumen is precipitated within the organism from any of the above causes. Other modes of explanation more closely approximate to the truth. Thus a modification of albumen has been lately recognized, which is precipitable by acetic acid, and another which is thrown down on the simple addition of water. It is probably of these and similar (still unknown) modifications of protein that these precipitates are formed. A wide and fruitful field for investigation is here open before us.

It has been already mentioned that Lehmann referred certain granular precipitates insoluble in caustic potash, to the protein-compounds. I must here remark, that after repeated examinations, I still regard the existence of these protein-granules as very doubtful. In all the cases in which I have met with molecular granules insoluble in caustic potash, I have found, on continuing my examination, that they were perfectly soluble in ether, and therefore consisted of fat.

Whether other organic substances occurring in the human organism, as ptyalin, pepsin, extractive matters, &c., form constituents of precipitates, must for the present remain undecided; the probability is that (with the possible exception of pepsin) they do not, since, under ordinary circumstances, they are readily soluble in aqueous fluids.

2. The *fats* very often occur as constituents of precipitates. The forms in which they present themselves differ with their chemical composition; thus some form very characteristic crystals, whilst others are amorpho-granular.

The following are the fats requiring especial consideration:

a. Cholesterin, which frequently occurs in a crystalline state, and then forms very characteristic rhomboid tablets, with angles of 80° and 100°.* These crystals are insoluble in water, acids, and alkalies, but dissolve in ether and hot alcohol. We have no certain knowledge regarding the causes of the separation of cholesterin; indeed, we do not even know how this substance, which in the normal condition occurs in small quantity in the blood, and many other animal fluids, and in larger quantity in the brain and nerves, is retained in solution. It probably exists in some still unknown combi-

* See Plate x. fig. 1. The numbers given in the text are the mean of twenty admeasurements made by me with the *camera lucida*. The individual admeasurements of the acute angle, varied from 78° to 83°, which affords sufficient evidence of the accuracy with which crystals may be measured in this way.

nation which renders it soluble, and whose gradual decomposition gives rise to its separation in a crystalline state. Cholesterin separates in large masses during the period of old age; and, in this point of view, the statement of Becquerel and Rodier,* that from the 40—50th year the amount of cholesterin increases in the blood of both sexes is very interesting. The augmentation of this substance in the blood is probably connected with an increased separation of it in the various parts of the body. A similar increase may, however, take place in young persons in consequence of a morbid process.

b. Margarin and *margaric acid.* These are crystallizable, forming very characteristic shapes, similar in both cases. They form microscopic needles which rarely occur alone, but usually in stellar or tuft-like groups.† They are most commonly devoid of colour, but sometimes, when occurring in large masses, appear of a dark brownish tint, when viewed by refracted light. The crystals both of margarin and margaric acid are insoluble in water and in acids, but dissolve readily in ether and hot alcohol, and, after prolonged ebullition, in the caustic alkalies.

Crystals of margaric acid may be distinguished chemically from those of margarin, by the circumstance that the former dissolve when boiled in weak spirit, while the latter require strong alcohol for their solution.

The formation of crystals of margarin may be explained in the following manner. Human fat, as it occurs in adipose tissue, consists of an admixture of olein and margarin in indefinite and extremely varying proportions. The margarin, which at the ordinary temperature of the body is solid, is held in solution in the fluid olein, which naturally has a greater solvent power at a high than at a low temperature. Now, when this fat at the temperature of the human body is nearly

* Comptes rendus, 1844, II. p. 1083.

† Plate x. fig. 3.

saturated with margarin, it follows, that on cooling, a portion of the margarin separates in the crystalline form. Hence crystals of margarin are chiefly (if not exclusively) found after death, when the body has become cold. When human fat contains only a little margarin, then of course these crystals do not present themselves on cooling. Their occurrence must be regarded as forming the exception rather than the rule.

Crystals of margaric acid are most commonly found in gangrenous parts, and appear to be a product of the decomposition of the margarin of the fat. The actual cause of this decomposition is still unknown, but may probably be traced to the presence of a free acid, which is frequently observed in gangrene.

c. Olein at the ordinary temperature of the body is fluid, and separates in drops of all sizes (fat-globules), the larger of which are characterized by the peculiar manner in which they refract light. They occur partly free in the liquids of the body, and partly enclosed in cells.* These globules are insoluble in water and in acids, but dissolve readily in ether and hot alcohol, and, after prolonged ebullition, in potash. The behaviour of oleic acid (a rare constituent of the human body) is precisely similar. It is seldom that these fat-globules consist of pure olein or oleic acid; they most commonly contain a portion of solid fat in solution.

The causes influencing the formation of these fat-globules are not always clear. In general this is the original form of olein—that in which, when it enters the body in large quantity, it proceeds from the food into the chyle. Subsequently, however, it appears to undergo changes, and to enter into combinations by which it passes into a state of solution. These combinations being destroyed, the olein again appears in the form of independent drops. Sometimes the free fat-globules proceed from the destruction of fatty

* See Plate I. fig. 9; Plate III. fig. 16; Plate V. fig. 1, b, fig. 4*; Plate VI. fig. 10 A; Plate VII. fig. 1 c.

tissue in which fluid fat is enclosed in fat-cells — as, for instance, in gangrene, in the softening of tumours, and in suppuration occurring in parts abounding in fatty tissue.

d. Moreover fat is often separated in a granular state, as fat-granules, to which some have incorrectly applied the term stearin-granules, for stearin in appreciable quantity does not exist in the human body. The fat in this condition usually occurs in molecular granules of indefinite form and size, their diameter rarely exceeding the 1000th or 800th of a line.* These granules are insoluble in water, acids, and cold caustic potash, but dissolve in ether and hot alcohol. Of what fats they consist we are still just as ignorant as we are regarding the causes leading to their formation and separation. It is possible, and indeed probable, that the serolin of the blood, which is uncrystallizable, and solid at ordinary temperatures, takes a share in their formation.

In addition to the fats that we have named, it is probable that others are sometimes separated, as, for instance, the fats containing phosphorus, and the fatty acids of the nervous system (Frémy's cerebric acid); nothing is, however, yet known with certainty on these points.

3. *Uric acid and the urates.* When uric acid occurs in deposits, we usually find it in the crystalline state. The primary form of its crystals is the rhombic prism, which frequently appears cut down to a tablet, whose principal surfaces are rhombs. The crystals are not unfrequently united in masses with the form of rosettes.† The crystals, which, when perfectly pure, are colourless, often present a reddish tint; they are insoluble in alcohol, ether, and acids; nearly so in water, and only dissolve slowly in caustic potash. Crystals

* See Plate III. fig 1 and 7 B; Plate IV. fig. 1 A; Plate VIII. fig. 1, 4 and 6; Plate IX. fig. 1 and 4.

† The most striking forms of uric-acid crystals are depicted in Simon's Animal Chemistry, Plate II. fig. 23.

of uric acid have hitherto only been found in the urine. For the causes giving rise to their formation, we must refer to our observations on urinary calculi.

Of the various salts of uric acid, the *urate of ammonia* demands the fullest consideration. It never occurs in the crystalline form, but always as a finely granular precipitate,* whose granules are sometimes connected by a tenacious membranous substance. These precipitates are scarcely ever colourless; they present every shade, from a clay or yellowish red tint, to a brownish red or bright rose colour. They are only slightly soluble in cold water, but dissolve more readily on the application of heat, and separate again from the hot saturated solution on cooling. They are insoluble in alcohol and ether; acids decompose them, liberating the uric acid—a circumstance which greatly aids their diagnosis under the microscope; for on adding an excess of acid to a precipitate of this nature under the microscope, the granules gradually disappear, and are replaced by rhombic tablets of uric acid.† Urate of ammonia existing in the sedimentary form has hitherto been found only in the urine: we shall, therefore, postpone our observations on its mode of formation till we speak of urinary calculi.

The *urate of soda* is likewise found in a separated condition in the human body, occurring in many of the gouty concretions of which we shall presently speak.

For certain other sediments which occur solely in the urine (as those of cystin, uric oxide, &c.), we must refer to our observations on urinary calculi.

4. *Salts of lime.* The following insoluble calcareous salts are of frequent occurrence as constituents of precipitates in the human organism.

a. Oxalate of lime forms octohedric crystals, insoluble in water, alcohol, ether, and acetic acid, but soluble in

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* See Simon, op. cit. fig. 28 a.

† See Simon, op. cit. fig. 28 c.

hydrochloric acid. They are sometimes so minute that it is impossible to recognize their crystalline form, and they present the character of a granular precipitate. They have hitherto been only observed in the urine.

b. Basic phosphate of lime, ($8\ CaO + 3\ PO_5$ according to Berzelius) forms, when recently precipitated an amorphous, transparent, colourless jelly, scarcely visible under the microscope, but gradually becomes converted into an indefinite granular mass. It is insoluble in water, ether, alcohol, and alkalies, but dissolves in acids without effervescing.

Phosphate of lime forms a common precipitate in nearly every animal fluid. In the normal condition of the body, it is either held in solution by an acid, or forms soluble compounds with certain organic matters, as protein-compounds, gelatin, (?) &c., a class of combinations which have not yet been sufficiently studied. If a compound of this nature is decomposed, and the phosphate of lime meets with nothing to redissolve it, it separates as a precipitate.

Whether neutral phosphate of lime occurs as a precipitate in the human organism is unknown.

c. Carbonate of lime occurs both as an indefinite granular precipitate, and as a crystalline mass. Perfect rhombohedric crystals of this substance have not yet been observed in the human organism, but have been frequently noticed in animals and plants. They are insoluble in water, ether, alcohol and the alkalies, but dissolve with effervescence in acids—reactions which, when observed under the microscope, are sufficiently characteristic.

Precipitates of carbonate of lime occur in almost every fluid of the body. How they arise is a purely conjectural point. Either the salt exists in the animal fluids as bicarbonate, and becomes precipitated when by the abstraction of carbonic acid, it is reduced to the state of the simple carbonate, or calcareous salts soluble in the animal fluids (as the oleate, or lactate of lime, or chloride of calcium) on meeting with the free carbonic acid which pervades all the usual juices, become decomposed, and form carbonate of lime.

Sulphate of lime is probably an occasional constituent of precipitates; it has, however, not yet been observed.

5. *Ammoniaco-magnesian phosphate* is crystalline; its form, however, varies in accordance with the rapidity with which its crystals are produced. If formed quickly we have stellar groups consisting of acicular crystals, or leafy aggregations presenting a great similarity to the indented leaves of the leontodon taraxicum.* The crystals, when slowly produced, have a very characteristic form; their regular appearance being that of a three-sided prism, in which the angles at the extremities of one margin are truncated by planes passing through the opposite angles at either end. Sometimes other corresponding angles are also truncated, as in fig. 4 b and c of Plate x.†

It is not easy to explain the causes of the numerous deviations in form, which these crystals present, and to reduce them to their common primary form, which appears to be the rhombic prism.‡

Crystals of ammoniaco-magnesian phosphate are insoluble in water, alcohol, ether, and alkalies, but dissolve readily, and without effervescence in acetic and the mineral acids. This chemical reaction, combined with their characteristic crystalline form, renders their diagnosis sufficiently easy. The former and less decided crystalline form of precipitate, generally speaking, only occurs when ammonia is added to the animal fluids, and a rapid precipitate is thus induced. Precipitates formed naturally within the body appear, as far as my experience goes, to consist invariably of the latter and more perfect form of crystals.

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* See Simon, op. cit. fig. 30, where, however, most of the crystals exhibit a more perfect form.

† See Plate x. fig. 4 a, or Simon, op. cit. fig. 27.

‡ See the description of Plate x. fig. 4.

The formation of this precipitate is easily explained: all the fluids of the animal body contain, as a general rule, phosphate of magnesia, and if ammonia is brought in contact with this salt, crystals of ammoniaco-magnesian phosphate are produced. Hence it is that these crystals are amongst the most common that are met with in the microscopic examination of the human body. In the dead body, in which ammonia is developed as a product of decomposition, all the tissues, as well as all the fluids, are often filled with them. Moreover, on examining under the microscope almost any animal fluid to which ammonia has been added, we observe groups of crystals of the first form.

6. *Sulphuret of iron*, when it occurs in large patches, appears to the naked eye as a black, dark blue, or blackish-green deposit. Under the microscope we observe it as a granular precipitate, whose granules vary from mere molecules to the 400th of a line in diameter. It is insoluble in water, but dissolves in acids; on treating an acid solution with hydrosulphate of ammonia, a black precipitate is again formed.

The manner in which this precipitate is formed has been already (see page 195) explained.

7. *Bile-pigment* (the *cholepyrrhin* of Berzelius, the *biliphæin* of Simon) appears as a finely-granular precipitate (sparingly interspersed with minute microscopic crystals) of a yellowish-brown, very fiery colour,* insoluble in water and in most acids. Nitric acid changes its colour in a very characteristic manner; first into a green, then into a blue and a red tint, and finally decolorizes it entirely. As a general rule, it only occurs in the bile. We shall return to the subject in our remarks on gall-stones.

8. *Silica* undoubtedly occurs as a precipitate in the animal fluids, but only in such small quantities that it has not hitherto been detected by the microscope.

* See Plate x. fig. 5.

9. Precipitates may be formed of substances which are readily soluble in the animal fluids, and are only separated by concentration or evaporation of the liquids in which they are dissolved.

To this class belong, in addition to many organic substances, most of the salts with alkaline bases, as chloride of sodium, the phosphates and sulphates of soda and potash, &c. These precipitates form amorphous, granular, or crystalline masses, in accordance with their chemical properties and the time occupied in their separation. They invariably appear, when we examine, under the microscope, fluids which have been exposed to the influence of evaporation; but these are mere artificial products, and do not require to be considered in this place. It would be very desirable if our knowledge of these crystalline forms were more accurate, as it would materially assist us in the chemical examination of the animal fluids.

The question now arises: Do such precipitates occur in the living body in consequence of concentration of the fluids? There are cases in which this certainly appears to occur. Thus, after the internal use of sulphate of magnesia as a purgative, I have observed microscopic crystals of this salt in the liquid evacuations; and probably other purgative salts appear in the fæces in a similar manner. This is, however, a point of little importance in relation to pathological anatomy.

On the other hand, it has been recently stated by F. Boudet,* that in concretions containing phosphate and carbonate of lime, there is also a large quantity of salts readily soluble in water (chloride of sodium, sulphate and phosphate of soda). If this is really the case, it is a very interesting fact, since it appears extremely remarkable that such salts do not, in a very short time dissolve, and thus disappear in the fluids moistening and surrounding them, which are not saturated, and further, are continuously being modified by endosmosis. Hence I think that Boudet's statement requires further confir-

* Journal de Pharmacie et de Chimie, Nov. 1844, p. 335, &c.

mation before it can be regarded as expressing an undoubted fact.

These are the substances which have been hitherto regarded as the constituents of the precipitates occurring in the human body. Further investigation will probably lead to a considerable extension of the above list.

From these precipitates, which are frequently invisible to the naked eye, and which, to be correctly observed in their various relations, require a microscopic examination, there are formed large concrements or concretions in a manner differing in individual cases, and not always very obvious.

The various concretions may be arranged into two large groups:

1. Such as arise in the fluid secretions of the body; and,
2. Such as are formed in the parenchyma of organs.

FIRST CLASS.

CONCRETIONS IN THE FLUID SECRETIONS.

These are invariably formed from the above-mentioned precipitates, but the mode of formation varies. They may arise in any or all of the following ways:

1. From an amorphous or crystalline precipitate there may be formed a tenacious crystalline mass—a concretion; the same process taking place on a large scale, as on a smaller scale influences the conversion of an amorphous into a crystalline precipitate.

2. A portion of a loose, disconnected precipitate, may be held together by mucus or some other connecting medium.

3. The precipitate may attach itself to a foreign body in just the same manner as crystals deposit themselves around such a body inserted in a saline fluid, forming an incrustation. In fact, there are two ways in which a foreign body exerts an influence in the formation of a concretion; one being, that it frequently excites a disposition in a fluid to form a precipitate. Thus, for instance, by exciting inflammatory

irritation, it may give rise to the secretion of a too alkaline state of the serum, or of pus, which on their part produce a precipitation of the earthy phosphates held in solution in an acid fluid, as, for instance, the urine. The other manner in which a foreign body acts, is by its causing a precipitate which, without it, would have been discharged, to collect around it, and thus form a concretion. Pessaries act in this manner in the vagina; and foreign bodies, in the nasal cavity and intestinal canal. They first become encrusted, and ultimately form the nucleus of a concretion.

In one of these three ways the nucleus of the concretion becomes formed, and as precipitates are continually being deposited around the nucleus, the concretion gradually increases. The augmentation proceeds either by layers, or in another manner. The mode of increase, and the consequent texture of the concretion, depend on the character of the deposits: if they consist of large pieces or crystals, the concrement is uneven and angular; if, on the other hand, the deposit consists of fine granules, it is regularly laminated and smooth. Hence the external form of concretions presents many varieties; generally it is round, but if several are simultaneously present, and they are at all soft, as, for instance, is the case with most gall-stones, their mutual pressure and friction render their form polyhedric. Their shape also depends on that of the organ in which they are formed; if it is a narrow canal, the concretion is elongated, acicular, or sausage-like; if it is of an irregular form, so also is the concretion; in cavities dividing into branches, as, for instance, in the pelvis of the kidney, the concretions have frequently a ramifying form. These relations are too obvious to require further comment.

When these concretions are large, they receive the name of calculi, or stones; when they are minute and numerous, they are termed sand, or gravel.

We now proceed to the consideration of the various sorts of concretions.

1. URINARY CALCULI.

To this class belong all concretions whose mother-liquid is the urine. They may be formed in any part of the urinary apparatus; their most common seats of formation are, however, the kidneys and bladder, and we consequently distinguish *renal* and *vesical* calculi. Calculi found in the ureters and the urethra are usually not formed there, but in the kidneys or bladder, and getting into those canals, become impacted there. It has happened, after injury to the urinary organs, that calculi have formed in the adjacent tissues into which there has been infiltration of urine.

According to the above terminology we distinguish between urinary calculi, and urinary gravel or sand. Under the latter denomination we include the innumerable minute concretions which are so small that they can be discharged through the urethra without pain.

Urinary calculi present great differences, not merely in their physical characters—as form, size, hardness, and colour—but also in their chemical constitution and in the relations inducing their formation. They sometimes consist of the same chemical ingredient throughout, sometimes of a mixture of several substances; hence they are simple and compound.

We shall first consider those which contain only a single ingredient:*

1. Calculi of *uric acid* and *urates* are the most common of all urinary concretions, but, according to the substances of which they are composed, they present many varieties.

* The literature of urinary calculi is very copious. A list of the older writers would occupy too much space. Of the more recent authors we may especially mention: Berzelius in his Lehrbuch der Chemie, translated into German by Wöhler, vol. IX. 4th Ed. p. 486, &c.; Scharling de Chemicis calculorum rationibus, Havniæ, 1839; or Dr. Hoskin's English translation, London, 1842; and Taylor's Catalogue of the Calculi in the Royal College of Surgeons, London.

Calculi of uric acid are very frequent, and often attain a considerable size. It is very seldom that the uric acid is perfectly pure, and that the calculi are white; it is most commonly associated with the colouring matters of the urine, which communicates to such concretions a yellow, red, or reddish-brown tint. They are sometimes smooth, sometimes (but more rarely) verrucose, and frequently consist of regular laminæ. They almost always contain minute quantities of other ingredients.

This species of calculus is very easily recognized by the characteristic reaction of uric acid; on dissolving it in nitric acid, with the aid of a gentle heat, evaporating nearly to dryness, and then adding a little ammonia, a very beautiful purple colour is evolved. Beginners may easily commit the error of exposing the nitric-acid solution to too powerful a heat, in which case the expected reaction does not occur. This is best avoided by adopting Jacobson's plan of gently warming a minute portion of the stone—not larger than a mustard-seed—in a watch-glass, with a couple of drops of nitric acid, till by evaporation the solution forms a thick fluid mass; this must now be inverted over a second watch-glass containing a few drops of caustic ammonia. The vapour of the ammonia will saturate the nitric acid, and the red colour will appear.

This reaction occurs equally whether the stone consists of pure uric acid or of urates. We now proceed to explain how the latter may be recognized.

Calculi consisting entirely, or for the most part, of urate of ammonia, are rare, and usually small. They are seldom white, being more commonly of a clay or yellowish-red colour. Their surface is smooth, or studded with minute warts; on making a fracture, they appear earthy or laminated.

The first step in the recognition of urate of ammonia is afforded by the characteristic reaction of the uric acid, from which, however, it may be distinguished by the following means:

Uric acid is almost insoluble in water, while urate of ammonia dissolves in hot water to a very considerable extent. We, therefore, boil a little of the pulverized calculus in water, and filter the saturated solution while still hot. On cooling, a portion of the dissolved urate of ammonia separates from the filtered solution as a granular precipitate. On treating it under the microscope with a little mineral acid, it gradually disappears, and is replaced by crystals of uric acid.

As the other urates, which, however, seldom occur in calculi, exhibit the same reaction, we must carry our researches further, in order to be convinced of the presence of urate of ammonia. We must extract the pulverized calculus with cold water, previous to its treatment with boiling water, in order to make sure that it is freed from any ammoniacal constituents of the urine that might be present. The urate taken up by extraction with hot water, may then be shown in two ways to be urate of ammonia. If we burn it, it will be found to be entirely volatile, while the urates with fixed bases leave an incombustible residue; and if we treat it with a weak solution of potash, and apply a gentle warmth, it developes ammonia, which may be detected by the smell, by the white vapour produced on holding over it a glass rod, moistened in hydrochloric acid, or by its communicating a blue tint to red litmus paper placed above it.

The other urates—the soda, magnesia, and lime salts—do not often form the sole constituent of urinary calculi, but sometimes occur in larger, or smaller quantity in calculi of which the principal mass consists of other substances.

The means of detecting these salts are similar to those employed for the urate of ammonia. They must first be obtained in a state of purity by extraction with hot water, filtration, and evaporation. On the application of a strong heat, the uric acid is destroyed, and the composition of the residual fixed basis must be determined by the ordinary rules of inorganic chemistry.

Causes and mode of formation of these concretions. The ordinary proximate cause leading to the formation of all calculi containing uric acid is a peculiar condition of the urine—its saturation with urates.

The practised physician detects this property of the urine by observing, that on cooling it becomes turbid, and deposits a sediment consisting of urate of ammonia. But, besides this, there is a second condition requisite, namely, that a portion of this excess should be precipitated either as urate of ammonia or as free uric acid, in the urinary passages within the body. In by far the larger number of cases, the precipitate consists of uric acid, arising from the urate being decomposed by a free acid in the urine; the uric acid being much less soluble in urine than its salts, the greater portion becomes separated.

Whether the urates can separate from the urine, as a primary precipitate within the body, appears to me to be doubtful, since the ordinary cause giving rise to the formation of a sediment of urates—namely, the cooling of the urine—does not occur there. Such a precipitate may, however, be formed if urine, saturated with urates, remains for a long time within the bladder, and loses water in consequence of endosmotic action established with the blood. The above conditions do not, however, lead to the formation of a stone, but merely of a precipitate, which frequently consists of such minute granules that they can only be detected by the microscope, and do not form a sediment till the urine has stood for some time. From these precipitates there may be formed urinary gravel, if its constituents, in consequence of any of the above-mentioned causes, adhere within the body, and there form larger masses. For the production of a stone, it is requisite that there should first be a nucleus formed; this may consist of uric-acid gravel retained in the urinary passages in consequence of its size or position, or a clot of mucus, blood, or fibrin, or a foreign body. For the formation of a uric-acid calculus, it is requisite that the above-mentioned uric-acid diathesis should persist for some time, that is to say, that there should be a continuous excess of urates in the urine. The precipitates separated from the urine then deposit themselves by preference, around the nucleus; these precipitates may consist either of uric acid liberated by the presence of a free acid, or of urates, which separate themselves from the saturated urine, in consequence of the presence of a stone.

Such are the formative relations of calculi containing uric acid, as far as morbid anatomy has yet taught us. The investigation of the causes inducing this diathesis, fall under the department of general pathology. Chemistry has been directly applied by Liebig and others to its elucidation. It, at least, points out the path which the investigator must follow, even if the special results already attained, are not to be regarded as decisive. In accordance with these principles, the occurrence of the uric-acid diathesis must be explained in the following manner.*

It can hardly be doubted that the greater part of the protein-compounds contained in the nutriment and in the constituents of the body, are metamorphosed into urea and uric acid, and in this form are discharged by the urine, even if we are ignorant of the intermediate links between the protein on the one hand, and the urea and uric acid on the other. This metamorphosis can only be effected by the addition of oxygen, as may be shown by calculation; and undoubtedly more oxygen is requisite to convert, theoretically, one atom of protein into urea, carbonic acid, and water, than is necessary to form uric acid, with carbonic acid and water: for

	1 equiv. protein. . .	=	C_{48}	H_{36}	N_6	O_{14}
is equivalent to	3 equiv. urea. . .	=	C_6	H_{12}	N_6	O_6
	42 ,, carbonic acid. .	=	C_{42}			O_{84}
	24 ,, water. . .	=		H_{24}		O_{24}
			C_{48}	H_{36}	N_6	O_{114}

Hence in this metamorphosis there are consumed 100 equivalents of oxygen.

But if, in place of urea, uric acid is formed, the case is different: 1 equiv. protein yields

3 equiv. uric acid. . .	=	C_{15}	H_6	N_6	O_9
33 ,, carbonic acid. .	=	C_{33}			O_{66}
30 ,, water.	=		H_{30}		O_{30}
		C_{48}	H_{36}	N_6	O_{105}

* See H. Bence Jones on gravel, calculus, and gout, London, 1842; Valentin's Lehrbuch der Physiologie, vol. I. p. 759, &c.

Hence for the conversion of protein into uric acid, there are required only 91 equivalents of oxygen. This explains how a diminished quantity of oxygen may be the cause of the formation of an extraordinary quantity of uric acid in the body, at the expense of the urea. Extending these considerations to the food, we see how certain forms of diet favour this uric-acid diathesis. As in the metamorphosis of protein, the greater part is discharged as urea and uric acid, so it cannot be doubted that many kinds of food devoid of nitrogen, at the termination of their metamorphoses, are for the most part discharged as carbonic acid and water. Moreover, for this purpose a combination with oxygen is necessary, which is supplied to the body by respiration. We may, however, show how different sorts of food require different quantities of oxygen, in order to effect this metamorphosis.

Thus 100 parts of starch (= 44.5 C + 6,2 H + 49.3 O) require:
118.5 parts of oxygen in order to form (163 CO_2 (44.5 C + 118.5 O), and 55.5 H O (6.2 H + 49.3 O).

100 parts of sugar (= 42.2 C + 6.4 H + 51.4 O) require:
112.4 parts of oxygen to yield 154.6 CO_2 (42.2 C + 112.4 O), and 57.8 H O (6.4 H + 51.4 O).

100 parts of fat (= 79 C + 11 H + 9 O) require:
289 parts of oxygen to form 289 CO_2 (79 C + 210 O), and 99 H O (11 H + 88 O).

100 parts of alcohol (= 52.2 C + 13 H + 34.8 O) require:
208.4 parts of oxygen to form 191.2 CO_2 (52.2 C + 139 O), and 117.2 HO (13 H + 104.2 O).

If under certain conditions of life the quantity of oxygen taken into the body be sufficient to convert into urea, carbonic acid, and water, those constituents of the food which consist especially of starch and sugar, together with the protein-compounds, we may easily conceive that in food rich in fat, associated with a free use of alcohol, the oxygen is no longer sufficient for the perfect conversion of the protein-compounds into urea, but that, in the place of the latter, uric acid will be formed. Experience also teaches us, that food, when of a fatty nature, and the copious use of alcohol, together with an imperfect supply of the oxygen necessary to respiration, favour the uric-acid diathesis. At all events, the above observations point out the way which may lead to a true explanation of this formation, although we must not forget that there may possibly be many acting intermediate agents with which we are unacquainted, and that the above statement can therefore only be regarded as hypothetical.

2. Calculi of *urous acid* (*uric* or *xanthic oxide*) are of rare

occurrence, but resemble, in every respect, those consisting of uric acid.

A stone consisting of this substance, which was examined by Wöhler, was externally of a light brown colour, mixed here and there with white; on making a fracture it exhibited a faint brownish flesh-colour, and was found to consist of concentric layers; by friction it acquired a wax-like polish, and was of about the same hardness as uric-acid calculi.

The characteristic chemical reaction of this substance consists in its solubility in nitric acid without effervescence, and on the solution leaving after evaporation a substance of a bright lemon colour, which is not soluble in water, but is changed to a deep reddish yellow by caustic potash. The characteristic purple which uric acid exhibits when acted on by nitric acid and ammonia, is in no way to be compared with the above-named substance.*

The structural relations of these calculi are unknown, but are most probably the same as those of the uric-acid calculi. Thus the same reasons which have been given concerning the formation of the uric-acid diathesis, may also explain the origin of this substance, since uric oxide exhibits no difference in its chemical composition from uric acid, excepting that it contains an atom less of oxygen than the latter. It is, therefore, probably formed, instead of urea and uric acid, from a deficiency of oxygen in the metamorphosis of the tissues.

3. Calculi of *cystin* (*cystic oxide*) are also rare, although less so than those of uric oxide. They are yellowish, of a smooth surface, and exhibit a crystalline appearance on fracture. The diagnosis of these calculi, and likewise of sediments consisting of cystin, will be most readily determined by the combined application of chemistry and the microscope. Cystin is almost entirely insoluble in water, but dissolves easily in alkalies. If its solution in caustic ammonia be left to evapo-

* See Wöhler und Liebig's Annalen der Pharmacie, vol. XXVI. Part 3.

rate, very well marked crystals—regular hexagonal tablets—appear; they are, in fact, tabular prisms.* But if the cystin be dissolved in a dilute mineral acid, and the solution suffered to evaporate at a moderate heat, groups of divergent radiating, acicular crystals appear. Cystin is also characterized by containing a considerable quantity (25.5%) of sulphur. On this circumstance is founded a method, proposed by Liebig, for ascertaining the presence of cystin. The calculus is dissolved in a strong alkaline solution, to which are added a few drops of acetate of lead, but no more than can be retained in solution. When this mixture is boiled, a black deposit of sulphuret of lead is precipitated, which gives it the appearance of ink.

Calculi of cystin appear to be most prevalent in children. Scarcely anything is known of their formation, relations, or the causes of their origin, although we may conjecture that the sulphur in the protein-compounds has something to do with the formation of cystin.

4. Calculi of *oxalate of lime* are tolerably frequent, and are either moderately large, with a rough surface, jagged, verrucose, and of a dark brownish colour—in which case they are named, from their peculiar appearance, mulberry calculi—or they are small, more faintly coloured, and smooth, and are then termed hempseed calculi. They may be best known by the following reactions—they are insoluble in caustic potash, but dissolve without effervescence when boiled in hydrochloric acid. If a portion of the stone is heated before the blow-pipe, and then moistened with a drop of water, it exhibits an alkaline reaction, in consequence of caustic lime having been formed. The solution of the heated mass in water is precipitated by oxalic acid.

The causes from which these calculi originate are also in a great measure unknown, although in some cases their origin may be explained by the action of oxalic acid which has been introduced into the body by food, &c. Thus, after partaking

* See Simon, op. cit. Plate III. fig. 32.

of food containing oxalic acid, as sorrel, &c. a sediment of oxalate of lime appears in the urine, and a long adherence to a similar diet may give occasion to the formation of these calculi. But it is not in every case that their origin can be explained by the oxalic acid taken in the food; and we are hence led to the conjecture that it may be formed in the organism from other substances. Indeed, Liebig and Wöhler found in their investigations regarding the products of the decomposition of uric acid, that on treating it with peroxide of lead or with nitric acid, oxalic acid, together with other substances, was formed. And this fact renders it highly probable that oxalic acid may be formed in the organism from other substances; but what these are, and under what condition it is formed, are questions which it is impossible at present to answer. At all events, oxalate of lime does not exist in the blood, since it could not pass undissolved into the urinary canals. Oxalic acid must either pass into the urine in a free state from the blood, or in some soluble combination, and there unite with the lime, forming an insoluble compound.

5. Calculi of *earthy phosphates* (phosphate of lime and ammoniaco-magnesian phosphate.) Calculi of phosphate of lime alone are very rare; those consisting only of ammoniaco-magnesian phosphate less so, while the most frequent present a combination of both salts. These calculi are of a whitish colour, sometimes earthy, chalky, very light and porous; sometimes laminated, in which case they are usually firmer. Those which especially contain calcareous salts are not easily fusible by the blow-pipe; they become more readily fusible in proportion as the magnesian salts predominate, when they are termed fusible calculi. They are characterized by dissolving in acids without effervescence, and by being precipitated unchanged from an acid solution by means of ammonia. The following points may serve to decide whether a stone contain more lime or magnesia:—1. The degree of fusibility before the blow-pipe. 2. If the acid solution of such a stone

be saturated with ammonia, and then decomposed by oxalic acid, the lime alone, as oxalate of lime, will be precipitated. If the filtered solution be treated with an excess of ammonia, ammoniaco-magnesian phosphate is precipitated in the previously described crystalline form, and we may then draw a comparison between the quantity of magnesian and calcareous salts.

The formation of these calculi is clearly explained by the facts we have already laid down. The urine always contains phosphate of lime and phosphate of magnesia. If from any cause it becomes ammoniacal, both salts are precipitated. But if, on the other hand, it contains an excess of carbonate of potash or of soda, then the phosphate of lime is alone precipitated. As the latter change of the urine occurs much less frequently than the former (only after the continued use of alkaline carbonates, and of vegetable salts which are converted in the organism into carbonates, while carbonate of ammonia very frequently occurs in the urine from the decomposition of urea,) and as phosphate of magnesia is generally found in larger quantities in the urine than phosphate of lime, it is easily explained why the magnesian salts should occur more frequently in urinary calculi than phosphate of lime. As soon, therefore, as conditions tending to render the urine continuously alkaline are established, a simple precipitate will probably be converted into a stone; and in this manner a calculus of this kind may be gradually formed.

6. Differing from the calculi already considered, are those which appear to consist wholly, or partially, of indifferent organic matter (fibrin and other protein-compounds, mucus, &c.) They have hitherto been only seldom observed (by Marcet, Morin, A. Cooper, Brugnatelli, and Scharling.) Concretions of this nature are almost entirely consumed before the blow-pipe, and yield an odour of burnt horn; they are insoluble in acids, but dissolve in alkalies, and exhibit no trace of crystallization.

They are produced in an entirely different manner from other urinary calculi, their formation resembling that of concretions occurring in the parenchyma of organs, which we shall consider presently; they arise either from vesical mucus, or more frequently from coagula of blood and fibrin which accumulate in the pelvis of the kidney or in the bladder, and subsequently experience further changes.

It is only in rare cases that we find urinary calculi so simple as we have described them; they generally contain several constituents, not merely those we have named, but also a small quantity of carbonate of lime, carbonate of magnesia, and silica. These are often variously associated; sometimes two only occur, sometimes more, sometimes all are found combined in a single stone. Thus there are calculi which consist of a mixture of uric acid and urates; others of uric acid and urates with earthy phosphates; and others, again, which are formed from a combination of oxalate of lime and earthy phosphates. Some calculi have been found to contain uric acid, oxalate of lime, phosphate of lime, urate of ammonia, carbonate of lime, and ammoniaco-magnesian phosphate, being thus composed of six different substances.* These different constituents are sometimes intimately united, but more frequently disposed in more or less regular layers, so that the same calculus may exhibit different chemical properties in the different strata, which have evidently arisen at various periods. The relations and order of deposition of these laminæ differ considerably in different cases.†

The progress of these varying laminæ in the same stone may, in most cases, be explained with tolerable satisfaction by the aid of the observations we have already made on the mode of formation of the individual calculi, and throws a new light upon the manner in which these concretions are produced.

* Loir, Journ. de Chimie médic. Sept. 1834.

† See Berzelius, op. cit. p. 501; Sandifort, Museum anatomicum, vol. III.; Bence Jones in Medico-chirurg. Transactions, 1843, p. 100, &c.

Thus we have alternating laminæ of uric acid and urates, if in a prolonged uric-acid diathesis the urine is occasionally very acid, by which the urates are decomposed, and uric acid separated; while at other times, on the contrary, the excess of acid abates, and urate of ammonia is deposited from the saturated fluid upon the surface of the stone. When the uric acid alternates with the oxalic diathesis, alternating laminæ of uric acid or urates and oxalate of lime are formed. The by no means uncommon calculi of uric acid or oxalate of lime with earthy phosphates, arise when the uric-acid or oxalic diathesis periodically abates, and in the interval the urine becomes ammoniacal by the decomposition of urea. This alkaline tendency is further increased by a copious discharge of mucus from the irritation of the stone, and the occasional retention of the urine by the stoppage of the urethra, or the outlet of the bladder.

The alternating laminæ of uric acid and phosphate of lime in the same stone may sometimes be induced by medicines—as the alkalies—which are given to hinder the enlargement of the uric-acid calculus, but may, in making the urine alkaline, induce an augmentation by the deposition of phosphates.

The nucleus of urinary calculi is often differently composed from the rest of the body. Crosse* found the nuclei of one hundred stones thus composed: seventy-two consisted of uric acid and urate of ammonia, nine of uric acid and oxalate of lime, fourteen of oxalate of lime, one of carbonate of lime, and two of earthy phosphates. In other cases the nucleus was found to consist of cystin, of organic matter, coagulated blood, mucus, or some foreign body. Sometimes the stone exhibits a cavity instead of a nucleus in its interior; in these cases the nucleus was probably formed of mucus, which subsequently dried up. In some rare cases the nucleus has been known

* On the Formation, Composition, and Extraction of Urinary Calculi, London, 1835; G. O. Rees, an Introduction to the Chemical Analysis of the Blood and Urine, London, 1845.

to rattle within the stone, which could only be explained by a similar drying of mucus. Sometimes the calculus consists of gravel or several minute stones, united together by a cement which is occasionally of the same nature as the concretions.

The occurrence of urinary calculi depends, as has been before mentioned, upon diet, but also on climate and other local relations, such even as the nature of the soil.

The further prosecution of this inquiry, however important it may be to the right knowledge of the origin and mode of treatment of urinary calculi, appertains, more properly speaking, to pathology than to pathological anatomy.*

We must accurately distinguish from urinary calculi those concretions which are not formed in the urinary system, but in the organs of generation.

To these belong concretions of the prostate gland. Prostatic calculi have, for the most part, very characteristic properties, by which they may be easily recognized; they are always small, somewhat about the size of a pin's head, and are usually of a brownish, reddish-brown, or yellowish-brown colour. They are crystalline or laminated, and frequently exhibit a polyhedric or facetted surface, like a granule of phosphate of lead fused before the blow-pipe. Their chemical constituents are phosphate of lime, with a little animal and colouring matter.

They are doubtlessly formed by a precipitate of phosphate of lime, but the causes which tend to their formation are not accurately known.†

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* See Windemuth, de lithiasi endemica, Marburgi, 1842; a work with copious references; and H. Textor, Versuch über das Vorkommen der Harnsteine in Ostfranken, Würzburg, 1843.

† For further information regarding prostatic concretions, see Gluge's Untersuchungen, Part 1, p. 90; Cruveilhier, Anatomie pathol. liv. 30, pl. I.; Dupuytren in Meckel's Archiv. VI. 3.

An illustration of the quantitative composition of these concretions is given by an analysis by Lassaigne. It yielded in 100 parts:

Basic phosphate of lime.	84.5
Carbonate of lime.	0.5
Animal matter (mucus, &c.)	15.0

Concretions of similar chemical composition are sometimes found in the vesiculæ seminales and the vasa deferentia. They are formed, doubtlessly, like prostatic calculi, from the secretion of these glands, when from any cause it contains more calcareous salts than in the normal condition. A precipitate then occurs, which, under favourable conditions, passes into a concretion.

Peschier found in 100 parts of such a concretion:

Phosphate of lime.	90
Carbonate of lime.	2
Animal matter.	10

Similar concretions are found in the female generative organs, consisting chiefly of earthy phosphates, which are formed in a similar manner as urinary calculi composed of the same substance.

Illustrations: A large calculus in the uterus, the nucleus, of which was a part of the tibia of a fowl, (consequently an incrustation), consisted of phosphate of lime. Another large stone in the uterus consisted of ammoniaco-magnesian phosphate, surrounded by phosphate of lime (Brugnatelli). A concretion from the vagina of an old woman was of a yellowish white colour, and consisted of phosphate of lime with animal matter (mucus ?) which remains in flocculi on dissolving the concretion in hydrochloric acid. (Thomson).*

II. SALIVARY CONCRETIONS.

The saliva contains amongst its normal constituents a very small number of those substances which, under favourable circumstances, might give occasion to the formation of an insoluble precipitate. These are the insoluble earthy salts (phosphates of lime and magnesia) whose solution is probably

* Leop. Gmelin, Chemie, II. 2, 1372.

occasioned by an unknown combination with organic substances, and soluble salts of lime, which, under certain conditions, can be converted by chemical decomposition into insoluble carbonate of lime. If the quantity of these constituents be abnormally increased, and if at the same time conditions occur by which their solution in the saliva is hindered, a precipitate occurs. This precipitate is either carried off with the discharged saliva as quickly as it is formed, or it remains, accumulates, and unites so as to form larger masses—concretions. Salivary concretions are, however, of two kinds, forming salivary calculi, and the tartar of the teeth.

Salivary calculi are formed when the precipitate occurs within the salivary glands, and there accumulates (in accordance with the general laws regulating the formation of concretions), frequently attaining such a size as to close up the excretory ducts, and prevent their being voided. Salivary calculi are thus continually increasing, by always receiving new precipitates. They occur either in the parenchyma of the salivary glands or in their excretory ducts. They are roundish or oblong concretions, varying from the size of an almond or olive, to that of a pigeon's egg, and are of a whitish colour; they are sometimes definitely laminated, consisting of concentric layers, sometimes of indistinct laminæ; they have a chalky, dead-white appearance, and are usually easily pulverized, but occasionally as hard as stone. They sometimes enclose a hard, thick nucleus of a greenish colour. Their principal constituents are always calcareous salts, viz., carbonate of lime united with animal matter (mucus, or modified protein.)

If the precipitate does not occur in the salivary glands, but is first observed in the buccal cavity, it deposits itself over the whole surface of the mouth. Thus, on examining the fur on the tongue, we often find the epithelial cells encrusted with a granular deposition of calcareous salts. But as the epithelial cells of the cavity of the mouth are being constantly abraded, the precipitates cannot of course accumulate to form concretions. It is only to the teeth, (and then from want of cleanliness,) that such an adhesion is possible, and thus we are able to explain the formation of the tartar which is deposited around the base of the gums, the body of the tooth, and between the teeth, exhibiting, when broken off, hardish particles of a grayish-white colour. The formation of this tartar is probably more dependant on an increased quantity of lime in the secretion of the minute glands of the buccal cavity, than on a similar alteration in the saliva.

An analysis made by S. Wright* will show how much the quantity of the calcareous salts of the saliva may be increased by morbid processes. The quantity of phosphate of lime which is only 0.6 in 1000 parts of normal saliva was once found to be increased to 14. And in some previous observations of the same author, the saliva was so calcareous that it stiffened to a white chalky mass.

The following tables will give an idea of the quantitative composition of salivary calculi. They contained in 100 parts:

	1	2	3	4	5	6	7
Carbonate of lime	81.3	79.4	80.7	13.9	20	15	2
Phosphate of lime	4.1	5.0	4.2	38.2	75	55	75
Phosphate of magnesia	—	—	—	5.1	—	1	—
Soluble salts	6.2	4.8	5.1	38.1 (soluble salts and animal matter together)	—	—	—
Animal matter	7.1	8.5	8.3		5 (animal matter and water and loss together)	25	23
Water and loss	1.3	2.3	1.7	6.3		2	—
	100.0	100.0	100.0	101.6	100	98	100

1—3. Salivary calculi analyzed by Wright, op. cit. p. 57.

4. v. Bibra. Medicin Correspondenzblatt für baierische Aerzte, 1843. No. 47. The stone had a specific gravity of 0.933, contained only in the nucleus, mucus and albumen. The above analysis explains the composition of the lamina surrounding the nucleus. It contained together with 35% of organic substances 3.1% fat with traces of soda.

5. Lecanu. This calculus consisted of a hard thick nucleus of a grayish colour with a white and easily pulverizable capsule. L. Gmelin's Chemie, II. 2, 1399.

6. Besson in Gmelin, op. cit. The stone was taken from the Whartonian duct of a woman, aged sixty years; it was roundish,

* Der Speichel, in Dr. Eckstein's Handbibliothek des Auslandes, Wien, 1844, p. 173.

white, pulverizable, and consisted of concentric layers; its specific gravity was 2.30. It contained, besides the above named constituents, 2⅙ peroxide of iron.(?)

7. Golding Bird. Die Harnsedimente, Handbibliothek des Auslandes, edited by Dr. Eckstein, p. 93.

For further analyses see Berzelius' Chemie, vol. IX. 4th edit. p. 229; John in Meckel's Archiv. VI. 4; Rath im Baumgarten's Zeits. von Chirurgen für Chirurgen, vol. I. Part 2, p. 29, &c.

Tartar from the teeth was found to be composed of:

	1	2
Earthy phosphate (lime and magnesia)	79.0	66
Carbonate of lime.	—	9
Mucus (with epithelium?)	12.5	13
Ptyalin.	1.0	—
Animal matter soluble in hydrochloric acid.	7.5	5
Water.	—	7
	100.0	100

1. Berzelius. 2. Vauquelin and Laugier.*

Denis† has examined the brown fur of the tongue in cases of deranged digestion, after it had been scraped off with an ivory knife and dried. It then formed a firm, translucent, yellowish gray mass, which contained no crystals. Its chemical composition was as follows:

Phosphate of lime.	34.7
Carbonate of lime.	8.7
Altered mucus (epithelium, &c.)	50.0
Loss.	6.6
	100.0

The sordes attached to the teeth of the same person were similarly composed. If, therefore, we except the fact that the depositions on the tongue must contain many more epithelial cells than the tartar of the teeth, there is a striking resemblance in the chemical composition of both, and it appears clear that they must originate from the same causes. According to Mandl, the formation of tartar is in no way connected with the increased quantity of lime in the saliva, but produced by the skeletons of dead infusoria, agreeing in form with those of the vibriones which deposit themselves in viscid matter, and between the teeth, and thus form concretions. This view appears to me to be wholly

* Berzelius, Thierchemie, 4th edit. p. 228.

† L. Gmelin, II. 2, 1397.

untenable. I certainly have occasionally, but not always found vibriones in large numbers in the fur of the tongue, and in the viscid matter around decayed teeth, &c.; they had, however, no calcareous skeletons, while on the other hand, granular precipitates of calcareous salts were to be met with together with these vibriones. If, therefore, the latter play any part in the formation of tartar, it must be a very subordinate one.

III. LACHRYMAL CALCULI.

These occur under similar circumstances to salivary concretions. Although, in the normal state, tears form a very watery fluid, they contain a small quantity of calcareous salts, which, when considerably increased by pathological conditions, can give rise to concretions. These are either formed in the lachrymal glands, in the eye, the lachrymal ducts, or the lachrymal sac. In the latter concretions, the fatty matter secreted by the meibomian glands occurs as one of the constituent parts.

Fourcroy and Vauquelin found in calculi of the lachrymal gland, a preponderance of phosphate of lime. The chemical composition of these concretions is often very complicated, as the following analyses show. These concretions contained in 100 parts:

	1	2
Phosphate of lime.	47.3	9
Carbonate of lime.	8.4	48
Carbonate of magnesia.	1.1	—
Peroxide of iron.	0.9	—
Chloride of sodium with soluble earthy matter.	5.9	Traces
Mucus.	20.3	18
Albuminous matter.	—	25
Fat.	11.9	Traces
Water.	3.0	—
	98.8	100

1. A concretion formed in the eye of a blind man, and examined and analyzed by Wurzer, (Berzelius, Thierchemie, p. 722). Yet it seems questionable to me whether this concretion can be reckoned as appertaining to lachrymal calculi. The fat was probably a product of the secretion of meibomian glands.

2. A lachrymal concretion found by Desmarres in the lachrymal duct and sac, weighed about six grains, and had a specific gravity of 1.4: analysed by Bouchardat, (Annales d'oculistique, Août, 1842).

Other cases may be found in Walther's Journal der Chirurgie, 1820, p. 164; Sandifort's Observat. anat. patholog. vol. III. p. 71, where many older cases are referred to.

4. *Concretions in the nostrils, the throat, the tonsils, and the bronchi,* originate in the same manner as salivary calculi, and have a similar chemical composition.

Such concretions sometimes occur as incrustations around foreign bodies. Ruysch relates* that an amber bead which had accidentally lodged in the nose of a child of five years of age, and was not expelled until the girl attained her fourteenth year, was surrounded by a stony crust. The same authority gives another case, where the same thing occurred with a cherry stone. Grandoni described† a stony concretion, which had formed in the left nostril of a woman, and was extracted with the forceps. It weighed seventy-six grains, and contained phosphate and carbonate of lime, carbonate of magnesia, and organic matter with traces of iron. Two other forms of concretions had the following composition:

	1	2
Phosphate of lime. . . .	46.7	79.56
Carbonate of lime. . . .	21.7	6.41
Carbonate of magnesia. . .	8.3	—
Chloride of sodium and other soluble salts.	Traces	0.58
Animal matter. . . .	23.3	4.52
Water.	—	8.93
	100.0	100.00

1. A concretion from the nose, which had occasioned a periodical hemicrania; it was of a yellow-grayish colour, and earthy: analysed by Geiger. The animal matters were noted as mucus, fibrin, osmazome and fat, (L. Gmelin, II. 2, 1397).
2. A concretion from the nose of a woman aged seventy years: analyzed by Brandes, (Berzelius, vol. IX. p. 722).

A concretion from the tonsils analysed by Laugier, was greyish-white,

* Observat. anatomico-chirurg. centuria. Observ. 45.

† Omodei annali universali di medicina. Ottobre, 1839.

rather hard, verrucose, and consisted of a rough crust, and a white nucleus. It contained:

Phosphate of lime.	50.0
Carbonate of lime.	12.5
Mucus.	12.5
Water.	25.0
	100.0

V. PANCREATIC CALCULI.

These are of rare occurrence, but appear to be occasionally formed from the pancreatic fluid, in the same manner as salivary and lachrymal calculi are formed from their corresponding secretions, and they resemble these latter in their chemical composition.

Golding Bird has examined a pancreatic calculus which contained in 100 parts:

Phosphate of lime.	80
Carbonate of lime.	3
Animal matter.	7
	90

(Die Harnsedimente, Handbibliothek des Auslandes, edited by Dr. Eckstein, p. 93).

Plates of pancreatic calculi are given in Baillie's engravings, fasc. 5, Plate VII. p. 117.

VI. GALL-STONES.

Under this term are included all concretions which are precipitated from the bile. They appear in all parts of the biliary apparatus, but most frequently in the gall-bladder, rarely in the biliary ducts of the liver, in the *ductus hepaticus*, *cysticus* or *choledochus*, and in the intestinal canal.

Gall-stones exhibit great differences in their chemical composition, and vary in a corresponding manner in their physical properties. Their chemical constituents are as follows:

1. Cholesterin, which may easily be recognized by the

rhombic tablets, in which it separates from a solution of the gall-stone in hot alcohol.

2. Bile pigment (cholepyrrhin of Berzelius, biliphæin of Simon,) has a fiery, brownish-red colour, and is easily known by its reaction with nitric acid, which changes its colour first to green, then to blue, violet, and red; the mixture lastly becoming colourless. It dissolves in boiling potash, producing a greenish-brown solution. Several modifications of this pigment occur which do not exhibit the characteristic reaction with nitric acid; as for instance,

3. A dark brown, almost black pigment.

4. Other constituents of bile, as choleic acid, choleate of soda, and their modifications, bilifellinic acid, dyslysin, &c.

5. Mucus and epithelium of the gall-bladder and the biliary ducts.

6. Earthy salts, namely, carbonate of lime.

7. Margarin and the margarates.

These constituents enter in different relations into the composition of gall-stones. They are seldom all found united in one stone, and those which are composite are generally blended equally, or one constituent predominates over the others. Cholesterin is usually the preponderating substance; cholepyrrhin rarely; in some few gall-stones the black pigment occurs in the largest quantity; while carbonate of lime is rarely thus met with.

It is only in very few cases that gall-stones consist principally of inspissated bile.

Gall-stones likewise vary in their physical characters. As in urinary calculi, so also here, they may present every transition, from a minute precipitate visible only by the microscope, to concretions of considerable magnitude. Hence we may distinguish between biliary deposits, biliary gravel, and gall-stones, which may be either consistent, or soft and doughy. The forms of these concretions are likewise variable; sometimes they occur as soft, amorphous masses; sometimes they have a distinct and well-marked shape. When occurring singly they are round; when several are present, they assume a polyhedric form.

There are two kinds of gall-stones which possess very characteristic forms—those consisting of crystallized carbonate of lime, which are pointed and jagged; and those formed of dark pigment, which usually present a nodulated appearance, like mulberry-calculi. The colour of gall-stones depends on their chemical constituents, and is hence by no means constant.

The following may be regarded as the principal forms of biliary concretions, arranged according to their physical character:

1. Fine precipitates of bile-pigment and crystallized cholesterin imbedded in mucus, mixed with epithelium whose cells are sometimes incrusted.

2. Biliary gravel—minute concretions of the size of a hempseed, or grain of sand; occasionally many such concretions are united by mucus so as to form a large mulberry-shaped calculus.

3. Soft biliary concretions, which in a recent state readily admit of being moulded between the fingers, consisting of crystalline depositions of cholesterin, between which there is bile-pigment.*

4. Crystalline calculi consisting for the most part of cholesterin, nearly colourless, transparent, with a crystalline fibrous fracture, granular on the surface, and usually covered with minute crystals of cholesterin.

5. Dark calculi of a reddish-brown colour, and earthy fracture which does not become bright by friction. These consist for the most part of bile-pigment.

There is a variety of this species, which is of a dark-brown, almost black colour, and exhibits a red, mulberry-like appear-

* See Plate x. fig. 5.

ance. These calculi seem to consist of a peculiar modification of bile-pigment.*

6. Calculi consisting for the most part of carbonate of lime: they are crystalline, with rough surfaces terminating in sharp angles, of a clear or sometimes rather brown colour.†

7. Gall-stones of a whitish colour, saponaceous feeling, and concentric laminated arrangement, which on scraping assume a polished appearance, and consist for the most part of cholesterin.

8. Gall-stones consisting of alternate white layers of cholesterin, and dark yellow layers of bile-pigment.

The two last kinds are by far the most common.

Gall-stones frequently exhibit a nucleus differing from the remainder of the mass, and consisting for the most part of mucus and epithelium coloured by bile-pigment: this, while the stone is fresh, is soft; but, on drying, shrivels up, and gives rise to a central cavity. Sometimes the nucleus consists of a foreign body—as a worm, or a portion of a needle.‡

The nucleus does not invariably lie in the middle of the stone, showing that the growth of the concretion has not been uniform; this is especially observed in calculi sacculated in a diverticulum of the gall-bladder. A gall-stone has sometimes more than one nucleus, namely, when several originally distinct concetions unite with, and become fused into one another.

The following analyses may serve to give an idea of the varying chemical composition of gall-stones.

	1	2	3	4	5	6
Cholesterin	96	65	67	50	4	—
Bile-pigment }	3 }	25	— }	35 }	89	—
Mucus }	— }		— }	}		—
Biliary matter	—	3	17	— }		—
Calcareous salts	—	2	—	8	3	100?
	99	95	84	93	96	

* See Simon's Beiträge zur physiolog. u. pathol. Chemie, Part 1, p. 117, with a plate; Scherer's Untersuchungen, p. 105.

† Bouisson, de la Bile, 1843, p. 220, Plate II. fig. 2.

‡ Bouisson, op. cit. p. 245.

These analyses made by various chemists are nearly all to be found in L. Gmelin's Chemistry, II. 2, p. 1431. I have somewhat modified them in order that they might admit of better comparison with each other, the biliary matter (choleic acid and its modifications) being determined according to the different views maintained by the different chemists. Whether the lithofellinic acid detected by Göbel, Wöhler, &c., in certain intestinal concretions of unknown origin, ever occurs in human gall-stones, as some have conjectured, cannot as yet be determined with certainty; it is, however, improbable. Scherer has submitted to ultimate analysis, the black pigment which occurs in many gall-stones; but in the absence of an analysis of healthy bile-pigment, we have no means of ascertaining its deviation from the normal standard.

The formation of gall-stones follows the same laws as those of concretions generally.

In order that a gall-stone may be produced, it is first necessary that a precipitate should be formed, and that this should not be discharged with the bile, but remain and accumulate into a larger mass; in this manner a nucleus is formed, which, under favourable conditions, becomes augmented by further depositions. In order that these depositions may take place, it is necessary that:

1. The bile should be in a state of concentration, which occurs when it has been retained for a long time in the biliary ducts or in the gall-bladder. By prolonged contact with a denser fluid—the blood—water is removed from it by the laws of endosmosis, and those substances become deposited from it which are the most difficult of solution—as the cholesterin, the bile-pigment, the salts of the fatty acids, and also the choleate of soda: the last-named substance is, however, very rarely separated, for it is only very seldom that we find it in any quantity in biliary calculi. Probably it undergoes decomposition even in the biliary passages, since by an acid it is converted into fellinic and cholinic acids, and dyslysin—substances which probably exist in considerable quantity in many gall-stones. However, further experiments are required on this subject.

2. In most cases in which gall-stones are formed, the bile is probably more abundant in certain constituents—as for

instance, cholesterin—than in the normal state. It is true, that such a peculiarity has never yet been detected by chemical analysis, but an augmentation of the cholesterin in the bile, is in the highest degree probable, since it is known that in advanced age, it increases to a considerable degree in the blood. Moreover, an augmentation of bile-pigment appears to occur, and to give rise to its deposition. In those rare cases in which gall-stones consist entirely, or for the most part of carbonate and phosphate of lime, the amount of calcareous salts in the bile is probably increased. Moreover, an increased secretion of mucus in the biliary apparatus, appears to take part in the formation of gall-stones, since it acts as a connecting medium between other precipitated matters, and consequently prevents their being discharged: moreover mucus forms the most common nucleus of gall-stones.

There are also certain mechanical relations which influence the formation of these concretions; as, for instance, diverticula of the gall-bladder or ducts, which receive and retain precipitates or foreign bodies forming nuclei around which precipitates can be deposited. The concentration of the bile caused by its retention appears, however, in most cases to be the most efficient agent, even when the other causes are also in operation. It is probably also the reason why gall-stones are mostly composed of biliary mucus. If a gall-stone is once formed, its further enlargement follows very easily, since the biliary constituents which are most difficult of solution—especially the cholesterin if it be present in tolerable quantity—become deposited on it. Although the preceding observations tend in some measure to elucidate the mode of formation of gall-stones in general, yet it is hardly possible in a given case to explain all the causes influencing the development from the first commencement, till it becomes a perfect calculus.

The literature of this subject is very abundant. We must especially notice the treatise of Bouisson *de la bile*, pp. 176—252, in which are contained an immense number of references to the older writers. See also J. F. Meckel, Path. Anat. II. 2, p. 455, and Sömmering, de concrementis biliariis, Francft. 1795.

We must likewise refer the reader to the chapter on the morbid anatomy of the liver and biliary apparatus, in the second volume.

VII. INTESTINAL CONCRETIONS.

Concretions are not often formed in the human intestinal canal, being much rarer than those hitherto considered. We meet with them after death in any part of the digestive tube, between the stomach and the rectum, or they are removed by vomiting, or with the fæces.

There are two distinct kinds to be considered:

1. Concretions formed in the intestinal canal itself, from its own contents—true intestinal concretions.

2. Concretions formed in other parts, and which find their way into the intestinal canal.

In the latter class belong all gall-stones, which getting into the duodenum are discharged by vomiting or by the rectum, or are occasionally found in the intestinal canal after death. They may be easily recognized by the characteristic properties of gall-stones. That actual gall-stones consisting of biliary constituents are primarily formed in the intestinal canal, is not improbable, although the individual constituents of the bile (modified bilin, dyslysin, &c.) are not rare in true intestinal calculi. Moreover, it occasionally seems to happen that true gall-stones, when retained for some time in the intestinal canal, serve as nuclei for other depositions, and then become converted into true intestinal concretions. Pancreatic calculi may also, in some few cases, escape through the orifice of the duct, and may be readily mistaken for true intestinal concretions, the chemical composition of both being very similar. Moreover, we must not mistake for true intestinal concretions the hard matter which has been observed by Gurlt, as forming in the mucous glands of the duodenum.

True intestinal calculi exhibit great differences in their characters, their chemical composition, and in their mode of formation. They arrange themselves in certain groups between which there is no very distinct line of demarcation.

1. Many intestinal calculi are formed in precisely the same manner as concretions in the parenchyma of organs, of which we shall speak presently. Their formation is due to an exudation of fibrin, or a coagulum of blood retained in the intestinal canal, and undergoing further changes, the constituents soluble in the intestinal fluid being gradually removed and merely the insoluble portion—the calcareous salts—remaining. Such calculi consist for the most part of protein-compounds—coagulated fibrin—mixed with salts of lime and fragments of food; they are formed after inflammatory exudation of the intestinal mucous membrane, and after hæmorrhage into the canal.

To this class belong the concretions which were analysed by Dublanc. They were discharged by a child after inflammation of the bowels, and formed irregularly shaped, smooth, yellow, hard, transparent pieces devoid of taste or smell. They consisted of fibrin with a trace of fat and phosphate of lime. Two concretions of a similar nature analysed by Davy, yielded in 100 parts:

	1	2
Fibrin. . . .	78	74
Salts. . . .	21	7
Other constituents (pigment, resin, fæcal matter, &c.) .	5	19
	104	100

Sometimes these calculi contain a foreign body as a nucleus, as for instance, a plum or cherry stone, which in consequence of the inflammatory irritation it excites in the intestinal canal, becomes surrounded with fibrinous deposits.

These intestinal concretions may be known by their insolubility in water, spirit, and dilute acids, which last only dissolve the salts of lime; they are partially soluble in a solution of potash. When boiled in concentrated hydrochloric acid, they for the most part or entirely dissolve, forming a lilac-coloured solution.

2. A second kind of intestinal concretion consists principally of earthy salts (phosphate and carbonate of lime, ammo-

niaco-magnesian phosphate, and phosphate of magnesia). These either form the entire concretion, or are mixed with fragments of food, namely vegetable fibres. They frequently contain a foreign body as a nucleus.

These concretions correspond in all respects with the salivary and lachrymal calculi already described, and are formed in a similar manner, namely by the earthy salts dissolved in the contents of the intestine becoming from any reason insoluble and being precipitated. Such precipitates are usually thrown off from the system, and we frequently meet with them in the intestinal excretions. The liquid evacuations of persons suffering from diarrhœa, almost invariably contain precipitates consisting of ammoniaco-magnesian phosphate, and phosphate of lime.

If these precipitates are retained, and become connected together by intestinal mucus, or deposit themselves around a foreign body, they give rise to the formation of a concretion. Calculi of this sort are most frequently found in diverticula, as for instance, in the appendix vermiformis of the cæcum.

The salts forming these calculi seem to rise from two sources—partly from the food which contains salts of lime and magnesia, and partly from the intestinal fluid itself, which, like the tears, saliva, and other animal fluids, under certain conditions of which we are ignorant, contains an excess of earthy salts. The earthy salts contained in the food are dissolved by the acid gastric juice, and if they are not previously resorbed, are again precipitated, when the chyle is neutralized in a lower portion of the canal by the alkaline intestinal fluid.

About three years ago I found a concretion of this nature in the appendix vermiformis of a phthisical patient. It had the thickness of a goose-quill, was about an inch in length, and perfectly filled the *cul de sac* of this intestinal diverticulum. It was of a whitish yellow colour; internally it presented a crumbling appearance, while the external portion was composed of thin, concentric layers. It was easily reduced to the form of a white powder, which under the microscope presented an indefinitely granular appearance, and dissolved in hydrochloric acid with considerable evolution of gas. It consisted of carbonate and phosphate of lime with a little magnesia. Two concretions of this nature—the former analysed by Thomson, and the latter by Davy—contained in 100 parts:

	1	2
Phosphate of lime. . . .	46	56
Ammoniaco-magnesian phosphate. .	5	
Animal matter (fibrin ?). . .	25	42
Vegetable fibre, resin, &c. . .	24	—
	100	98

Sometimes, as has been already mentioned, calculi of this nature form around a foreign body as a nucleus. Children has analysed concretions from the large intestine of a man who had swallowed plum-stones. They were formed of the stones surrounded by a clear brown, smooth, firm mass, consisting of alternate concentric layers of earthy phosphates and fibrous matter (the vegetable fibres derived from the food). The outer portion consisted of:

Animal matter soluble in water, with traces of soluble calcareous salts. .	25
Phosphate of lime. . .	46
Ammoniaco-magnesian phosphate. .	5
Woody fibre. . . .	20
Resin (modified bile ?) . .	4
	100

If the amount of fibrin be increased, these concretions merge into the first class; if the amount of vegetable matter (remnants of food) be large, they become almost identical with the third class. They are soluble for the most part in acids, which take up their earthy salts. The residue is best examined by the microscope which sometimes enables us to determine the nature and origin of the concretion.

3. Many intestinal concretions consist for the most part of undigested fragments of food, vegetable cells, &c. They frequently exhibit a woody appearance, and generally have a foreign body as their nucleus.

The following seems to be the mode of their formation:

Many portions of our food are absolutely indigestible, as, for instance, hair, epidermis, all the woody parts of the vegetables in general use, the shells and husks of fruit, &c. These cannot be digested, but pass through the system unchanged. It can scarcely be doubted that from these cells, united by a viscid connecting medium, woody concretions may take their origin. But we are ignorant of the conditions necessary for the production of this rare form of concretion. Probably in this, as in most other concretions of this nature, the presence of a diverticulum or a coarctation of the intestine is necessary to retain these masses, and thus to allow of the gradual formation of a concretion.

Laugier has analysed a concretion of this nature taken from the rectum of a man. It contained as a nucleus, a piece of bone, and was surrounded by interwoven vegetable fibres, from which water extracted 14% of animal matter, with a stercoraceous odour, together with some muriate of ammonia, and chloride of calcium. In a man aged forty-one years, who always lived regularly, but subsisted chiefly on vegetables, oat and barley-meal, and pulse, there were formed a large number of intestinal concretions, which after causing much pain were discharged by the anus. They had a smooth surface, were brown, and was formed of concentric laminæ; in the centre there was a nucleus resembling dried blood, which was surrounded by a thin layer of carbonate of lime. The analysis of these concretions yielded albumen, fæcal matter, fat, soluble vegetable matters and salts, silica, phosphate of lime (20%) and fibrous matter (36%) consisting of undigested remains of oat grains.* An intestinal concretion which had formed around a cherry-stone, consisted chiefly of the colouring principle of rhubarb, together with phosphate of lime and ammoniaco-magnesian phosphate.†

Intestinal concretions of this class naturally exhibit very different physical and chemical characters, according to the nature of their predominating ingredient. The best method of ascertaining their nature is by a microscopic examination of the residue left after successive extractions with water, acids and alkalies.

4. Other concretions consist for the most part of fatty matters, with which a little fibrin and salts of lime are usually combined. They must not be confounded with gall-stones consisting of cholesterin. We know less of the mode of formation of this

* London and Edinburgh Monthly Journal of Medical Science, vol. I. p. 630.

† Valentin's Repertor. 1837, p. 118.

class of concretions than of any of the preceding. It must remain still undecided whether they derive their fat directly from the food, or whether they obtain it from the secretion of the intestinal canal and the glands connected with it. In all probability they may obtain it from both sources, but, I conceive, more frequently from the former than the latter.

In order to give an idea of the chemical composition of these concretions, I will give two analyses, one made by Lassaigne and the other by Robiquet.

	Lassaigne.	Robiquet.
Fatty matters. . .	74	60
Animal matter. . .	21	8
Phosphate of lime. . .	4	30
Chloride of sodium. . .	1	—
	100	98

The concrements analysed by Lassaigne were discharged from the bowels of a phthisical girl. They were passed in great numbers, varied from the size of a pea to that of a musket-ball, were laterally compressed and smooth; externally they were of a yellow colour, internally they were white and granular; and they could be easily pulverized. The fat appeared for the most part to consist of the fatty acids (oleic and stearic (?) acids); the animal matter resembled fibrin, and was undoubtedly a protein-compound. In Robiquet's case, the fat resembled spermaceti; no particulars are given of the animal matter.

Caventou has likewise analysed fatty intestinal concretions, which were surrounded with a coriaceous membrane.

Such concretions may be recognized by their being for the most part soluble in boiling alcohol, and by the fat not separating, as the solution cools and evaporates, in the tablets which indicate cholesterin. They fuse when heated, and burn with a clear, but carbonaceous flame.

Some concrements which have been regarded as intestinal calculi probably owe their origin to some other source. This is not merely the case with biliary and pancreatic calculi, but with certain others. Thus Brugnatelli analysed concretions which were stated to be passed from the rectum of a woman, and which were composed of urate of ammonia with a little phosphate of lime, and a tolerably volatilizable animal matter of a not unpleasant odour. That intestinal concretions should have urate of ammonia for their principal constituent, is so improbable, that we must be allowed to suspect that there must be some error. I believe that this concretion was either not discharged from the rectum, but from the urinary passages or the vagina; or else that in this person there was a communication between some of the urinary organs and the rectum, through which the urine passed, in which case there would be no great difficulty in accounting for the presence of a concretion of urate of ammonia in the latter organ.

The literature referring to intestinal concretions is very scattered. Most of the illustrations which I have given, may be found in Berzelius' Thierchemie, p. 355, and L. Gmelin, II. 2, p. 1446, &c. In the article "Enterolithen," by Jaeger,* the reader will find a full and very excellent account of intestinal concretions in man and animals, together with a copious bibliography: a Memoir by Meckel on the concretions in the human intestinal canal, and published in the first volume of his Archiv, may also be consulted with advantage.

VIII. CONCRETIONS IN THE CUTANEOUS GLANDS.

Nearly all the glands of the human body seem capable, through a change of their secretions, of giving rise to the formation of concretions, and the minute cutaneous glands, although very rarely affected in this manner, form no exception to this rule. The anatomical relations of the concretions occurring in these glands are still imperfectly known; however, it is probable that they occur not merely in the sebaceous glands—both those that are free, and those accompanied by hair, forming hair-glands—but also in the sudaminous glands with spiral ducts.

Two kinds of these concretions may be distinguished, which are, however, associated together, and may pass one into the other.

If the normal or slightly changed secretion is retained

* Encyclop. Wörterbuch der medicinischen Wissenschaften, Berlin, 1834, vol. II. p. 172—204.

in the gland by the stoppage of the duct, or for any other reason, it thickens and forms a concretion. In this case the concretion consists principally of those substances which constitute the normal secretion, namely fats and fatty acids, epithelium, extractive matter, and a certain amount of salts. If the salts predominate, the concretion belongs to the second class.

These concretions occur for the most part in the sebaceous glands: they are essentially identical with the false encysted tumours formerly described, which are formed by an accumulation of the secretion in an occluded gland, and are distinguishable from them only by their more solid contents.

2. The secretion of the gland may deviate from the healthy standard, and contain an excess of earthy salts; in this case precipitates will be formed which, on drying, will be gradually converted into stony concretions.

The following may serve as illustrations of concretions in the cutaneous glands. A concretion of the former sort, analysed by Fr. von Esenbeck,* consisted of a soft mass, which when dried by exposure to the air, formed a yellowish white powder. On triturating it with water, a milky liquid was produced which, after standing for several days, did not putrify, and which did not coagulate on boiling, but was precipitated by acids, corrosive sublimate, and infusion of galls. It consisted of:

Solid fat.	24.2
Alcohol-extract with a trace of oil.	12.6
Water-extract.	11.6
Albumen (cells ?).	24.2
Carbonate of lime.	2.1
Phosphate of lime.	20.0
Carbonate of magnesia.	1.6
A trace of acetate and hydrochlorate of soda, and loss.	3.7
	100.0

A concretion of the second kind formed in the scrotum, and analysed

* L. Gmelin, II. 2, 1397.

by myself, is described in the explanation of Plate x. fig. 2. It consisted chiefly of calcareous salts.

In these two cases, although it was not strictly proved that the concretions actually had their seat in the cutaneous glands, and not in the adjacent parenchyma of the skin, yet the former is the more probable.

With the concretions already considered, we must associate others in which the organs yielding the secretions from which the concrements are formed are themselves morbid epigeneses. To this class belong the ossified encysted tumours mentioned in p. 255, where the epidermic or epithelial cells, which invest their walls or fill their interior, become incrusted by the deposition of calcareous salts, and, adhering together, form a concretion; and the cases in which cholesterin occurs in solid masses as a cholesteatoma. Moreover, the reported ossifications of many entozoa—of hydatids, the trichina spiralis, &c., of which we shall speak presently—belong to this category.

SECOND CLASS.

CONCRETIONS IN THE PARENCHYMA OF ORGANS.

Concretions not only occur in the glands and their excretory passages, but frequently also in the parenchyma of organs. These concretions are generally formed in accordance with the same principles and in the same manner as those already considered, but they do not exhibit so great a diversity, since the mother-liquids from which they are formed almost always present the same, or very similar chemical properties. Their physical properties exhibit great variations. When they occur in small quantity, they form extremely fine precipitates, which are generally only visible through the microscope, and appear as incrustations of foreign bodies or of organized tissues; collected in larger masses, they form more or less isolated, and more or less solid portions—cretaceous masses, stones; or they become as it were, fused into the organized portions, and form the so-called ossifications. All these distinctions and terms are, however, very indefinite, since they are only based on external, and for the most part, fortuitous and unessential characters. The manner in which these concretions are formed being different in individual cases, it is not easy to deduce any general law on the subject; however, in most cases the following remarks will be found to approximate tolerably closely to the truth.

All the vascular tissues of the body are infiltrated by a fluid which proceeding from the vessels, and consequently from the blood, is being continuously renewed, since a portion is being continuously removed by the lymphatics, and further, because it is subjected to a continuous metamorphosis of its constituents by endosmosis with the contents of the vessels. To this fluid we may apply the term *general nutrient fluid*, although it is not always the same, but exhibits many differences, not only in different parts of the body, but also in the same part at different times. In general this fluid resembles the *liquor sanguinis*, and its changes are principally only qualitative. Some of its constituents under certain conditions become insoluble, and separate as precipitates; these most commonly are the earthy salts—the phosphate and carbonate of lime, ammoniaco-magnesian phosphate, carbonate of magnesia, and silica; more rarely, the salts soluble in water—chloride of sodium, phosphate and sulphate of soda, and sulphate of lime; fats—as for instance, cholesterin, and very rarely, some other salts of difficult solubility in water—as urate of soda. The conditions which must be fulfilled in order to give rise to the separation of these substances from the general nutrient fluid, are identical with those already described in our remarks on the individual precipitates. It is, however, very difficult in individual cases, to recognize the acting causes. One frequent cause is an extraordinary relative augmentation of certain substances in the blood, as when concretions are formed not only at isolated spots, but in considerable number, and over a great part of the system, as, for instance, in the extensive ossification of the arteries, so commonly observed in aged persons. In such cases we can easily trace the formation of concretions to a general disposition or diathesis.

Depositions of this nature form precipitates, or incrustations, or (where they occur in large masses) ossifications; we use the word in the popular sense, and mean only to imply that organized tissues become surrounded, enclosed, and thus, in a manner, petrified: it is very rarely that they form isolated calculi. They may occur in all vascular organs of the body, and in morbid fluids, as for instance, pus.

For the special relations of these concretions in individual organs, we must refer to the second volume. In the present place we shall only give one or two illustrations by way of showing how their chemical composition varies in different cases.

Thus twelve concretions found in pus taken from the pleural sac of a man aged sixty-six years yielded:*

Phosphate of lime. . .	49.1
Carbonate of lime. . .	21.1
Insoluble mucus (modified protein?)	27.8
Fat.	1.8
Soluble salts. . . .	0.2
	100.0

In this case the concretions lay perfectly free in the fluid, and were only united by a mucoid mass.

Examples of incrustations of this kind are very frequent. To this class belong the depositions which are not unfrequently met with in the choroid plexus of the brain, consisting of round microscopic cells, coated with phosphate and carbonate of lime.† When occurring in large masses, these incrustations resemble ossifications in the cellular tissue, the muscles, the biliary ducts, and especially in the heart and arteries. The following examples will serve to give an idea of their chemical composition:

	1	2	3
Areolar tissue yielding gelatin on boiling.	68	26	—
Carbonate of lime. . . .	8	23	a trace
Phosphate of lime. . . .	24	51	80
Ammoniaco-magnesian phosphate. .	—	—	20
	100	100	100

* Prus—Valentin's Repertorium, 1837, p. 118.

† Henle's Allgem. Anatomie, p. 10.

1. Concrement in the muscles of the thigh of a man, analysed by Lassaigne, (L. Gmelin, II. 2, 1367).
2. Annular ossification of the tricuspid valve, (Walchner, ditto).
3. Pulmonary concretion analysed by Henry, (L. Gmelin, II. 2, 1370).

In the above cases the earthy salts predominate: whether there exist concretions in which, as Boudet supposes, the soluble (namely the soda) salts form the principal ingredient, must still remain questionable.

There are still two kinds of concretions occurring in the parenchyma of organs, presenting distinct chemical characters:

1. The depositions of cholesterin which are of tolerably frequent occurrence in the arterial tissue of aged persons.* The diagnosis of these depositions is very easy, being based on their seat (the arterial walls) and on the well-known microscopical and chemical characters of cholesterin. Their formation is probably dependant on a great excess of cholesterin and serolin in the blood, but the causes are not by any means obvious, why this fat is only deposited in particular spots of the body and of the arteries, instead of being equably distributed. Moreover these fatty deposits sometimes occur in other parts besides the arteries, as for instance in obsolete tubercle.

2. Concretions consisting principally of urate of soda (sometimes with a little urate of lime) are deposited in the neighbourhood of the joints and sometimes in their interior, in the areolar tissue, and in the tendons of gouty persons. They occur as earthy masses of indefinite form and size, are very light and porous, and of a yellowish white colour: they are smooth to the touch, and may be readily scraped by the knife. The following analyses will serve to give an idea of their chemical composition:

	1	2	3
Water.	8.3	10.3	(2.00)
Animal matter (areolar tissue yielding gelatin).	16.7	19.5	10.34
Uric acid.	16.7	20.0	59.43
Soda.	16.7	20.0	15.09
Lime.	8.3	10.0	8.25
Chloride of sodium.	16.7	18.0	5.60
Chloride of potassium.	—	2.2	—
Loss.	16.6	—	1.29
	100.0	100.0	100.00

The first analysis is by Laugier, the second by Wurzer (see Berzelius's Thierchemie, p. 723), and the third by H. C. van der Boon Mesch, in

* See Plate x. fig. 1.

Bijdragen tot de natuurkundige Wetenschapen, Deel 1. Amsterdam, 1826, p. 131. The reader would do well to consult J. Moore, Medico-chirurg. Transactions, vol. I. p. 112, &c., where the progressive formation of these concretions is explained; and Lobstein, Compte rendu sur les Travaux anatomiques, Strasburg, 1824.

These concretions may be easily recognized by their exhibiting the characteristic reaction of uric acid. Their formation depends on the circumstance of there being an excess of urates in the blood, but why the urate of soda should, as it were by preference, be deposited at particular parts of the body, is by no means clear.

There is also another mode by which concretions are produced within the parenchyma of organs, differing theoretically from the preceding, but actually very often associated with it. The following observations will serve to explain it.

It has been already shown (p. 101) that many pathological epigeneses arise from a mixed plasma, that is to say, from a fluid, which may at the same time serve as the formative material for organized and unorganized epigeneses. The source of this formative fluid is generally, probably always, a fibrinous dropsical effusion, whose fibrin coagulates. In this exudation, two formative processes are simultaneously going on—an organization of the fibrin, and the formation of concretions consisting generally of earthy salts. The product of this formation consists chemically of two distinct steps, one relating to the conversion of the fibrin and its modifications into areolar tissue, pus-corpuscles, granular cells, and typhous, scrofulous, and tubercular matter; the other, to the constituents of concretions, as the salts of lime and magnesia, the urates, fat, &c. The individual constituents of either group may assume a vicarious position; moreover, the whole of the first group may assume the place of the second, and conversely the second may replace the first, so that the one is subordinate in the same degree in which the other predominates. This explains the extreme differences in chemical composition, which are observed in this class of concretions.

As illustrations of their chemical composition, we may refer to the urinary and intestinal concretions formerly described (p. 358 and 376), which belong to this class, and may add the following analyses:

	1	2	3	4
Protein-compounds and water.	35	10	24.3	53.16
Soluble salts. . .	—	4	4.0	—
Phosphate of lime . .	61	30	65.3	43.67
Carbonate of lime . .	4	54	—	3.17
Carbonate of magnesia. .	a trace	—	6.5	—
Phosphate of magnesia. .	a trace	—	—	a trace
	100	98	100.1	100.00

1. A concretion from the thyroid gland, (Prout, quoted in L. Gmelin, II. 2, 1370).
2. A concretion from the thyroid gland of a cretin, (Iphofen über den cretinismus, Dresden, 1817).
3. A concretion from the pericardium, analysed by Robinet and Petroz, (Berzelius, Thierchemie, p. 721). It was formed of several thick layers which were covered with earthy, pulverizable, verrucose concretions. The organic constituents were partly organized (areolar tissue which on boiling yielded gelatin); and partly unorganized (soluble in liquid potash—fibrin); the soluble salts consisted of sulphate of soda, with a trace of sulphate of lime.
4. A concretion from the uterine surface of the placenta, analysed by Wiggers (Berzelius, op. cit. p. 723). The organic constituents were fibrin, with a little fat, areolar tissue, and albumen. The water amounted to 7§.

The morphological relations of these concretions, present even greater diversities than their chemical composition: they are not merely different in different concretions, but may also vary in the same concretion in different stages of its development. Sometimes the epigenesis is soft, and the organic constituents predominate; we can then discover by chemical analysis that there is a considerable increase in the salts of lime. In many cases the mass appears as an incrustation, ossification, or calculus. Illustrations of these forms may be seen in the second volume, in the chapters on the individual organs.

Almost all exudations may, under certain conditions, pass into concretions, as in the lymphatic glands, the kidneys, the spleen, the lungs, the areolar tissue, apoplectic sacs in the brain, scrophulous depositions, tubercles, &c. The conditions governing these transitions are not clear, but the following may be provisionally indicated :

1. Great abundance of calcareous salts in the primary exudations, as appears to prevail in arthritic persons.

2. Subsequent separation of calcareous salts, &c., in the manner mentioned in p. 384, at a period when the exudation predominates, and is either in the act of development or absorption. The insoluble earthy salts remain in both cases, while the protein-compounds are either entirely or partially developed, or dissolved and resorbed. The relation that these concretions bear to true osseous formations, deserves especial attention. As a rule they have, as we have already mentioned, no resemblance to true bone, and the term ossification is therefore very unsuitable and liable to be misunderstood; still there appear to be cases in which these concretions occasionally reach a higher degree of organization, and thus form transitions to new formations of true bony substance.* The mode of transition is, however, little known, and requires more accurate examination.

Of the works treating especially of concretions, the following, besides those to which we have already referred, deserve mention : John, chemische Tabellen des Thierreiches, p. 60 ; Duncan, jun., Edinburgh med. and surgical Journal, vol. I. p. 407 ; J. F. Meckel, pathol. Anat. II. 2, Gurlt medicin. Vereinszeitung, 1833, No. 31 ; Gluge, mikrosk. Unters. Part 1, p. 90, &c. ; Henle, allgem. Anatomie, p. 7, &c. ; Remak, Casper's Wochenschrift, 1842, p. 1, &c.

* See Valentin in his Repertorium, 1836, p. 317, &c.

CHAPTER VI.

PATHOLOGICAL CHANGES IN THE PHYSICAL PROPERTIES OF THE TISSUES AND ORGANS OF THE BODY.

Hitherto we have, with the exception of the changes in the blood, treated only of substances which, either do not occur in the normal body, or are at least modified and in different combinations—as those presenting themselves in many pathological conditions. These pathological epigeneses, taken in the widest sense of the word, are accompanied by certain pathological changes, affecting the physical properties of the body.

These changes are numerous, and extend to all the perceptible properties of the tissues and organs of the body, most frequently, however, altering their colour, size and consistence. They seldom occur singly, but generally simultaneously with other pathological changes, which, indeed, give rise to them; it is therefore impossible to separate them accurately from one another. Their consideration is only so far important to pathology, in as much as a description of them, and the knowledge of their differences may tend to clear up their causes and consequences. But such an attempt would at present be accompanied with great difficulties, since the causes of these changes are still very little known, and are extremely numerous and involved.

The most important of these changes are the following:

1. CHANGES OF COLOUR.

Every part of the body has in its normal condition a specific colour which depends upon very different causes—solid and fluid pigments—and which may differ considerably within certain limits, without being abnormal. But when the change in the normal coloration exceeds these limits, it becomes pathological; it is, however, neither theoretically, nor practically possible to separate accurately these normal and pathological alterations. Sometimes these changes are of no importance, but in many cases, they afford valuable aid in recognizing and judging of other pathological conditions.

It is of course necessary to be well acquainted with the normal colour of the various parts of the body, in order to form a judgment of the changes it has undergone; and this knowledge, at least in reference to minute shades of difference cannot be learnt from descriptions alone, but must be sought in the frequent observation of nature.

Colour in most cases depends upon the blood, which circulates through all the vascular parts of the body; and the changes thus effected are of the highest importance to pathology. They generally accord with the changes already described (p. 83—98) in the quantity and distribution of the blood, and appear as increased or diminished blood-colouring (paleness, and heightened redness) or as an alteration of the normal colour into other shades.

Abnormal paleness. This, as a general rule, leads to the conclusion that there is a diminution of the colouring matter of the blood in the part affected; and may depend upon very different causes.

1. On a contraction of the capillaries, by which the quantity of the blood-corpuscles, and consequently the intensity of the red colouring is diminished. There are many familiar examples of this state; as, the paleness of the face, in conse-

quence of emotions of the mind, and the transient deadness of the fingers. The diagnosis of this condition may be determined by the microscopic investigation of the dead body, by which we learn by measurements that the capillaries have a smaller diameter than in the normal state. But this process presents some peculiar difficulties, which often prevent our obtaining the desired result. For during the preparation of the parts for microscopic investigation, the blood often flows out of the capillaries, which then contract in consequence of their elasticity. The diagnosis in the living subject is more certain since local paleness, during a state of unchanged redness in other parts, allows of our drawing a conclusion regarding this condition.

2. Paleness may depend upon a diminution of the corpuscles in relation to the other constituents of the blood, and as they are the conveyers of the colouring matter, a less intense redness is naturally occasioned.

3. Upon a diminution of the colouring matter, or a chemical change by which its intensity is diminished, so that while the number of the blood-corpuscles remains the same, each separate one, or at least, a given number contains less colouring matter, than in the normal state.

The two last causes appear to bear on anæmia, chlorosis, and similar conditions, but our knowledge is still so deficient on this point, that we must look to chemical investigations for affording us some better grounded, and more certain information on the subject.

It will be clearly seen that the changes mentioned under 2 and 3, combine with 1, and may occasion in addition to a general paleness, a more decided local pallor. A limited local, or a generally diffused pallor may be occasioned by causes, only taking effect during the last moments of life, or even after death. This cadaveric paleness is caused by the contraction of the capillaries in consequence of their natural elasticity, when the heart's movements have ceased, or the blood following the laws of gravitation is poured forth, (see the chapter upon the changes of the body after death). This gives us no insight into the pathological conditions during life.

The paleness, thus elicited by various causes is not always purely white, but has frequently a tinge of green, blue, or brown; and this is owing to the tissues themselves not being of a pure white colour, and to other faint tints from granular or fluid pigments, as bile-pigment, hæmaphaein, &c., (which, in a normal condition, are concealed by the deeper colour of the blood), now appearing more distinctly; moreover the blue coloration of the veins, which we shall presently notice, contributes to these results.

Besides the paleness, which depends upon the blood, other causes may induce a pallor in parts which are, normally, coloured—as fatty depositions, fatty degeneration of the muscles, liver and other organs, coagulated fibrin, tubercular matter, especially non-vascular epigeneses, and unorganized depositions of the most various kinds. They act in a twofold manner, first by compressing the vessels of the part, whose normal redness depended upon their quantity of blood, and secondly by thrusting a new and faintly coloured mass into the original tissue.

Local pallor is further called forth by a deficiency of pigment in parts where in a normal condition it exists, as in the skin, the hair, and the eyes in cases of leucosis (Albinos).* For further particulars of all these changes of colour, and their causes, we must refer to the special part.

Abnormal redness appears much more frequently than abnormal paleness, and likewise admits of classification under different heads, according to its causes; although it is easier to do this theoretically than to decide, with certainty, empirically upon any individual case. We may have:

1. Redness from hyperæmia of the capillaries, the characteristic properties of which have been already described, (p. 86).

* See Meckel, Patholog. Anat. II. 2, p. 2.

The colour is, as a general rule, of a vivid red, and appears to the naked eye, on account of the smallness of the capillaries, as if the parenchyma of the part were tinged with red; and it is only by microscopic examination, that the colour is seen to resolve itself in red capillaries and colourless interstices.*

2. Redness from venous hyperæmia, (p. 85). Here there is mostly a bluish red, but sometimes a brownish red, or even blackish brown colour exhibited by the dead body, frequently changing into a clear red, after prolonged exposure to the air. The hyperæmic veins are distinguishable with the unaided eye or with a lens, and their interstices appear colourless. In this category we have the blue disease, (cyanosis), in which several parts of the body, as the lips, cheeks and finger ends, are more or less deeply tinged with a purple hue.†

In both these varieties of abnormal redness from vascular hyperæmia, the deepened colour may not depend alone upon hyperæmia of the normal vessels, but may be occasioned by newly formed vessels, as in granulations, telangiectases, and in encephaloid.

3. Redness from extravasated blood (p. 89—97) is frequently associated with that which arises from capillary hyperæmia.

4. Redness from infiltration of dissolved hæmatin, (page 97—8).

The diagnosis of, and the distinctions between these different conditions, were so fully discussed in their proper places, that nothing further remains to be added.

I will merely remark, that by changes in the dead body, a state of hyperæmia of the capillaries, having existed during life, may disappear; and conversely that venous hyperæmia, and infiltration of hæmatin, which did not exist during life,

* See Plate II. fig. 1 A, B.

† See a plate elucidating this point in den chirurgischen Kupfertafeln, 1820, Plates LIII—LV.

may be called forth, so that in judging of these conditions of the dead body, much circumspection should be used.

In all these cases of increased redness from hæmatin, the blood may present manifold shades of colour, appearing either of a light or dark red, purple, brownish red, of the colour of tar, &c., without our being as yet able to give with certainty the causes of these changes in every individual case, (see p. 61, &c.) Sometimes as in extravasated blood, these changes go so far that the red colour entirely disappears, and gives place to another tint; thus extravasated blood becomes at times blue, orange, bistre-brown, or even black. The little that is as yet known concerning these changes has been already mentioned, (see p. 193, &c.) These modifications in the hæmatin may occur after death, as well as before; and our judgment regarding their causes and importance in the dead body, demands the same careful attention that we recommended in the case of abnormal redness.

In addition to the changes of colour already considered, there are others, of which the most important are:

Dark coloration from granular pigment (melanosis) which has already been specially noticed, (see pp. 189 and 233).

Yellow coloration of the tissues, depending as far as is yet known upon two very different causes. The most frequent form in which it appears is dependant on the bile-pigment, (the cholepyrrhin of Berzelius), and occurs to the greatest extent in jaundice, when it accumulates in the blood, and passes from thence into all the fluid secretions, colouring all solid and fluid parts of the body. Thus we find it in the brain, in cartilage, bone, nerves, lungs, liver, kidneys, ovaries, &c.; there being different shades of colour, according to the extent of the deposited pigment, alternating from pale yellow, to yellowish green, or even olive green, or dark blackish tint. Under the microscope we sometimes observe that the tissues are merely saturated with a yellowish fluid, while at other times, we discover firm, granular, accumulated depositions of a deep yellowish red colour, between the interstices of the primary histological elements of the tissues. Independently of icterus, the elementary cells of the liver frequently appear to be tinged yellow, and to be filled, or covered with minute deeply yellow granules.*

The diagnosis of the coloration dependant upon bile-pigment is easy, and is based upon its peculiar reaction when treated with nitric acid (see p. 63).

Another yellow coloration which appears occasionally in the organs, but which is invariably local, depends upon a change of the hæmatin in extravasated blood. It is observed after sugillations, pulmonary and cerebral apoplexy, and similar morbid processes.

Green coloration of the tissues is but rarely met with. It is sometimes observed in the lungs, the intestinal canal, and the muscles. Thus the upper lobe of the left lung of a soldier, which was emphysematous and void of blood, appeared to the unaided eye of a grayish-green colour. Under the microscope, the pulmonary tissue itself was tinged with green; the coloration was, with the exception of a few intensely green spots, tolerably regular, did not originate from granular pigment, and could not be washed off with water. The cause of the colour could not be discovered. The same is the case with the green coloration occasionally perceptible in the intestinal canal. Most of these green tints probably belong to the changes in the body after death; and at present we can do no more than hazard a conjecture concerning their causes. Many may depend upon sulphuret of iron, which in a very finely divided state sometimes exhibits a blackish-green colour; many may originate from the effects of putrefaction, with which we are but ill acquainted. Probably many changes of this kind depend upon the bile-pigment, which permeates the walls of the gall-bladder after death, and spreads itself, by imbibition, into the surrounding parts, or even sometimes to a considerable distance, as the following case will show. A hawk

* See Plate I. fig. 8.

that had been dead three days was opened. The muscles of the abdomen appeared tinged with green, while those of the chest, the extremities, and other parts still exhibited their normal colour. Under the microscope the greenish muscles and the surrounding tissues appeared saturated with a yellowish-green fluid, without the presence of any abnormal, granular pigment. On the addition of nitric acid, the green changed first to blue, then to violet, and lastly to purple and pale red. The colouring fluid was, therefore, precisely similar to bile-pigment. A closer examination of the abdominal cavity showed that the gall-bladder, which was very full, formed the central point of coloration. Further investigations must determine whether this kind of coloration of the dead body is seen in man at any distance from, or whether it is confined to the immediate neighbourhood of the gall-bladder.

Blue coloration of the organs is very uncommon, excepting in those cases which have been already named, where it depends upon venous hyperæmia. To this head belong the rarely observed cases of coloration of the skin by blue sweat.* As yet very little is known regarding the composition of this blue pigment, or the causes of its origin. I have several times observed, that in microscopic preparations of the different parts of the body—as of the human skin, exhibiting roots of hair—which had been laid in sugared water between cemented glass plates, a very finely granular deposit of a beautiful blue colour was precipitated, which, however, was yielded in too small a quantity to admit of chemical analysis. A further prosecution of this subject may lead to an explanation of the blue coloration of the skin, which appears during life.

Many abnormal colorations depend upon matters which have reached the body from without; in this manner we can account for the red bones of animals, which have been fed

* An interesting case of the secretion of a bile-pigment from the skin has been described by Dr. Büchner.—Schmidt's Jahrbücher, vol. XXXVI. No. 2.

upon madder, the yellow colour which the pigment of rhubarb yields to many organs, and the ashy gray or olive-green tint imparted to the skin by the internal use of nitrate of silver. To these may be added accidental, or intentional colourings of the skin (tatooing), by means of the penetration or rubbing in of gunpowder.

For some other cases of such colorations by means of medicines, &c., with notices thereof, see Otto's Lehrb. d. Patholog. Anatomie, p. 34, or South's translation, p. 33. A full enumeration of the different pathological colorations which appear in the human subject, may be found in Hodgkin's Lectures on the Morbid Anatomy of the Serous and Mucous Membranes, vol. I. pp. 297—327.

II. CHANGES ON FORM AND SIZE.

In a general point of view, the observations already made, regarding the changes of colour, may be applied to those of size and form. Every organ has in a normal state a certain size and form, but these relations are not so accurately defined, but that many individual modifications of both may appear. By disease these deviations may be so far augmented as to transfer their consideration to the department of pathological anatomy, without, however, enabling us to draw any very strictly defined limits between their normal and abnormal conditions. On dissection, when these modifications are in any degree considerable, they are the first to attract the attention of the most superficial observer, and hence in pathological anatomy they have been regarded before other changes, and thus in its infancy usurped a large portion of the consideration of this science. The more the science is developed, and its attention is directed from the accidental to the essential, and the more it seeks to clear up the causes and importance of individual changes, the less importance will be given to external modifications. A general consideration of these alterations is of very little value to science; it leads to a mere abstract system of arrangement, while the actual significance of the changes, the category of their causes and consequences, must vary with almost every individual case. I will, therefore, leave a more minute consideration of the subject to the special part, and limit myself here to a few general remarks.

To the department of pathological anatomy belong, as we have mentioned, only the higher degree of those changes which may be distinguished with certainty from mere physical modifications; but as no strict line of demarcation can be drawn between health and disease, it is useless to dispute concerning individual cases, as to whether certain changes do, or do not, belong to pathological anatomy.

The *causes* of these changes, on which as a rule their character depends, are very different, and in a great measure unknown; yet, from what has already been observed regarding them, they may be divided into the following groups:

Many deviations in form and size are congenital. Of these some are inherited by children from their parents, and thus appear to be inherent in the peculiar properties of the generative matter—of the germ—in an extended sense of the word. As many species of animals, so are also many races of men distinguished both externally and internally by peculiarities in the form and size of certain organs of the body. Examples of this fact are so numerous, and must be so familiar to all, that it would be useless here to adduce any. But in these cases, it often happens that it is not possible to decide the difference between pathological and physiological deviations. (This subject will be more fully treated, under the head of malformations.)

Other differences of this nature depend upon abnormalities of development. In the fœtus and the child many parts are relatively larger or smaller, and even of a different form from the corresponding organs in adult age. If, now, the subsequent and natural development of these parts be arrested by morbid causes, that which was previously normal will appear to us as disproportionate to the rest. The special causes of this impeded development may be very different, and are for the most part still obscure. Examples of such deviations occur, for instance, in the unusual size of the thymus gland, at an age when it is generally reduced to a minimum. In the fœtus, the left lobe of the liver is proportionately larger, and the walls of the heart are proportionately thicker than at a subsequent age, and this condition may continue to exist as a pathological deviation from the normal type, if its further development be arrested. (For further information on this subject, see *malformations*, and the special part.)

Other changes in the form and size arise from external influences of a mechanical nature. We may mention the changes in the form of the skull, which many tribes effect in their children by compressing or binding the head in a peculiar manner; also, the feet of the Chinese, which being arrested in their growth by mechanical means, become deformed and contracted; also, the changes in the thorax from tight lacing. By means of tightened bandages and stays, especially amongst women of the lower classes, the liver is so altered that it often exhibits a permanent ridge or furrow impressed upon the surface. The action of these influences is that the flow of the blood, and consequently organic epigeneses are impeded from pressure on the vessels, and the growth thus arrested, while the retrogressive activity of the metamorphoses (disintegration and resorption) continue uninterrupted. By these processes even very hard parts of the body—as bones—are by degrees modified, while the form of the softer parts is quickly and directly changed by such influences.

What has been here mechanically induced through external agents, is frequently effected in a natural way by pathological changes. Thus by the pressure produced by tumours, aneurisms, concretions, &c., soft organs may be changed in form and size, and the harder parts, as bones, gradually destroyed. Morbidly formed fibrous tissue presses by its elasticity, or by the spasmodic contraction excited by the nerves, on soft organs —as the lungs, liver, kidneys, &c., and thus diminishes their volume, and alters their form. In these cases also the action of the cause is compounded of several factors, being influenced by direct pressure on the tissues, the blood-vessels, and the nerves.

Many changes of organs, especially those affecting their size, and, less frequently, their form, are dependant upon the intensity of their physiological functions, and their greater or less activity. By increased activity, the nutrition and growth, as well as the bulk of most organs are augmented; while, on the other hand, by decreased activity they remain small, or continue to diminish. Thus, for instance, the muscles increase in volume in proportion as they are exercised. But in this case the increased nutrition is not the unconditional consequence of increased activity; both are only the final points of a series of processes connected together by causes, which are as yet but imperfectly known. By increased activity, a greater flow of blood—a capillary hyperæmia, the cause of which has hitherto not been sufficiently explained—is occasioned, attended by an augmented secretion of blastema, which induces the formation of new tissue, and causes a local augmentation.

Hence we must not necessarily conclude that the increase of size in a part arises of necessity from its increased activity, since every cause which calls forth hyperæmia of the capillaries may also become the cause of an increase in the part effected. According to the different modifications and consequences of hyperæmia, the increase of volume may also vary in its characters. Thus, for instance, venous hyperæmia in the soft parts, may call forth transient enlargement by the infiltration of serous fluid; indeed, hyperæmia may occasion an evanescent increase of volume by an augmentation of the mass of blood contained in the organ; as, for instance, in the erectile organs—the corpora cavernosa of the penis. But capillary hyperæmia can lead in a very different manner to an increase of volume, and it may do this independently of an augmentation of bulk resulting from the increased quantity of blood, by the copious secretion of fibrinous fluid. If the fibrin coagulate, a new form of increase of volume is called forth. A different one occurs when the exuded fibrin acts as a cytoblastema, and passes into persistent tissue, by which either a true hypertrophy, or a formation of some kind of tumour appears as the final result. But all these processes do not necessarily lead to an augmentation of bulk; and it only requires a slight alteration in the process to induce a diminution, rather than an increase of size: as, for instance, when exuded fibrin is converted into fibrous tissue, which in accordance with its character contracts and diminishes the part, as in most cicatrices. We observe, therefore, in many morbid processes, first an increase of volume, which subsequently diminishes, and is followed by a contraction of the organ attacked, as in Bright's disease of the kidneys.

In many cases of augmentation or diminution of the bulk of an organ, these conditions are extremely complicated, and much more conjectural than those already considered; as in the tendency to corpulency (Polysarcia), where there is often a very considerable deposit of fat in the form of adipose tissue in different parts of the body, as in the Panniculus adiposus, (see p. 181). The explanation of this process must be gained from a knowledge of the nature of digestion, which we do not yet possess. It is the same with morbid emaciation, which is far from being satisfactorily explained by suppressed nutrition, or arrested epigenesis, since these explanations themselves need elucidation.

Hollow organs are the most changeable in relation to form and size. They increase by the accumulation of their contents—as the stomach by food, and the intestinal canal by gas—decreasing as these are voided. Such an evanescent augmentation or diminution may, however, become permanent, if the cause continue long; thus, in great eaters, the stomach may attain a considerable size, while in those not taking sufficient nourishment, the whole intestinal canal may appear permanently contracted; and in cases in which an artificial anus has existed for some time, the portion of intestine below it becomes much narrowed.

Many hollow organs may entirely or partially disappear, as, for instance, the gall-bladder after biliary fistula, with the simultaneous closing of the cystic duct.

As the causes, so also are the results of these changes of form and size very different. They depend upon special relations, upon the situation and importance of the part affected, on the nature of the change, &c.; so that no general laws regarding them can be laid down. Indeed, changes which affect the same organ, and arise from perfectly similar causes, are often very different in their consequences; while, for instance, an enlargement of the muscles of the arm of a blacksmith is a consequence of their increased use, and, so far from being attended with evil consequences, is a sign of power and health, if a corresponding augmentation had occurred in the muscular walls of the heart, arising likewise from a continuously heightened activity, very injurious consequences, and even death itself would, as a general rule, occur.

We usually designate the diminution and augmentation of the bulk of an organ by the terms *atrophy* and *hypertrophy*. These names must, however, be regarded as nothing more than rubrics under which we include a number of changes, which, as we have already remarked, independently of accidental alterations of form, have often very little in common. It is of especial importance to the consideration of all these changes, accurately to ascertain their causes, to arrange these causes in suitable groups, and to estimate, qualitatively and quantitatively, the action of each. This is at the present time possible only to a very limited degree, and must, for the most part, be left to future investigators. The literature of these changes is, however, tolerably copious. Any one desirous of studying this somewhat unprofitable subject, will find a considerable amount of information on *atrophy* in Otto's Pathological Anatomy (p. 23 of South's Translation), and in J. F. Meckell, II. 1, p. 314; in the Treatises of Andral, Lobstein, and Carswell; and in the article "Atrophy," by Canstatt, in Wagner's Physiolog. Wörterbuch; Regarding Hypertrophy, the reader may consult Otto (p. 25 of South's Translation); Meckel, II. 1, p. 223; and the Treatises of Andral, Lobstein, and Carswell.

III. CHANGES IN THE CONSISTENCE OF THE VARIOUS ORGANS.

An importance has been attached to alterations in the consistence of organs which, as in the cases of change in form and size, has, we think, been over-rated. The attempt to take a general view of certain conditions of the organs, which in regard to their causes, consequences, and importance have little or nothing in common—to arrange them as cases of induration and softening—is, from its very nature, one likely to yield no useful results. The view that we shall take of this subject in the following pages must be consequently limited to the consideration of certain changes of frequent occurrence.

By hardening or *induration* is implied an abnormal increase in the consistence of an organ; this may vary from a scarcely perceptible increase of consistence to a degree of stony hardness. It seldom happens that an entire organ is uniformly hardened throughout; we more commonly find the induration limited to particular spots.

The cause of induration is very different in different cases.

The consistence of a portion of the body may be increased by a deficiency of blood (capillary anæmia), since the solid elements of the tissue are better able to retain their original degree of firmness, than when much blood is present, which, like any other fluid, tends to soften the animal tissue. This is frequently the case in the spleen, and appears sometimes to occur in the substance of the brain. However, the increase of consistence arising from (relative) anæmia is always slight; I do not know of a single instance in which a great effect has been produced.

Fibrinous dropsy is a frequent cause of induration, the fibrin coagulating and forming a solid substance, penetrating between the histological elements of the tissue, and thus increasing its consistence. This induration is naturally the more striking in proportion as the normal consistence of the part affected is less than that of coagulated fibrin: hence it is most marked in porous and spongy organs, as the lungs, cellular tissue, &c. In some organs it has received special names; thus in the lungs, it is termed hepatization, because to a certain degree it communicates to the pulmonary tissue a resemblance to liver.

Numerous cases of induration are dependant on the formation of pathological epigeneses which penetrate between the histological elements, and render them firm and resisting. This effect may be produced by epigeneses of the most distinct kinds, as for instance, tubercle, scirrhus, fibrous structures, or concretions (ossifications). Since many of these epigeneses arise from coagulated fibrin, one kind of induration may gradually vary in its nature, and be converted into another.

Hence it follows that induration is often merely an incidental consequence of other morbid elementary changes which have been already described. The consequences, like the causes of induration, differ extremely, in accordance with their nature and distribution, and the importance of the organ affected.

Copious information on induration in general, and in individual cases, may be found in J. F. Meckel, II. 2, p. 14, &c.; Andral, op. cit. and Bayle's Journal de Med. vol. IX. p. 285.

The reverse of induration is *softening*—a rubric under which it has been attempted to include all abnormal diminutions of consistence.

Theoretically we may distinguish between lesser and greater degrees of consistence, although there is no definite line, separating one from the other.

Softening to a slight degree is often only transitory: it generally arises from an excess of fluid in the part, from saturation of its tissues with serum, or the accumulation of a more than ordinary quantity of blood in it. In this way many organs lose their normal degree of consistence, and become soft and yielding. This arises from causes which have been already considered—hyperæmia and serous dropsy. Hence, it follows that some organs are more liable to this form of softening than others. Thus the spleen very frequently softens, since this organ more frequently than any other becomes overloaded with blood. The same is the case with the lungs; moreover the brain whose tissue normally possesses but little firmness may, by the addition of much fluid, become softer. There are other organs which from their very nature are incapable of undergoing softening of this nature, as for instance, the bones and elastic tissue. Many of these cases are merely transitory, disappearing when the hyperæmia ceases, or the dropsical fluid is resorbed.

Higher degrees of softening invariably lead to a partial solution and destruction—a death of the affected tissue—or rather, they arise from it. We have had occasion to notice several of these cases of softening in our remarks on suppuration, and on the softening of tubercles and of the pseudoplasmata. It is, however, at present hardly possible to take a general view of these cases of softening, since their causes like their forms are very different, and we are not sufficiently acquainted with their various conditions. The only method by which we can possibly obtain correct views regarding the occurrence of softening, is by endeavouring to work out its various conditions, in the same manner as Engel has done, in relation to the softening of tubercle, (see p. 287). At present, however, scarcely an attempt has been made, and since the conditions are very numerous and highly complicated, there seems to be little prospect of attaining this object for some time. It has been attempted to explain individual kinds of softening by making their occurrence dependant on certain general processes, and thus distinguishing inflammatory softening, softening from gangrene, and softening from obliteration of the afferent arteries. Something is certainly gained by this, but nothing very important, as long as the mechanism and the chemistry of the processes induced, are not better known. At present the following observations embrace most that is known on this subject.

Most softenings arise from the deposition in the organism of substances from the blood, which take no part, or but a small one in the general process of metamorphosis, either because, on account of their great size, they cannot be penetrated by the fluids of the body, or because their circulation has been entirely stopped by the stagnation of the blood in the vessels of the surrounding parts. As in these depositions, the separation of decomposed tissue, which is maintained in the normal state by means of the circulation and the secretions, ceases, these substances undergo further decomposition, and extend this process to the adjacent tissues, which they immediately infect. This term decomposition or putrefaction, is a mere illustration of the active cause of softening in these cases, which may convey a slight idea of these processes, but cannot be regarded as any comprehensive explanation, since we have as yet a very unsatisfactory chemical knowledge of the conditions of the decomposition of nitrogenous organic matter, and the concomitant processes. The same is the case regarding the transfer of this process of decomposition to the tissues, on which we as yet have no special knowledge. It is clear that all depositions and all tissues are not affected with equal facility by this decomposing process; hence, evidently the reason of the great differences which occur under this process in individual parts. An accurate knowledge of all similar cases can only be gained, when the decomposition suffered by different organic substances, if left unmolested, or brought under certain conditions be more accurately studied than it has hitherto been.

To this group belong further all those kinds of softening which we have previously included under the general term of suppuration—the deposition of fibrinous exudations, which pass into unhealthy pus; similar depositions of tuberculous, scrofulous, and typhous matter, and in part also the softening of cancer. These softenings have this peculiarity that they are mostly preceded by induration, as may be observed in many kinds of inflammatory softening. The chief condition inducing the process of decomposition seems to be local interruption of the circulation, and of the metamorphosis of tissue, as far as is dependant upon the circulation, that is to say, in relation to the removal of decomposed matter, infecting the adjacent parts.

In other cases, the softening originates in extravasated blood; which, when occurring in large masses, seems more disposed than any other of the constituent parts of the body to undergo decomposition; it influences also the adjacent parts, if its products, in consequence of the large quantity of the extravasation, or owing to local disturbance of the circulation, be not carried off, but are able to exercise their influence upon the neighbouring tissues. To this head belong most cases of inflammatory gangrene.* The blood undergoes a peculiar change, being converted into brown or blackish clots, in which granules of sulphuret of iron sometimes appear.† But the chemistry of these changes is almost entirely unknown. The modifications of the different histological elements in these gangrenous softenings are extremely various.

The soft tissues, as might be expected, are first altered, and sometimes wholly destroyed. The areolar tissue is either broken up into a fine granular mass, which at first has the form of fibrous bundles, or it is gradually softened, so that larger portions still exhibit the original contour, after the individual connecting fibres have disappeared. The cells of adipose tissue disappear, and their contents become mixed, as drops of fat, with the surrounding fluid; and crystalline masses of margarin or margaric acid generally occur. The primitive bundles of muscles lose by degrees their striated appearance,‡ and at last become changed into a pale, gelatinous mass which for a long period retains the external con-

* See Wagner's Handwörterbuch d. Physiologie, vol. I. p. 340.

† See Plate IX. fig. 10.

‡ See Plate IX. fig. 9.

tour of the primitive bundles.* Tissues with greater power of resistance, as the vessels, elastic tissues, bones, and epidermis are decomposed at a much later period, or not at all.

Similarly to extravasated blood, other fluids which easily pass into a state of decomposition, as urine, intestinal excretions, &c., may give rise to a decomposition and softening of the tissues, when in any manner they are infiltrated into them. To this class of softening belongs unquestionably another, which depends more upon general than local causes: for instance, there are cases, in which the whole mass of the blood undergoes a certain change or decomposition, which we must designate under the term putrefaction, without at the present time knowing what are its chemical changes.

The fluids separated from the blood, as the general nutrient fluid, being more or less modified, may induce a decomposition and softening of the tissues. Thus in typhus, and when the blood is loaded with bile-pigment, (as for instance in severe cases of icterus), very extensive softening occurs, which has been well designated under the term, *gangrene*. This condition is naturally susceptible of the most numerous modifications, and it is probable that it would ultimately lead to a general softening of the whole body, if, as a rule, death did not rapidly ensue. In such cases, the changes already begun, progress much more rapidly after death, but it is not generally possible to decide from the examination of the body, how far this softening had proceeded before, and how much had occurred subsequently to death. In a few cases, a local softening of a higher degree, appears to be induced in the softer parts, by the mere presence of serous fluid. Thus in the brain, we sometimes find in high degrees of serous dropsy, that the walls of the cerebral ventricles have a pultaceous appearance, extending to a slight depth (from half a line to

* See Plate IX. fig. 8.

a line). That a naturally soft substance like the brain should be gradually softened and decomposed by the long continued contact and saturation of so mild a fluid as that of serous dropsy, is not improbable, although experience seems to prove that such a softening is not perceptible in all cases of hydrocephalus. Possibly the softening only occurs when from the presence of a very large amount of fluid, or from other causes, the metamorphosis and frequent renewal of matter are arrested; so that these cases also rank under the previously described classes of softenings.

In many cases a softening, or more correctly the death and decomposition of organs, may be traced to obliteration, or closing of the afferent arteries, as many writers (and amongst others Carswell) have correctly stated. But here the closure of the arteries does not directly occasion the softening; it is only the result of a series of processes, which finally result in softening. The most probable explanation seems to be, that by the closure of the arteries in the part affected, the necessary renewal of the nutrient fluid, through the afflux of arterial blood, is arrested, and that the part thus passes into a state of decomposition, which extends to the adjacent structures. According to this theory, these cases may also be ranked under the head of those previously considered.

It appears very doubtful whether softening can arise from a direct influence of the nervous system, that is to say, differently from the manner in which the latter acts upon the vascular system, and indirectly induces softening by means of one of the previously mentioned conditions. At any rate it is expedient to meet such assumptions with some distrust, and only to receive them, when it can be proved that mechanical and chemical causes are not sufficient to explain the case.

In all these softenings of higher degree, the softening itself is properly only a secondary matter—the consequence of decomposition, the death of the tissue. Hence the various forms of death of the tissues in which no softening occurs, become directly associated with those previously noticed. To these belong dry gangrene, gradual dessiccation of dead organs (mummification), and necrosis of bone. In these cases the absence of softening depends partly upon the character of the tissue, and partly on external influences, as want of humidity.

For further information on softening in general, see Andral's Patholog. Anat., and Carswell, fasc. 5, Softening, and fasc. 7, Mortification. For the softening, and gangrenous destruction of the individual organs, we must refer to the special part.

CHAPTER VII.

MUTUAL COMBINATIONS OF MORBID ELEMENTARY CHANGES.

THE changes described in the preceding pages do not always occur singly; many sometimes being manifested simultaneously in the same, or different parts of the body. The recognition of the connection in which they stand to each other, forms consequently as important a question as the investigation of the individual changes themselves.

We may pursue the investigation of this combination of different changes in two ways. The first is by means of the numerical method, which leads to a correct conclusion, in as much as it shows the greater or less frequency of the simultaneous occurrence of these changes, but leaves the cause of these combinations, and the intimate connection of different changes entirely in the dark. The second method endeavours to point out the intimate connection of individual changes, and thus explain the facts elicited by the first method. In our introduction we spoke of the various degrees of importance existing between these two methods in their application to pathological anatomy. We will here consider the latter mode, since, as far as is compatible with certainty, it deserves a preference over the former.

In deciding between those pathological changes which occur simultaneously in the same part, and those which affect different parts at the same period, we must not lose sight of the fact, that here the question relates to the smallest parts visible through the microscope—the elementary parts of tissue—and not only to larger masses, as whole organs, or those parts that are seen by the naked eye. In the earlier ages of pathological anatomy, observations were limited to what could be detected by the unaided eye, the consequence of which was that changes of whole organs were treated *en masse*, and brought under one category of common names; accurate histological investigations have, however, led to the conviction that most of those changes, which were formerly regarded as simple, are of a composite nature; and the combinations of morbid changes have consequently been studied with increased attention, and show us that many which were formerly overlooked, are really of the highest importance to pathology. It further follows that changes, which are the opposite of each other in their nature, may yet co-exist in the same organ—as induration and softening, increased redness and pallor.

The connection between co-existing morbid changes may be more or less intimate. Many changes of this kind stand in the relation of cause and effect: in some the connection is either very remote, or not to be traced; we might even term it accidental, if we could admit the idea of chance in the phenomena occurring in the human organism.

The pathological changes arising from a common cause may be ranged in certain groups, of which the following are the most important.

FIRST GROUP.

VENOUS HYPERÆMIA AND SEROUS DROPSY.

Every venous hyperæmia may apparently occasion serous dropsy (see p. 40) and hence both changes occur very frequently in the same organ. We seldom meet with venous hyperæmia without dropsical effusion, except in cases where the hyperæmia is so recent and slight that the effused fluid escapes detection on account of its small quantity, or of its having been carried off by the activity of the lymphatic vessels. We more frequently meet with serous dropsy without venous hyperæmia. This may arise from the fact that the venous hyperæmia has already disappeared, while its result—the serous dropsy still remains; or owing to the dropsy having originated from some other cause than venous hyperæmia, (see p. 42). But these causes are still very obscure, and venous hyperæmia appears to be by far the most frequent origin of serous dropsy. This group is limited to these two changes, generally speaking the degree of softening produced by serous fluid is only slight, but in the brain, a higher degree of the same change may be occasioned.

SECOND GROUP.

CAPILLARY HYPERÆMIA AND FIBRINOUS DROPSY.

The consequences of these processes form a very comprehensive department, extending over most of the elementary changes already considered. The two principal links of this department are connected with each other, since fibrinous dropsy, as we have already shown, is a consequence of capillary hyperæmia; but between them there are so many intermediate links, that it appears advisable to separate this department into two divisions.

1. *The province of capillary hyperæmia*, which is in the first place characterized by distension of the capillaries, and an accumulation of blood in them, and further by a stagnation of the corpuscles, and consequently a local stoppage of the circulation (*stasis*, see p. 88). As consequences of this state there may be laceration of the capillaries, and consequently extravasation of blood. The latter may undergo the changes already described (see p. 93), may be resorbed with or without change of colour, or may act as a cytoblastema for organized, and a plasma for unorganized epigeneses; it may

further undergo decomposition, and thus lead to the destruction of tissue, and gangrene. With this condition, there usually also occurs, (either preceding or accompanying it), a solution of the hæmatin, and a saturation of the tissues with it. All these changes, although from the nature of the case they succeed one another, are yet very frequently simultaneously present in the same organ.

2. *The province of fibrinous dropsy.* The occurrence of this fluid as a consequence of capillary hyperæmia, leads us to a second very comprehensive series of morbid changes. To this class belong all the changes affecting the effused fluid, which have been formerly described (see p. 52.) The fibrin may coagulate, and thus give rise to false hydatids, apparent serous dropsy, induration of the affected organ, &c. Then follow the great number of changes which arise from the further development of the fibrin—suppuration in the widest sense of the word, with all its modifications and forms, the formation of granular cells, and ulceration—epigeneses of the most varying kind, tumours, hypertrophies, concretions, changes of colour, softening, induration, &c.; in short, almost all the above described elementary changes.

Connected with this subject are two questions, whose answers possess a high theoretical and practical interest. They are the following: 1. Is every case of capillary hyperæmia necessarily succeeded by fibrinous dropsy? And, 2. Does every case of fibrinous dropsy necessarily arise from capillary hyperæmia? or may it arise in some other manner? Allusion was formerly made to these questions, but a perfect answer was impossible till the above facts had been individually considered.

The former question, whether every capillary hyperæmia must be succeeded by fibrinous dropsy, is answered by experience in the negative. We often find the capillaries distended and loaded with blood, without being able to recognize the existence of an increased quantity of fibrinous fluid in the surrounding parts, and thus our separation of this department into two provinces is justified, and the independence of the former—capillary hyperæmia—established. However, we should assign to the above-mentioned experience no more value than it really deserves; it merely shows that all cases of this hyperæmia are not followed by a considerable secretion of fibrinous fluid. The exudation may be very slight, and we are altogether without means of distinguishing a small quantity of a fibrinous fluid yielded by dropsy, from the ordinary nutrient fluid pervading the tissues; moreover, as was stated in relation to serous dropsy, the whole or greater part of the exuded fluid may be resorbed by the veins and lymphatics. Further, in many cases of exudation the fibrin appears to undergo a chemical change which hinders it from being detected by the ordinary means of recognition; thus it frequently becomes converted into a species of mucus. An instance of this nature is afforded by menstruation, which admits of no other explanation. The blood which is effused externally, undoubtedly arises from the ruptured vessels of the ovaries, and probably, also, of the Fallopian tubes and the uterus. Although this blood, when it is effused from the vessels, must necessarily contain fibrin, yet generally on its discharge this constituent is absent, and the fluid does not coagulate. In its place there is mucus, and a larger amount than arises merely from the vagina; I have convinced myself of this fact by the observation of a case in which the menstrual blood proceeded directly from an inverted uterus.* The fibrin is doubtless converted, during the discharge of the fluid, into mucus, through certain chemical influences of which we are still ignorant, but probably through the influence of the alkalies. This fact elucidates an analogous relation of the mucous membrane. Whenever hyperæmia exists in this tissue, there is thrown off a viscid fluid not containing fibrin; the only exception being in what is termed croupy inflammation. The probable explanation of this fact is, that the fibrin of the

* See R. Wagner's Lehrbuch d. speciell. Physiologie. 2nd Edit. p. 236.

blood-plasma, during its effusion on the surface of the mucous membrane, is converted into mucus. Hence I believe that all those cases in which, after capillary hyperæmia, no fibrinous effusion is observed, are rather apparent than actual exceptions to the general rule.

The second question: Whether every case of fibrinous dropsy must necessarily have been preceded by capillary hyperæmia, or whether it may arise from any other cause? is one regarding which experience is still more at fault. It is true that we frequently meet with cases of fibrinous dropsy and its consequences, without, at the same time and place, observing capillary hyperæmia; but in such cases the hyperæmia may possibly have disappeared, whilst its product—the fibrinous dropsy—remains. On this point we must still rest contented with theoretical speculations which, from their very nature, can lay claim only to probability, not to certainty. As long as we suppose that the connexion between these two processes is the same as we have stated (p. 50), namely, that fibrinous dropsy arises from an extravasation of blood through the attenuated walls of the capillaries, then it will remain probable that every case is dependant on capillary hyperæmia, till it has been demonstrated that it may arise from some other cause.

The processes occurring in this group are designated in pathology by different names, in part individually, in part collectively. Those most in use are ranged under the heads of *congestion*, *stasis*, and *inflammation:* they are, however, of little value in pathological anatomy: but pathologically considered *capillary hyperæmia* would be a more appropriate term than congestion, which may, doubtlessly, lead to an incorrect hypothesis.

Pathological anatomy can only, in very rare cases, give any explanation concerning the presence of a stasis, and that solely where a microscopic examination of the circulation in living structures is possible. Moreover, this does not appear to be the right place to enter upon a discussion of the causes of the stagnation of the blood, since no very satisfactory explanation of this process has been given; and since, in all probability, the views which for the moment seem most correct will soon yield to others, in their turn to give place to newer ones. Critical surveys of the views entertained on this subject up to the latest date, may be found in Henle u. Pfeuffer, Zeitschrift für rationelle Medicin. Vol. 2. Jahresbericht von Henle.—Wharton Jones's Report on the Changes in the Blood in Inflammation. (British and Foreign Medical Review, No. 35)—and Spiess, Physiologie des Nervensystems. Braunschweig, 1844, p. 269, &c.

Inflammation belongs as little to pathological anatomy as stasis and congestion; it is only the individual processes, or rather the changes effected by the latter in the body, that belong to this department of science. But as it is customary to speak of inflammation with reference to pathological anatomy, it appears necessary to say a few words as to the extent to which we may receive the idea of it. Inflammation is not a simple process, but rather the common result of a series of processes, standing in connexion one with the other. Such are the processes which we have already included under the department of capillary hyperæmia and serous dropsy. These processes, however, show themselves different in almost every individual case. Sometimes the whole series is not passed through, and the process is arrested in its development, while in some individual cases those processes which we consider as associated with inflammation are changed in the most various ways. Hence inflammation is very variable in its manifestations, and it becomes almost impossible to fix its real definition, or to determine its limits. The same is the case regarding other complicated natural phenomena which occur externally to the human and animal organisms; and it would, therefore, be just as great a waste of time for meteorologists to contend whether or not we should consider every flash of lightning in a clear sky, as a storm, as for us to dispute upon the point whether we dared reckon certain processes in the human body as inflammation. Practical medicine, in its present condition, endeavours to hold fast to a peculiar idea of inflammation for the sake of its bearing upon therapeutics; trying, at the same time, to include it within definite limits. We will not contest the point in this case; but general pathology and pathological anatomy, which have not the same mere temporary interests, should not allow such a view to be forced upon them. Yet these sciences will be unable to answer satisfactorily the questions of practical medicine, until general ideas have been elucidated by another form of language—that is, till they have been reduced to their elementary phenomena.

On similar principles some other questions must be answered upon which we have cursorily touched; as, for instance, the opinion of Engel (pp. 289 and 313) and others, that tubercles, and the pseudoplasmata generally, are always products of inflammation. The consideration of this view resolves itself into two parts, one of which must be answered by pathological anatomy, the other by pathology. In relation to pathological anatomy, the term inflammation signifies capillary hyperæmia, with fibrinous dropsy and its results. Here we are led to ask, whether this appearance occurs in every formation of tubercle; but a direct answer to this question is impossible, since the earliest stage of tuberculous formation is in most cases hidden from our observation. Analogy alone enables us to draw the conclusion, that, as in most other pathological epigeneses, this appearance precedes, and seems to furnish matter for the new structure, so in the formation of tubercles the same is most probably the case. This, however, does not exclude the possibility that in many cases, a qualitatively changed, nutrient fluid, even without abnormal increase—without capillary hyperæmia and fibrinous dropsy—may directly pass into tubercles. It is the province of pathology to discover, whether those appearances generally considered to belong to inflammation, and which do not fall under the department of pathological anatomy—as disturbances of the nervous system—do, or do not occur in the formation of tubercles. If even in the course of time science should succeed in being able to give an affirmatory reply to these two questions, it must still be left to the judgment of the individual physician to decide upon this point according to the idea that he attaches to the term inflammation. This one example may suffice to point out the principles on which similar points must be decided.

We shall notice, in the special part, the elementary changes which occur simultaneously, but which unlike those considered above, appear to be accidentally associated together, and not connected by one originating cause.

CHAPTER VIII.

INDEPENDENT ORGANISMS IN THE HUMAN BODY.—PARASITES.

All the pathological formations which have been hitherto considered are products of the formative power proper to the organism; however much they deviate in form, they are still parts of the body. Contrasted with these, are other formations in the human subject, which must be regarded, not as parts of the body, but as independent individuals, although their presence is more or less due to the condition of the organism in which they are found. These independent organisms are termed *parasites*, and they so far have a bearing on pathological anatomy, that they are, more or less, connected with pathological conditions.

As all self-existing organisms which are found upon the earth range themselves in two great natural kingdoms, that of plants and animals, so also do these parasites. Hence we distinguish *parasitic plants*, without animal motion, with simple organization, developing themselves, and growing after the manner of plants; and *parasitic animals* which, as regard motion, organization, and propagation, belong to the animal kingdom. But the line of demarcation between the two natural kingdoms is so indefinite, that with our present means of determination, it sometimes remains doubtful whether an organized individual must be regarded as a plant or an animal — as, for example, in the case of *bacillaria*, *closteria*, and other allied species, which some, with Ehrenberg, include in the infusoria; while others, with equal propriety, refer them to the vegetable kingdom. This uncertainty applies also to some rare parasites, as for instance, the *naviculæ* which appear in human excrements, and the *sarcina ventriculi.*

To parasitic formations is superadded a condition, by means of which it becomes difficult in many cases to determine, not merely to which of the two natural kingdoms a structure belongs, but even whether it is to be considered as an independent parasite, or only a degenerated portion of the body. This, for instance, is the case with the highly curious pathological structures which J. Müller has observed in fishes, and has named *psorospermia.** It is only by future observations, carefully conducted with an especial view to the origin of these structures, that the question can be decided whether they are to be regarded as cells degenerated through morbid influences, or as independent (parasitic) individuals. These formations have not, as yet, been observed in man, and are, therefore, in our case, objects of subordinate interest. But even in the human subject there are pathological structures respecting which it is questionable whether they are to be regarded as independent individuals, or as mere degenerations of particles of the body. Thus cancer-cells and other similar structures are by many classed with parasites, as independent structures (semi-individual cells).

It appears to me that the question, "what are parasites?" is not yet ripe for decision, but I venture to predict that a more advanced knowledge will limit the acceptation of parasites to those organic structures whose germs have penetrated into the organism *from without;* although, in order that they may develop themselves, there must prevail not merely a general, but often a special pathological disposition of the system. This view pre-supposes that parasites never arise by equivocal generation, but by propagation alone—a point which is no longer doubtful. Of cancer-cells, however, it is more than probable that the germs are not necessarily derived from without, and, accordingly, I cannot regard them as parasitic formations. I will remind those who affirm cancer-cells to be parasites, merely because nothing like them is found in the normal body, that they must consequently

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* Muller's Archiv, 1841. p. 477, &c. 1842. p. 193, &c.

also consign to the same class the pus-corpuscles which exist in the same cases.

Confining our observations to those formations whose parasitic nature cannot be called in question, we are met *in limine* by two points of more than general interest, which claim our attention, before entering into a detailed account of the individual parasites. They are—1, the origin of parasites; and, 2, their baneful influence on the human organism.

Respecting *the origin* of parasites, there have existed from the most remote periods, when they were first remarked, till the present time, two opposite opinions. According to one view they are generated, in the same manner as most other animals and plants, by propagation from progenitors of like species; according to the second view, they originate from equivocal generation. That many parasites can and actually do arise by descent from parents of a similar kind (by gemmules, seeds, and ova,) is at the present day allowed even by the believers in equivocal generation. The controversy hinges only upon the question: can some parasites, in certain cases, also originate *de novo*, or are those at present occurring invariably and in every case derived from parents of like species? A positive reply to this question, based upon convincing observations and researches, is as little possible now as at the time when Pallas wrote his interesting dissertation upon the subject,* although since that period numerous eminent investigators have devoted their attention to the formative relations of parasites; but, nevertheless, it appears to me that a majority of important reasons favours the view that at the present time no parasites are spontaneously developed, but that all are, in some way or other, derived from parents of like species.

* P. S. Pallas, de infestis viventibus intra viventia. Lugduni Batavorum. 1760.—"Traditis nunc omnium sententiis de viventium intra viventia origine, expositisque argumentis propugnantibus singulas et contrariis, cujuslibet erit verosimillimam mente comprobare, donec experimenta quæ in hac parte maximopere deficiunt, certos nos reddunt."

It is out of the question in this place to submit the doctrine of spontaneous generation to a comprehensive criticism; and I am satisfied, therefore, to give for those of my readers who are not familiar with the subject, a brief abstract of the present state of the doctrine, and refer those who are desirous of further information to the interesting work of Hein.*

The idea of spontaneous generation is a philosophical necessity. All organisms with which we are acquainted, that are now derived from parents of like species, must at one time have arisen in another manner without parents. Whatever name may be applied to this primitive origin, or whatever view may be taken of it, whether it be termed creation, or receive any other name, it is in reality spontaneous generation, in contrast with derivation from parents. This necessity of a spontaneous origin of the organisms at present existing is, moreover, daily proved by experience. Geology demonstrates that many, indeed the greater number of the organisms now on the earth's surface, did not exist at an earlier period, since we find no vestiges of them. Accordingly, it is undeniable that spontaneous generation occupies a prominent position in the history of the world, as a mode of origin of all organisms. The question, therefore, turns only upon this point: can *existing* organisms, which at a former period originated spontaneously, and have subsequently propagated themselves in another manner, again arise spontaneously? or, in other words, is there a repeated spontaneous origin of creatures of the same species?

Let us now consult experience for materials in order to reply to this question. We find that in all cases where opportunity has been afforded of tracing, by direct observation, the origin of an organism, it has taken place by propagation; whilst, on the contrary, not a solitary unexceptionable observation of a spontaneous origin exists in the records of natural history. Analogy is, therefore, completely in favour of the view that propagation is the only manner in which existing organisms are engendered. The value of this evidence is further enhanced by the history of science. In earlier times it was admitted that even the vertebrate animals were produced by repeated spontaneous generations; geese and ducks from barnacles, (Lepas); the batrachia and serpents from mud; and still, at later periods, insects, as the coprophagi, from dung; and fleas from putrid urine. No one, at the present day, doubts that all these animals are generated by propagation alone. Indeed, in modern times, chiefly through the labours of Ehrenberg, even the generation of infusoria has been limited to the propagative system. Analogy would, therefore, lead us to conclude that parasites are also produced in this manner alone. The

* J. A. Hein, die Lehre von der Urzeugung. Halle, 1844.

objections which have been urged against this view, and the arguments which have been adduced in favour of a spontaneous production of parasites, rest chiefly on the ground that in many cases the origin of these organisms, by means of propagation, is inexplicable; and is, therefore, held to be impossible. But it is overlooked that the assumption of their spontaneous origin is in reality merely a formal explanation, which leaves us completely in the dark respecting the true reasons and conditions of their production. Moreover, many of these reasons have latterly become invalidated by the progress of knowledge, since not merely the possibility, but also the reality of their propagation to other organisms, and the inducing conditions, have been demonstrated in various parasites; and although in this respect at present much appears mysterious, yet the numerous experiences of latter years must raise a hope in every unbiassed observer, that the further advancement of knowledge will clear up the obscurity which at present envelops this province, and will establish the origin of all parasites by propagation, to the exclusion of spontaneous origin. The prevalence in the belief of spontaneous generation was an important obstacle to the progress of knowledge, since it hindered accurate investigations regarding the formative relations of parasites; and with the general diffusion of the view that all parasites originate by propagation, observations concerning their actual transference from one individual to another, will, doubtless, also accumulate. We shall return to this subject in our remarks on the individual parasites.

We shall now consider the relations of parasites to the organisms which they inhabit, and to disease. If we assume that parasites are invariably derived from parents of the same kind, and are never produced spontaneously, it follows that they are never a true product of a disease, and cannot, therefore, originate directly from degenerated particles of the body, depraved secretions, &c. It is, however, undeniable that morbid changes of portions of the body frequently exercise a certain influence upon their origin. These changes may favour their development, and, indeed, alone render it possible, by inducing conditions essential to it; they can again prove injurious to it, since they may remove conditions necessary to its occurrence. Thus, for example, vegetable parasites (fungi) do not in general develop themselves upon mucous membranes, until, by morbid processes, a deposit of coagulated fibrin, which serves as a bed, has become prepared for them, and until this exudation has passed into a state of putrid decomposition. An abundant secretion of mucus favours the development of worms which have entered the intestinal canal from without. Some states of the organism, on the contrary, disqualify it as a habitation for parasites. Thus, most of the entozoa in the intestinal canal are expelled by increased peristaltic action; some fluids of the body, as bile, urine, gastric juice, and some medicines, prove deleterious, and indeed, fatal to some of them; inflammation, or at least suppuration, may injure, and even destroy them.

As the organism exerts an influence on the parasites inhabiting it, so conversely the latter react upon the organism. They frequently prove injurious to the system, either by mechanical irritation (even by their mere presence, when occurring in large quantity, or by obstructing canals,) or by exerting a specific action, possibly by fluids which they secrete, or in some other unknown way. This pernicious influence of parasites upon the organism—their morbific power—varies extremely in relation to different species. Whilst some produce scarcely any apparent symptoms, so that their existence during life is frequently not ascertained (as in the case of the *acarus folliculorum*), others give rise to positive diseases, as the *acarus scabiei*, *pulex penetrans*, and *filaria medinensis*. This subject, therefore, allows of no general statements; and we must postpone the special consideration of the effects which the different parasites entail upon the organism, to the descriptions of the individual species. The disease which accompanies their presence is, however, invariably either *an effect* of their presence, and is called into existence by the influence which they exert upon the organism, and by the reaction of the latter; or the development of the parasites is, in the manner formerly explained, first rendered possible by *the presence* of a disease: the parasite should never be identified with the disease itself.

We now proceed to the consideration of the separate species of parasites, with especial regard to those hitherto observed in man, although, so far as they serve to elucidate the subject, we shall also notice those which occur in animals.

PARASITES DERIVED FROM THE VEGETABLE KINGDOM—EPIPHYTES.

All the parasitic plants which, up to the present time, have been observed in the human organism, belong to the lowest forms of vegetation—the algæ and the fungi. They are all very minute, so that, to the unaided eye the greater number are totally invisible, and others are only perceptible when accumulated in large masses. In order to recognize their peculiar structure, and thus to arrive at a more accurate diagnosis, the microscope is invariably necessary, and very high powers are often required. They are found either upon exposed surfaces, namely upon the skin and mucous membranes, or floating in the fluids of the body. I am acquainted with no authentic case in which they have been observed during life in the parenchyma of human organs.

Respecting the origin of vegetable parasites, there are the same two different views which have been noticed in relation to the origin of parasites generally. Whilst, for instance, Kützing,* who has devoted much of his attention to the lower algæ, maintains that their origin, by repeated spontaneous generation, is possible, others limit their origin to the mode by propagation. Although a positive decision of this disputed question may at present be impossible, it nevertheless appears to me that there are overwhelming reasons in support of the view that they invariably owe their origin to propagation alone. These reasons are chiefly founded upon the researches of Schwann on fermentation, upon similar investigations of Helmholtz,† and upon others which Dr. Merklein has abundantly

* Phycologia generalis. Leipzig, 1843. p. 129, &c.; or his remarks in Erdmann's Journal f. prakt. Chemie. 1837. vol. XI. p. 391.

† Müller's Archiv. 1843. p. 453, &c.

instituted upon this subject, all of which show, that under conditions which otherwise prove favourable to the formation of fungi and algæ, these do not present themselves, when the possibility of the transference of uninjured germs is precluded. Moreover, all the parasites hitherto observed, increase in enormous ratios by means of gemmules or spores: the latter are so infinitely numerous, so minute, and maintain their germinating power so tenaciously against the most common external agents, that by means of water and currents of air they certainly become universally diffused, and can, therefore, develop themselves wherever they meet with favourable conditions. That we have hitherto, in most instances, failed to demonstrate the origin of fungi by transference of germs, can be no argument against this mode of propagation; for, even in the most careful examination, certain fungus-spores, whose diameters are sometimes less than the 1000th of a line, may, and indeed always will escape the notice even of the most practised observer. In some cases the transference of parasitic fungi, or of their spores from one subject to another becomes facilitated by distinct relations, as immediate contact, &c.; as may occur in porrigo, in some forms of impetigo, mentagra, &c. These are the cases which are especially regarded as contagious. In general, however, peculiar conditions appear requisite for the development and increase of the transferred germs—conditions which are in general only realized by pathological relations. It appears, for instance, that the surface upon which they are to develop themselves must in general, if not always, be in a certain state of chemical decomposition (putrefaction or fermentation); as, indeed, we find that externally to the human and animal organisms most fungi are developed only on putrefying substances. Experience shows us that parasitic fungi are especially liable to occur on foul ulcers, and probably only exist on the skin or mucous membrane, in the cases where these are furnished with a layer of decomposing exudation. Parasitic plants have so far a diagnostic value, that they indicate that a process of decomposition is going on, however locally circumscribed it may be. Hence it follows that they do not become developed at all spots on which the germs are deposited; their growth indicates a certain morbid disposition.

This view is opposed by the results of experiments made with the view of showing that parasitic plants can be transferred by inoculation to apparently healthy organisms, and there give rise to morbid phenomena: thus, for instance, Hassal* was able to transfer, by inoculation, parasitic fungi from diseased to healthy lettuces, in which they produced the same disease (softening of the stem). These cases, however, prove but little; they merely show that in some instances the disposition to fungoid development need not be great; and they are, moreover, open to the objection that the plants which were inoculated, having, perhaps, the same *habitat*, and living under similar relations, already bore within them the morbid disposition.

The pathological signification of parasitic plants, that is to say, their power of engendering disease, appears extremely various in different cases. Sometimes through their great bulk they may become mechanically injurious, as by obstructing canals, &c.; of this, however, no instance has yet occurred in the human subject; they may accelerate incipient decomposition of the secretions, and thus prove chemically deleterious; in some cases they may destroy or modify histological elements, (for instance, hairs). Moreover, it is deserving of notice, that, by their tenacity of life, which in many cases, especially in some cutaneous diseases, (impetigo and favus) defies most chemical agents, they ensure to the concomitant affection a very long duration. To animals they are sometimes more injurious than to man; in the smaller animals they may even, through their bulk, occasion death, by obstructing canals, &c.† At all events, the part which these parasitic

* Froriep's, N. Notizen. Oct. 1843. p. 54, &c.

† Instances of parasitic plants injurious, and even fatal to animals, in consequence of their mass, are already very numerous, and fresh cases will almost daily be revealed. Amongst the more important cases in which animals have been attacked by vegetable growths, we may place those noticed in the following memoirs;—Regarding the muscardine of

fungi act in the diseases which accompany them, is a question which renders more extensive investigations still desirable.

A classification of parasitic fungi might be carried out according to botanical principles. It would, however, be very difficult, since the greatest number show no distinct fructification, and the *mycelia* of most fungi in their early stages of development resemble each other in an extraordinary degree. Their elementary forms are simple cells, which enlarge by the protrusion of new cells, or by prolongation into filamentous structures. Their fructification consists of spores which are either free and agglomerated into pulverulent masses, or appear enclosed in proper fruit-beds (sporangia).

The numerous experiments which I have instituted, compel me to join in the opinion of Kützing, who, in his observations on the low forms of vegetation, occurring in fermenting fluids, says:* "It is extremely difficult to reply to the question: Can these structures be arranged into genera and species? I once attempted this distinction at a time when I had examined and observed only a few of these forms,

the silkworm, see Bassi, del mal del segno, calcinaccio, o moscardino. 2nd ed. Milano, 1837; Audouin, recherches anatomiques et physiologiques sur la maladie contagieuse qui attaque les vers à soie. Annales des sciences natur. t. 8, p. 229 and p. 257. Nouvelles expériences sur la nature de la maladie, &c.

A. Hannover über contagiöse Confervenbildung an Wassersalamandern, in Müller's Archiv. 1839, page 338, and 1842, page 72; Stilling über contagiöse Confervenbildung auf Fröschen; in Müller's Archiv. 1841. page 279; Deslongchamp, sur des moississures développées pendant la vie à la surface interne des poches aériennes d'un Canard Eider. Annales des sciences natur. 1841, t. 14, p. 371; Klenke, Neue physiolog. Abhandlungen. Leipz. 1843, pp. 1—93; J. Müller über pilzartige Parasiten in den Lungen und Lufthöhlen der Vögel, in his Archiv. 1842, p. 198; F. J. G. Meyer über Schimmelbildung im thierischen Körper (in the Membrana nictitans of falco nisus) in his Neue Unters. aus d. Gebiete d. Anat. u. Physiologie, Bonn, 1842, p. 34, &c.; B. Langenbeck, Confervenbildung in dem Nasenausflusse eines rotzkranken Pferdes. Froriep's N. Notizen, 1841, v. xx. p. 58. Confervæ do not, however, always occur in the mucus of glandered horses; Henle never found them, (Pathologische Untersuchungen, 1840, p. 69); neither was I more successful.

* Erdmann's Journ. f. prakt. Chemie, vol. XI. p. 409.

yet, even then, their astonishing variety discouraged me from it." This announcement from one who has devoted so much of his attention to this subject, applies, I believe, equally to the parasitic forms of plants occurring in man and animals. There can be no doubt, that here, as well as in the other organized productions of nature, there are distinct species which do not, as Kützing imagines, pass into each other; but they present such manifold varieties, and the lower grades of development of different species so closely resemble each other, that a definitive separation of them cannot, for a long time, be contemplated. It is, therefore, very questionable whether the division, which some have attempted, and which we shall adopt, of human parasitic plants into distinct species, will be confirmed by future investigators. With respect to the questions, whether definite species of fungi are invariably found only in definite forms of disease, or conversely, whether in the same forms of disease, different species of fungi can sometimes occur, and the same species of fungus in different forms of disease, I believe that their reply must be for the present deferred, and that only by the unanimous co-operation of physicians and botanists, we can hope to arrive at a safe conclusion.

The following are the forms which have been hitherto observed in the human subject.

I. FUNGI IN HUMAN FLUIDS.

1. *The Yeast plant. Torula cerevisiæ,* Turpin; *Saccharomyces; Mycoderma cerevisiæ,* Desmazières; *Cryptococcus fermentum,* Kützing.

This plant not unfrequently occurs in vomited fluids and in fæcal evacuations; hence it is principally found in the intestinal canal, into which, in the majority of cases, it is introduced from without, with fermenting fluids, especially beer. It is also possible that it may be developed in this locality by morbid fermentation taking place in the stomach and intestines, particularly by lactic-acid fermentation. It exists also, in the saccharine urine of diabetes mellitus, but, in all the cases with which I am acquainted, (and I have observed a considerable number) not until after its evacuation from the bladder.

These plants are round or oval corpuscles (cells), varying in diameter from the 800th to the 400th of a line, and many having smaller corpuscles in their interior. This is their most simple form. They grow by protrusion of gemmules which, after some time, attain to the size of the original corpuscle, and germinate sometimes on one, sometimes on several spots of the primitive fungus-cell. These shoots throwing off new gemmules, the yeast plant gradually forms rows of oblong cells, connected together like beads. A congeries of such cells consisting of from three to five, frequently even more, commonly forms one plant.* This peculiar arrangement of the cells is characteristic of this plant, and in doubtful cases, ensures its diagnosis by microscopic examination. They are not acted upon by acetic acid.

As single cells detach themselves from the parent plant, they form new individuals which again pass through the process of development already described. In this manner they may increase abundantly. In rare cases a mother-cell enlarges and there are generated within it, small granules (sporidia) which, after the rupture of the mother-cell, emerge and serve as germs for new plants.

It appears to me that these fungi do not possess any peculiar pathological value; at most they serve as an indication that fermenting substances containing yeast, have been conveyed into the organism, or, that the animal fluids contain elements susceptible of fermentation. In this manner we may infer that a specimen of urine in which they occur contains sugar. Nevertheless, their presence in this fluid is far from a safe indication of a saccharine condition, for I have repeatedly observed fungi, more or less nearly resembling the yeast plant, in urine which contained no sugar; as, for instance, several times in the urine of an uncleanly prostitute, and likewise in a specimen of urine which contained fibrinous coagula corresponding to the urinary canals. In the latter case, besides simple cells, the fungi consisted of elongated, partially ramifying filaments, so that their structure approximated to the

* See Plate x. fig. 8.

more developed forms of the favus plant. In all these cases the fungi undoubtedly did not develop themselves till after the evacuation of the urine, and then probably from an especial condition of the secretion presenting to them a genial soil for their growth.

Fungi are probably not unfrequent in the fluids of the intestinal canal, but they readily escape observation when they occur singly, and form minute isolated cells.

Cases of this kind are specified and described by Böhm,* Henle,† myself, Gruby,‡ and others. There are two totally different classes of cases, between which we must discriminate:

1. Those in which the whole of the yeast plants have been conveyed into the body with fermenting drinks, and have there undergone no further change, but have only passed through it (as in cases described by Böhm and Henle).

2. Those in which the fungi, their single spores having probably penetrated unobservedly into the body, have become further developed and multiplied, in consequence of a special morbid disposition (by the formation of lactic acid, (?) and perhaps also of acetic acid (?), cases of which have been observed by myself and Gruby). The latter cases alone have a pathological signification.

2. *Sarcina ventriculi,* Goodsir.

This parasite has been hitherto found in only a few instances, and never except in vomited fluids. In its entire *habitus* it is allied to the species *gonium*, which although placed by Ehrenberg amongst the infusoria, is, however, probably a plant. The *sarcina* forms quadrangular or oblong plates varying in diameter from the 100th to the 120th of a line. The thickness of the plates amounts to about the eighth of their diameter. Under low powers the sides appear straight and the angles sharply defined, but under higher powers, the

* Die kranke Darmschleimhaut in der asiatischen Cholera, Berlin, 1828, p. 57.

† Patholog. Untersuchungen, p. 42.

‡ Comptes rendus, 1844, t. XVIII. p. 586.

sides appear indented, and the angles rounded off. Each plate appears divided into four squares (secondary squares), by two bands intersecting at right angles in the centre; each of these four squares subdivides in a similar manner, into four ternary squares; and each of these sixteen ternary squares appears with stronger powers composed of four squares which are in immediate contact.* The cells are of a brown colour, and their interstices are transparent. Iodine communicates to the sarcina a dark yellow or brown colour; alcohol renders it somewhat shrivelled; it is not destroyed by boiling nitric acid. It propagates by division. Nothing is at present known with certainty respecting its primary origin, and its pathological indications.

The sarcina was discovered by Goodsir in a fluid vomited at regular intervals by a man; the fluid was in a state of fermentation, and according to Wilson's analysis contained, besides some hydrochloric and lactic acids, a very large quantity of acetic acid.† It has since been observed in three cases by Busk.‡ Whether we place the *sarcina* with the genus *gonium* in the animal kingdom, or whether we regard it as a vegetable, it most probably, like the yeast plant, stands in the most intimate relation with chemical decomposition (phenomena of fermentation), occurring in the stomach. Although it has been hitherto found only in the stomach, yet its germs may have penetrated from without.

II. PARASITIC FUNGI ON THE HUMAN INTEGUMENT AND ITS APPENDAGES.

Fungi of this nature have, during the last few years, been frequently observed in the human subject, and fresh observations are being continually made. As a general rule presenting but few exceptions, they appear incapable of being developed immediately on the epidermis, or on the epithe-

* See Plate x. fig. 11.

† Edinburgh Medical and Surgical Journal, 1842, vol. LVII. p. 430, et seq. with figures.

‡ Microscopic Journal, January, 1843.

lium of the cutaneous glands, and can take root and multiply only when, by peculiar relations, a favourable soil has become prepared for them. These conditions are presented by fibrinous effusion of the cutis, the fibrin of which coagulates whilst the albumen, together with the other elements, dries and forms tenacious masses (crusts). To these, when they have undergone a peculiar chemical decomposition, which is not at present clearly understood, fungus-spores and gemmules seem to adhere, and there develop themselves. Uncleanliness appears greatly to favour this development.

That under fixed relations the same definite forms of fungus are alone developed, although, no doubt, very different species of germs fall upon the skin, need occasion no surprise, if we consider that the evolution of fungi is generally confined to very decided relations of soil, and that most forms of fungus in their lower grades of development, when they exhibit only a *mycelium*, resemble each other in an extraordinary degree. Under favourable circumstances, by assisting in a direct transference of germs from one individual to another, the development of these fungi can, at all events, be facilitated; and thus far, some of these forms can be deemed contagious; but the *vis contagiosa* is very slight, and appears to be associated with a completely defined disposition, so that in a perfectly healthy individual, the transferred germs of most fungi are probably incapable of developing themselves. We shall recur to this subject in our observations on the separate forms.

In their elementary form the fungi of this class usually consist of simple cells which, like the yeast plant, evolve new cells by gemmation: these, again, commonly grow out into jointed filaments of varying length, and it is only in rare cases that these fungi appear to undergo perfect development, and to exhibit decided fructification. Their botanical determination thus becomes very difficult.

The pathological importance of these fungi is in most cases small; occasionally, however, they acquire an importance from obstinately resisting all efforts to eradicate them; and in certain cases, they appear, by their development, able to destroy organized parts of the body, as for instance, the hair. In a diagnostic point of view their value is greater, since, where they occur in large masses, they are accustomed to impress upon the pathological change a peculiar character.

The following are the most important of the forms hitherto observed.

1. *Fungi in the scrofulous scald-head*, (*Tinea favosa*—*Porrigo lupinosa*—*Favus* and *Alphus*: Fuchs). The crusts in this disease consist for the most part of fungi, which are united by, or rather, are rooted in an amorphous matter, (dried fibrinous effusion.) The fungi of favus closely resemble yeast plants; in their most simple form they appear as roundish or oval cells which increase by gemmation. The gemmules are frequently elongated into filaments, which are either simple or ramified.* Acetic acid produces no change in these fungi, but renders them more distinct, in consequence of rendering transparent the amorphous mass in which they are enclosed.

I am firmly persuaded that in tinea the (scrofulous) exudation from the vessels of the cutis, is the primary cause and essential condition; it prepares the bed in which the transferred germs are developed. Attempts to inoculate the disease by transference of fungi to other parts of the skin of the same body, or to other individuals, commonly fail, as has been shown by the experiments of Gruby, J. H. Bennett, and myself. That the development of the fungi originates within the epidermis or beneath it, is improbable: yet the germs may gain access to its inferior (most recent) layers by means of fissures in it, occasioned by the exudation,

* See Plate x. fig. 6 and 7.

and thus it might seem as if they had been engendered beneath the epidermis.

The most accurate description of these fungi has been given by Gruby,* although they were previously noticed by Schönlein,† and E. H. Fuchs.‡ See also, the memoir of J. H. Bennett.§

2. *Fungi in the sheath of the hair in cases of mentagra,* have been observed by Gruby. They form a layer around the root of the hair, between it and the sheath, investing it as closely as a glove fits itself to the finger. The fungi resemble, generally, those of favus, but their spores are not oval, as in that case, but present a roundish appearance, and the thallus-filaments proceeding from the spore-cells, have frequently small granules in their interior. In reference to the origin and pathological indication of these fungi, no doubt the same holds good, as has been stated in relation to tinea.‖

3. *Fungi in the interior of the hair roots* have been observed in *herpes tonsurans* by Gruby and Hebra, and in *plica polonica* by Günsburg. They are developed in the interior of the hair-root, from small round spores; these soften, render the hair brittle, and finally cause it to break off, or to fall out.¶

Under this head, we must include the fungi which are observed in certain cases upon the skin in gangræna senilis, and upon blistered surfaces a few days before death;** also

* Comptes rendus, July and August, 1841.

† Müller's Archiv. 1839, p. 82, with figures.

‡ Die krankhaften Veränderungen der Haut, Göttingen, 1840.

§ Trans. of the Royal Society of Edinburgh, vol. xv. Part II.

‖ See Gruby, Comptes rendus, 1842, t. xv. p. 512, where there are also laid down distinctions, which I, however, believe to be unessential, between this plant, and other parasitic fungi.

¶ See Gruby, Comptes rendus, 1844, t. XVIII. p. 583; Günsburg in Müller's Archiv. 1845, p. 34, with figures; see also the chapter in the special part, on the anatomy of the hair.

** Heusinger, Bericht von der Königl. zootomischen Anstalt in Würzburg, 1826, p. 29.

a case described by Mayer,* in which fungi had developed themselves in the external auditory meatus of a girl—an observation which is especially interesting from the fact, that the fungi attained a much higher grade of development than in the cases previously described.

Fungoid structures have been observed on the integument of animals more frequently than on man. In addition to the instances already cited, Bennett, (op. cit.), has found upon a domestic mouse, fungous structures perfectly similar to those which occur in the tinea favosa of the human subject. He also observed fungi upon the skin of a gold fish (cyprinus auratus).

III. PARASITIC FUNGI ON THE MUCOUS MEMBRANES OF THE HUMAN BODY.

These are by no means unfrequent, and in recent times have been seen by numerous observers. In essential relations they perfectly resemble those occurring on the skin, and they appear never to take root on sound mucous membrane, but always upon a decomposing exudation from the mucous surface.

We find them in the aphthæ of children, and on the pseudo-membranes which cover the mucous membrane of the mouth and fauces in diphtheritis attacking adults; in certain cases they are found in ulcers of the mucous membrane in typhus and other diseases.

In form they sometimes approximate to the fungi of favus; at other times they differ from them in growing out into long thallus-filaments, which at certain parts, commonly at their termination, present protuberances in which granules (spores) are developed.

Vide A. Hannover in Müller's Archiv. 1842, p. 281, with figures, who also gives the earlier literature of the subject; also Gruby in the Comptes rendus, 1842, t. XIV. p. 634. Respecting the very frequent fungoid structures on the mucous membranes of animals, see the above

* Müller's Archiv. 1844, p. 404, with plates.

mentioned works. J. H. Bennett once found fungi in the sputa and lungs of a man with pneumothorax,* and several times in the black matter which invests the teeth and gums of patients in the last stage of typhus, (loc. cit.)

PARASITIC ANIMALS.

The parasitic animals occurring in the human subject, present in their relations a much greater diversity than the parasitic plants. Attempts have been made to classify them according to various arrangements.

1. According to the parts of the body, and the organs which they are accustomed to infest. In this respect a distinction is drawn between *epizoa* (*ectoparasites*) which live upon the surface, and *entozoa* (*entoparasites*), which inhabit the interior of the body. This division is, however, somewhat arbitrary since, for example, the intestinal cavity, which lodges by far the greatest number of entozoa, compared with the external surface of the body, is undoubtedly and relatively internal; compared, however, with the parenchyma of the organs it is relatively external. Moreover, some only of the parasitic animals have a definite part of the body or an organ for a habitation, out of which they are never, or only rarely found, whilst others have a very wide distribution, and probably in different stages of development can exist in the most dissimilar parts.

2. They have been classified according to their position in the zoological system. This classification of parasitic animals is the most valuable even for the practical physician, since it alone leads to a perfect comprehension of the forms and distinctions of the separate species, and since we must look exclusively to scientific zoological investigations for further information respecting the obscure mode of origin of these animals, and their occurrence in the human body.

3. Parasitic animals may be distinguished into those

* See Plate x. fig. 12.

whose special abode, ordained to them by nature, is the human or animal body—*true essential parasites;* and into those, to whom nature has assigned another habitation, and which only incidentally, and in consequence of peculiar circumstances, occur within the body, and are unable to survive there—*incidental parasites.*

Animals of almost every class, even vertebrata, as for instance, amphibia (toads, frogs, salamanders, blind worms), also insects, and their larvæ, snails, &c., have been occasionally met with, forming incidental parasites. Many of the cases registered in the annals of science are, however, at least doubtful, and some reports of the kind, are evidently founded upon false statements, or even intentional deception.

We shall not at present enter more deeply into the consideration of these incidental parasites. With respect to the different species observed in separate parts of the body, and the pathological changes elicited by them, we must refer to the special part. In this place we shall only consider the true parasites, especially those which occur in the human subject, citing those which are found in animals, only so far as they serve to the elucidation of the cases observed in man.

The questions regarding their mode of origin, and the pathological phenomena occasioned by their presence will be had regard to, so far as our present deficient observations allow, partly in our remarks on the individual species, and partly in our remarks on special organs, since on these points general laws cannot be laid down. Every unbiassed observer must arrive at the conviction that the morbific power is very different in the separate species, and will regard it as a far from completed scientific labour to point out, exactly, the extent of this power in each individual case. According to the prevailing systems, pathology has caused the parasitic animals to perform, amongst the causes of disease, sometimes a very subordinate, at other times, a very conspicuous part. Indeed, animal parasites have been regarded by some as the causes of almost every disease. See J. C. Nyander, Exanthemata viva in C. Linnæi amœnitates academicæ, vol. v. Holmiæ, 1760, p. 92—105; also in recent times F. V. Raspail, Histoire naturelle de la santé et de la maladie, &c., Paris, 1843, t. I. p. 285—496, t. II. p. 1—286, with numerous figures—a strange mixture of truth and fiction, yet, for the critical reader, containing some interesting facts, and profitable suggestions for further investigations. The reader may also consult the work of v. Olfers, which in some respects, however, is becoming a little antiquated, de vegetativis et animatis corporibus in corporibus animatis reperiundis, P. 1, Berol. 1816, c. tab.*

I. PARASITIC INFUSORIA.

In the inferior animals, infusoria very frequently occur as true parasites, both on the external surface of the body, and in their internal cavities. Thus in the intestinal canal of the frog, Ehrenberg distinguished no less than five different species of *bursaria.* The infusoria occurring in the human body appear, on the contrary, to be not so much *true* as *incidental* parasites. The condition most essential to their development appears to be a degree, however slight, of putrid decomposition, such as occurs normally in fæces, and in many animal fluids as a pathological phenomenon. Infusoria are consequently very frequently seen in fæces, and sometimes also in foul and impure ulcers.

The infusoria which, under these circumstances, appear most frequently in the body are *vibriones*, especially a species of them which is met with in almost all putrescent fluids containing protein (*vibrio prolifer ?* Ehrenberg). Seen under strong magnifying powers these vibriones form sometimes simple, sometimes compound (from two to six) bead-shaped globules, ranged upon each other,† and exhibit a very active animal motion. By feeding them with carmine, I have sometimes succeeded in bringing the gastric cavity into view. I have frequently, but not invariably found these vibriones in fæces, especially in liquid evacuations, also in the pus of foul, sluggish ulcers. Donné has found this or another

* I regret exceedingly that I had not the opportunity of consulting the excellent article "Parasiten," by K. Th. v. Siebold in Wagner's Handwörterbuch der Physiolog. vol. II. p. 641, &c.; which did not reach me till these sheets were printing; hence, instead of incorporating his results in the text, I must content myself with referring to his most important conclusions in the notes.

† See Plate X. fig. 10.

species of vibrio (*v. lineola?*) in the pus of chancres.* Of other infusoria, I have sometimes found in fæces the exuviæ, and less frequently, active specimens of *navicula*. Upon foul ulcers and in the pus from them, *vorticella* and also *colpoda cucullulus* have been occasionally observed.

Donné† asserts that he has found a peculiar infusorium, which he names *trichomonas vaginalis*,‡ in the vaginal mucus of syphilitic females; it is supposed by R. Froriep and Ehrenberg to be a species of acarus. I, however, agree in opinion with Gluge and Valentin, that probably this imaginary infusorium is not an animal at all, but separated ciliated epithelium from the uterus.§

The occurrence in the living body of the infusoria which have been described, and of other species which probably will yet be occasionally observed, need occasion no surprise, if we consider that infusoria generally, and especially the specified forms belong to the most abundant of all the lower animals, which make their appearance by millions whenever conditions favourable for their development are afforded. They have little or no pathological importance, and at most serve but to show that, where they appear, there exists a putrid decomposition of the elements of the body to a greater or less extent, not otherwise demonstrable by exact means. Donné maintains that the vibriones of chancres (and even the trichomonas) constitute the true contagion of syphilis, an opinion which is directly controverted by the fact, that these animalculæ do not exist in the pus of syphilitic buboes, which, nevertheless, according to Ricord's experiments, by inoculation also produce actual chancres.

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* Recherches microscopiques sur la nature des mucus sécrétés par les organes génito-urinaires, Paris, 1837.

† Op. cit.

‡ See Plate x. fig. 9.

§ Siebold also maintains this opinion, op. cit. p. 660.

Beauperthuys and Adel de Roseville assert that in cancer, as well before as after softening, they have invariably found animalculæ, and believe that to these must be attributed the origin, progress, and fatal termination of this disease,*—a view which is undoubtedly erroneous, even allowing that infusoria do sometimes occur as incidental parasites in cancerous ulcers. Klencke states that he has observed in the human blood the appearance of animalcules resembling infusoria, and traces their connection with the occurrence of periodical attacks of vertigo.† In the blood of animals, infusoria have been often found; thus proteus-like infusoria (*amœba* of Ehrenberg) have been seen by Valentin in the blood of *salmo fario*,‡ and by Gluge in that of frogs.§ How these animals gain access to the vascular system, is a point upon which at present we can only entertain conjectures, although I have no doubt that they penetrate from without, and are not engendered by equivocal generation. It is not every form of infusorium, which artificially (by inoculation) introduced into the circulation of an animal, develops itself further; this ensues only when the conditions are very favourable for their development, which is rarely the case; otherwise they are very soon lost. In this point of view, an experiment I instituted myself appears to be worthy of communication. From a full grown cat, about one ounce of blood was abstracted, and in the place of it, there were injected two ounces of a fluid containing very numerous infusoria. This fluid was water in which an ape had been macerated during a period of two months; it contained millions of infusoria which belonged to one and the same species; they were oval, the 200th of a line in length, and the 300th in breadth (either a species of *monas*, or the young of *cyclidium glaucoma?*). Besides these infusoria no solid particles were contained in the fluid. After the lapse of twenty-three hours, about sixteen grains of blood were drawn from the cat. They contained no trace of these infusoria. Two days afterwards the animal was killed, and the blood carefully examined; it contained no trace of infusoria; they had all (notwithstanding that millions had been injected) disappeared without leaving the least vestige. It was interesting to observe that, in consequence of the injection (?) the blood of this animal presented a very decided increase of its fibrin. Whilst before the injection the blood contained in 1000 parts only 1.4 of this constituent, two days afterwards the same quantity yielded 6.68 parts.

* Froriep's Neue Notizen, vol. v. p. 112.

† Neue physiologische Abhandlungen, Leipzig, 1843, p. 163, &c.; see also Siebold on this point, op. cit. p. 649.

‡ Müller's Archiv. 1841, p. 435.

§ Comptes rendus, 1842, 14, p. 1050.

II. PARASITIC INSECTS.

Insects have been very frequently observed as incidental parasites in and upon the human body; as the ear-wig (*forficula auricularia*), the eggs and larvæ (maggots) of different species of flies (*sarcophaga carnaria*, *musca cadaverina*, *m. Cæsar*, *m. vomitoria*, &c.), which are sometimes found in foul ulcers, even upon the living body.

To those might be added many other species, whose enumeration in this place would carry us too far; we shall revert in the special part to the most interesting of this class of cases. For those who desire to prosecute this subject, the above-mentioned work of Raspail, Histoire naturelle de la santé, &c., offers an abundant fund of information, which, however, requires to be very cautiously employed.*

Of this class the only true human parasites are *fleas*, *lice*, and *bugs*.

A. FLEAS, pulicina.

The *common flea* (*pulex irritans*) lives upon the skin of man, but occasionally forsakes it, particularly in the summer, and is then to be found in gardens and woods, in sand, earth, &c. The female deposits her eggs in putrid materials, manure, saw-dust, decayed vegetable matter, rags, &c.: sometimes also under the toe-nails of dirty persons. From the eggs, which have the size of a small pin's head, there are developed minute apodal larvæ, which after ten or twelve days become transformed into chrysales. Out of the pupæ come the perfect fleas which then subsist as parasites on man and animals.

The pathological importance of the common flea is known to every one; whilst piercing the epidermis with its proboscis, it effects, by suction, a small extravasation of blood which appears as a red point surrounded by a paler red areola.

* See also Siebold, op. cit. p. 654.

Representations of the common flea may be seen in Dugès Annal. des sc. natur. 1ère série, 27, 147, pl. 4, fig. 1; in Raspail, op. cit. t. 2, p. 48, &c.; in Joerden's Entomologie und Helminthologie des menschl. Körpers, vol. I. p. 41, taf. 4. The fleas of domestic animals (pulex canis, felis, gallinæ, &c.), which likewise occur occasionally as transitory inhabitants of the human skin, are different from the true human flea. See also Bouché, Nova acta natur. curios. vol. XVII. Part 1, p. 503, and Dugès, op. cit.

2. The *chiggo*, (*pulex penetrans*) is a smaller, almost invisible, black flea, which inhabits South America. The female penetrates through the skin of man and the domestic animals into the cellular tissue of the toes, and there deposits its eggs which, if not removed in time, may produce very malignant ulcers, and even cause death.

See Dugès, Ann. des sc. nat. 2e série, 6, p. 129, with figures; Perty in the Voyages and Travels of Spix and Martius: Delect. Insect. Brasil, p. 34; Pohl and Kollar, Bras. vorz. läst. Insekten, Wien, 1832.*

B. LICE, pediculina.

1. The *crab-louse*, (*pthirius inguinalis*, Leach. *pediculus pubis*, Linné.) exists among the hairs around the genitals, and in the eyebrows of dirty persons.

Pale or dirty yellow, reddish brown in the centre, short and broad, almost quadrangular, from one half to one line long; the legs different, the anterior pair being for progression (the tarsus with only one joint, which prevents the separation of the claw), the four posterior climbing feet, (the claws being retractile from the presence of two joints). The thorax is broad and not distinctly separated from the abdomen. Representations by Burmeister, genera insector, phthirius, f. 1; Denny, Monographia anoplurorum Britanniæ, p. 9, Pl. XXVI. fig. 3; Alt, Dissertat. de phthiriasi, Bonnæ, 1824, 4to. fig. 5.

2. The *common louse* (*pediculus capitis*) exists on the hairy parts of the head, and is especially frequent in children.

The genus *phthirius* is distinguished from all other species of the genus *pediculus*, by all its limbs being *climbing limbs*. Whitish, thorax ob-

* Siebold, op. cit. p. 656.

longly quadrilateral; abdomen larger than the thorax, projecting behind in the form of an indented oval point, and having lateral serrations; all the segments are edged with black upon the outer border. Length of body from $\frac{3}{4}$ to $1\frac{1}{5}$ of a line. Figures: Burmeister, Genera, Ped. cap. fig. 1, males. Fig. 2, females. Denny, Anopl. Brit. p. 13, pl. 26, fig. 2. Alt, de phthir. fig. 2.

3. The *clothes louse* (*pediculus vestimenti*) lives upon the parts of the skin which are free from hair, and in the clothes of unclean persons.

It appears by many observers to have been confounded with the common or head-louse, from which, however, it is clearly distinct. Its entire body is paler, it has a much more slender form, and a more sharply defined neck; its thorax is narrower and shorter; its abdominal segment has an obtuse apex, which is not serrated, and its margins are not so deeply indented as in the foregoing species. Length of body from 1 to $1\frac{1}{2}$ lines. Figures: Burmeister, Genera, Ped. vestim. fig. 8. Denny, Anopl. Brit. p. 16, pl. 26, fig. 1. Alt, de phthir. fig. 3.

4. The *louse occurring in phthiriasis* (*pediculus tabescentium*), is found on persons, suffering from marasmus and other diseases, from whom, however, it appears not to be propagated to healthy persons; at least this is not constantly the case. They multiply very rapidly, and may therefore occur in large quantity; nevertheless we must consign to the region of fable the statement of Amatus Lusitanus, who relates that two slaves were incessantly occupied in conveying to the sea in baskets, the lice which appeared upon the body of their master. On account of the rapid increase of these animals, many have been and still are of opinion, that they arise by equivocal generation. This view, however, is altogether unnecessary when we consider the astonishing rapidity and abundance with which lice increase by propagation. Indeed, Leeuwenhoek has calculated that two female head-lice, which multiply far less rapidly than this species, can present in two months a progeny of 18000 individuals.

The *pediculus tabescentium* is of a pale yellow colour; the head is rounder, and the thorax is larger and broader than in the preceding species; the abdomen is of the breadth of the thorax, but shorter, narrowing, somewhat, posteriorly; the margins not serrated, but only undulated. Length of body $1\frac{1}{4}$ of a line. Figures: Alt, op. cit. fig. 4. Also Burmeister, Genera, and Denny, Anopl. Brit. p. 19. This, like all the species of lice, has been hitherto found by all trust-worthy observers only *upon* the human skin, at most, in crusts, but never *beneath* the integument. It appears to me very improbable that the cases in which small louse-like insects have been discovered in abscesses, &c., beneath the skin, (Rust in Bremser, Lebende Würmer im lebenden Menschen, p. 55, Hufeland's Journal, 1813, Part 3, p. 122, et seq.) belong to this place. These were probably acari. See Alt, op. cit.

Besides the above species of lice, others probably occur which are *true* parasites in relation to domestic animals, and are occasionally to be found as *incidental* parasites on the human subject.

These lice belong to a genus very rich in species—*hæmatopinus*, whose generic characters are the following: all limbs have climbing feet, the thorax is *distinctly separate* from the abdomen, and usually much narrower; the abdomen is broad, and consists of five or nine rings. See Burmeister genera.—Denny, Anopl. Brit.—Rayer, Archives de pathologie comparée, t. 1, in several places,—and the two very interesting treatises of Gurlt, über die auf Haussäugethieren und Hausvögeln lebenden Schmarotzerinsekten und Arachniden, in Gurlt and Hertwig, Magaz. f. d. gesammte Thierheilkunde, Berlin, 1842, p. 409, 1843, p. 1.

C. BUGS, cimices.

The *bed-bug* (*cimex lectularius*) is a well known animal infesting beds, &c., which by night perforates the epidermis with its proboscis, and sucks the blood of man.

See figures in Burmeister—and Raspail, t. 2, p. 41, pl. 5, fig. 5 and 7, &c.

If we take a comparative review of the human parasites belonging to the class, *insects*, we arrive at the conviction, that they arise by propagation, and not spontaneously, —a conclusion which, at the present day, scarcely any one will question. And although some, as has been mentioned, are still inclined to attribute the origin of *pediculus tabescentium* in certain instances to spontaneous generation, yet I entertain no doubt, that even here, future and more minute researches will point out an origin by propagation in all cases.

For the abundant occurrence and increase of most species of lice, certain conditions, as want of cleanliness, &c., appear to be necessary; and indeed, sometimes even a certain disposition of body, delicate skin, youth, &c. This appears especially the case with *ped. tabescentium,* which as several observers attest, never pass to healthy individuals, their occurrence always indicating an antecedent morbid character of the fluids. Nevertheless upon this subject much still remains to be perfected by future researches. In fleas, on the contrary, the incursion appears to be much less restricted to any peculiar disposition.

It is very interesting in a pathological point of view to observe how unequally different species of these parasites rank as morbific agents. Pulex irritans, pediculus pubis, capitis et vestimenti are rather troublesome than dangerous guests; pulex penetrans, on the contrary, always induces serious consequences, and sometimes even proves dangerous to life. The same holds good regarding ped. tabescentium, where it occurs in great abundance, although it is not established, whether its occurrence be the cause, or merely the effect of a general disease.

In addition to the works on this subject already quoted, we may mention: Nitzsch, über die Gattungen und Arten der epizoischen Insekten in Germar's Magazin der Entomologie, vol. III. Halle, 1818, p. 261.

III. PARASITIC ARACHNIDA.

In the class *arachnida* there are many animals injurious to human life by their venom, as for instance, many kinds of scorpions and spiders; these, however, do not bear on the present subject. One family of this class, however, that of the *mites* (*acarina*) comprises several species which infest the human subject, and are more or less pernicious. These must now occupy our attention.

They are very minute, almost microscopic animals with distinct and separate sexual organs; they live upon, and sometimes beneath the skin, in abscesses, &c., multiply very rapidly, and for the most part, possess a great tenacity of life, as may be seen by the following startling examples, which are related by Hering. A portion of skin from a recently killed mangy horse, was laid in a solution of alum and common salt, where it remained perfectly covered during eight or ten days; it was then stretched out and dessiccated in a hot chamber. A very large number of surviving acari then made their appearance.

A strip of skin from another mangy horse, after having lain for several days in a cold place, was macerated during four days in an aqueous solution of alum and common salt, and afterwards dried. There were found upon it, nearly four weeks after the death of the animal, some still surviving acari.

1. *The human itch-mite* (*acarus scabiei, sarcoptes hominis, sarcoptes exulcerans*) lives upon persons affected with the itch. It is white, very minute (from one tenth to one fourth of a line), in the form of a point; when magnified it presents an oval body, which upon its superior (dorsal) surface, presents rugous transverse striæ, having between them, in the middle of the back, mamillary projections. It has no true head, but upon the anterior extremity of the body, proboscis-like mandibular organs of roundish somewhat compressed form, which are furnished with four hairs or bristles. The point of junction of the proboscis with the thorax is continued in a roundish channel which descends upon the under side of the thorax, almost to its centre. Similar projecting channels proceed from the points of insertion of the eight feet. Of the latter, the four anterior limbs are inserted into the thorax by the side of the proboscis, are jointed, and furnished with hairs and bristles, the last joint of each terminating in an adhering disk. The posterior legs without adhering disks, terminate in very long bristles. The abdomen obtusely rounded off posteriorly carries two additional pair of bristles, of which the inner

is somewhat the longer. The bases of the extremities, and the mandibular organs are of a red brown colour.

The acarus bores channels, often many lines long, in the epidermis of the human skin; and when these have not become destroyed, or obliterated by friction of the clothes, by scratching, &c., they may be perceived with the unaided eye, and more easily with a lens. Upon certain spots where the animal either penetrates deeper in the epidermis and comes in contact with the cutis, or where it deposits its eggs (for which purpose it usually selects the hair or cutaneous glands), vesicles and pustules are formed in consequence. The animal does not, however, live in these pustules, but usually soon abandons them, in order to continue its progress. This circumstance must be borne in mind in searching for it; its eggs are frequently seen in the pustules, while the animal is more commonly found at the further extremity of its burrow. It appears as a small whitish speck, with a still smaller brownish point, which depends upon the coloured anterior extremities, and mandibular organs, and admits of ready extraction with the point of a needle.

The relation of these acari to the itch has been much debated, and opinions are still divided upon some points. The following are the principal views that have been brought forward on this subject.

1. The acari are the cause of the itch which is called into existence by their presence.

2. The acari are the effects of the itch; they arise either spontaneously in consequence of conditions established by the disease, or they are parasites to whom the possibility of existence and propagation is afforded by the presence of the itch.

3. They have nothing at all to do with the itch, and their presence in this disease is accidental.

Although at the present day it is impossible positively to establish any one of these views, and as certainly to refute the others, yet after an unbiassed examination of all arguments and objections, it appears to me that the first of these opinions is the only correct one. Experiments which have been instituted upon the human subject, and in still greater number with the perfectly analogous itch-mites of animals, prove that the transference of acari is capable *per se* of producing the itch in healthy individuals. If males only are transferred, a transient irritation may, indeed, ensue, but no scabious eruption, since the transferred individuals cannot multiply, and their individual operation, unless very many are transferred, is too slight to call forth a perceptible exanthema. If, on the other hand, females are transferred, actual contagion results. Inoculation with the contents of the itch-pustule occasions, at most, local irritation, but no itch (Hering). These facts establish, beyond question, that the itch *can* be conditional solely on the presence of the acari. The negative proof that there exists no other cause of itch than the transference of acari is more difficult. Nevertheless, most of the objections which are wont to be urged against this view are very easily met. Although acari have not been detected in every case of scabies, this partly depends upon the fact, that most of the physicians who search for the itch-mite have not the tact to discover it, and, therefore, in many cases deny its presence where in reality it abounds. Again, the itch-mite may be already destroyed by the remedies which have been applied, and, nevertheless, new eruptions of pustules succeed, since the irritation of the skin, occasioned by the long-continued presence of the acari, need not necessarily disappear immediately on their removal; indeed, probably in many cases it becomes temporarily augmented by the irritating ointments applied. Moreover, it is not to be denied that a cutaneous disease, perfectly similar to the itch, can be produced by other causes than the itch-mite. Many questions upon this subject still remain, therefore, to be resolved by pathology. That the itch-mite can be spontaneously produced, as Hering conceives, appears to me, from the above-mentioned general reasons, to be highly improbable. I believe that whenever these animalcules occur upon the human body, they have been transmitted to it from without. The appearance of itch-pustules, ulcers, &c., appears produced partly by the mere presence of the acari and their mechanical effect, and partly by the violent scratching of the patient; that the acari secrete acrid juices, and thus exert a chemical irritation upon the skin, is improbable. The more violent irritation, which itch-patients suffer by night and in the warmth, depends upon the natural habits of the acari; they are especially nocturnal animals, and love warmth, and are rendered more lively by it. For this reason the disease is especially liable to be caught by sleeping with an infected person.

The different forms of scabies depend, no doubt, on the unequal susceptibility and disposition of the cutaneous organs, or upon other external and internal circumstances. If, by the destruction (by means of ointments, &c.) of the greater part of the animals, the itch is for the present cured, the disease may after a few weeks, even without new contagion, again break out; for these acari are remarkably tenacious of life, and a few of them or of their ova may have escaped extermination. The itch-mite, like the chiggo, appears to take up its abode upon all (even the most healthy) individuals, and to indicate by its presence no special disposition. Notwithstanding this, however, certain conditions, especially uncleanliness, favour its transference and extension, whilst others, as extreme cleanliness, restrict them.

In order to arrive at a correct apprehension of the relations of the human itch-mite, it is essential to have regard to the allied forms of acarus which occur on the inferior animals; the more so, since, in the latter, experiments with respect to contagion, can be made much more readily than in man. To the most important literature on this subject, I therefore subjoin that of the itch-mites of animals. Respecting human itch-mites, see Stannius das Insekt der Krätze. Medic. Vereinszeitung, 1835, No. 29.—Müller's Archiv. 1836. Jahresber. p. 228.—Raspail, Naturgeschichte des Insektes der Krätze, aus d. Franz. mit Anmerkg. von. G. K. 1835.—Raspail, Histoire natur. de la santé, &c. t. I. p. 441, &c.—Dugès, Annales des sc. nat. 2e série. 3. p. 245. —P. Gervais, Ann. des sc. natur. 2e série. 15. p. 9.—Nitzsch Art.

Acarus in Ersch and Gruber's Encyclopädie. Also the following dissertations: E. M. Heyland, de acaro scabiei humano. Berol. 1836. J. A. F. Rohde, de scabie et acaro humano. Berol. 1836. C. G. Schwartz, de sarcopte humano. Lipsiae, 1837. H. Sonnenkalb, de scabei humana. Lips. 1841. G. A. Deutschbein, de acaro scabiei humana. Halis, 1842. Upon the acari of animals, see E. Hering, die Krätzmilben die Thiere, in Nova acta natur. curios. Vol. XVIII. Part II. Hertwig in Gurlt and Hertwig's Magazin, f. d. ges. Thierheilkunde, 1835, No. 2; and Gurlt, in the same periodical, 1843, No. 1, p. 18, &c.

Besides the true human itch-acarus, those peculiar to animals are sometimes communicated to man, and may even occasion a scabious disease of the skin, as the acarus infesting the horse (*sarcoptes equi*), of which Hering (op. cit. p. 591) has collected several instances, also those of the dog, of the wombat (*phascolomys ursinus*), of the cat, rabbit, and camel; these are, however, exceptions, and the few recorded cases of this kind still require confirmation.

An acarus, which originally lives upon birds, has been repeatedly observed upon the human subject (*dermanyssus avium*, Dugès; *acarus gallinæ*, Degeer; *a. hirudinis*, Hermann; *gamasus maculatus*).* This animal appears to be always a transitory inhabitant of the human subject, and only very rarely to induce pathological conditions (erythema and vesicles). Raspail has described, in detail, an interesting case of the kind (Histoire naturelle de la santé, &c., t. I. pp. 376 and 379); although he has correctly depicted the acarus in Plate III. fig. 1—3, he mistakes it for *rhyncoprion columbæ*, Hermann; whereas it is the *acarus hirudinis* of the same author.

Amongst the acari, we must doubtless include the animalcules mentioned in our remarks on lice, which have been discovered by some observers† *beneath* the skin, in the interior of the body, in abscesses, &c. Although at present they have not been minutely examined, and we are, therefore, unable even to fix their species, yet the relations under which they have been observed are perfectly analogous to those under which Nitzsch (in Ersch and Gruber, Part 1, p. 250), has observed the *sarcoptes nidulans* in birds. This careful observer found in the greenfinch (*fringilla chloris*, Temminck), upon the wing and under the skin of the breast several yellow tubercles, varying in diameter from three to eight lines, which formed open abscesses, and upon closer examination proved to be enormous nests of a species of acarus, and were lined with a peculiar yellow membranous crust. They were quite full of oval eggs,

* See Alt, de phthirias. dissert. fig. 1; Gurlt in Gurlt and Hertwig's Magaz. für ges. Thierh. 1843, No. 1, Pl. 1, fig. 16, 17.

† Rust in Bremser, Lebende Würmer im lebenden Körper, p. 55, &c.

intermingled with young just hatched, and when first opened, also with old acari.

In addition to these are a few problematical cases, in which peculiar forms of acari have been observed in the human subject.

Bory de Saint Vincent describes peculiar acari (*dermanyssus*), which infested the body of a woman in great abundance, but were not communicated to her husband. (Annales des sc. natur. 1ère série. 18. p. 125. Pl. I. fig. 6.) To these are allied the acari observed by Busk, in a pustule, on the foot of a sailor. (Microscopic Journal. Vol. II. p. 65. Pl. III. fig. 7.)

We must here also doubtless include the *argas persicus*, an animalcule which in the Persian town of Miana is an extreme annoyance to strangers.* Also the *nigua* (*ixodes americanus*).† The *acarus dysenteriæ*, which by early authors‡ is stated to occur in dysentery, is problematical, and, at all events, is not the cause of this disease.

2. The *acarus of the human hair-sac* (*acarus comedonum ; a. folliculorum*, G. Simon ; *demodex folliculor.* Owen ; *simonea folliculor.* P. Gervais).

This animal varies from the 12th to the 8th of a line in length, and from the 30th to the 50th of a line in breadth. Its mandibular organs consist of two palpæ, which have between them a proboscis. They pass immediately into the anterior segment, which amounts to about one-fourth of the length of the body. On it (the anterior segment) are situate four pairs of short, thick feet, each consisting of three parts, and furnished at the extremity with three short claws, of which one is somewhat longer than the other two. The anterior segment has four grooved transverse bands, which unite at the middle line in a longitudinal stripe. To the anterior is joined the posterior segment. It is longer, rounded off posteriorly, and filled with a dark, granular substance. It shows throughout its entire length fine transverse bands. This animal presents very decided varieties and deviations from the form

* Fischer, Acad. de Moscow, 1823.

† P. Gervais, Histoire nat. des insectes. Aptères. T. III.—(Nouvelles suites à Buffon). Paris, 1844. p. 247.

‡ Nyander, Exanthemata viva in Linné amœnitat. academ. t. V. p. 97.

just described, which are probably connected with different grades of development. The form which is probably the earliest has only three pair of feet and a very long, slender, posterior segment; then comes the above described form, as the most frequent; subsequently the posterior segment appears always to become shorter.

The *acarus folliculorum* very frequently exists in the hair-glands of the human subject, on the nose, upper lip, and the glands of the hair of the beard; it is sometimes solitary, sometimes ten or more are found in a single gland. It seems to possess no great pathological importance, since the gland which it inhabits frequently shows not the slightest morbid alteration; probably, however, it may sometimes irritate the hair-gland, occasion an increase in the quantity of its secretion, and thus favour the generation of *comedones.*

I do not entertain the slightest doubt that this animal arises, in the usual manner, by propagation and transmission, and not by equivocal generation.

The *acarus folliculorum* was first observed and described by G. Simon.* I have occasionally found it in the perfectly normal glands of the hair of the chin in the dead body. See Wilson, in the London, Edinburgh, and Dublin Philosophical Magazine, June, 1844.

IV. PARASITIC WORMS, INTESTINAL WORMS, HELMINTHA. (*Entozoa, Enthelmintha, Splanchnelmintha*).

The intestinal worms which occur in man are represent - tives of only a few species of the large class of these animals, from which scarcely any living being is exempt; and a correct knowledge of the human entozoa, and of their various relations, can only be obtained by likewise studying those which occur in animals. I must here also repeat my conviction that these animals arise solely by means of propagation and transmission from without, and that it appears to me the duty of science to demonstrate this mode of origin, even for the human entozoa, in every individual case. The pathological

* Müller's Archiv. 1842, p. 218, &c., with numerous figures.

indication of the individual worms is so different, that its consideration must be reserved for the description of each.

The most important works respecting entozoa generally, are: Rudolphi Entozoorum historia. Amstelod, 1808 & 9.—J. G. Bremser Icones helminthum. Viennae, 1824, fol. — Rudolphi Entozoorum Synopsis. Berolini, 1819. The latest comprehensive work is that of F. Dujardin, Histoire naturelle des helminthes. Paris, 1845, avec 12 pl. (Part of the Nouvelles suites à Buffon). For the human entozoa we can especially recommend: Bremser, über lebende Würmer im lebenden Menschen. Wien, 1819; a work which presents accurate descriptions and correct representations, with abundant literature, and entirely supersedes all preceding works, as those of Brera, Joerdens, &c. For the anatomy of the entozoa, see Owen in Todd's Cyclop. of anatomy and physiology, art. Entozoa; Schmalz, 19 tabul. anatom. entozoorum illustrantes, Dresdæ.

In the classification of the human entozoa, I follow the system established by Rudolphi, and let the false succeed the true, in the form of an appendix.

FIRST ORDER.

NEMATOIDEA.

ROUND WORMS, THREAD WORMS.

1. *The thread or guinea-worm, filaria medinensis, filaria dracunculus.* This worm consists of a long filament of whitish, or sometimes brownish colour, of the thickness of pack-thread. It is of equal thickness throughout, and it terminates posteriorly, as may be perceived on microscopical examination, in a curved point. The anterior termination appears truncated, with several suckers. In length it varies from half a foot to twelve feet. As yet only females have been observed; they are viviparous, and contain in their interior such a prodigious quantity of young, that some maintain that the worm is not an animal at all, but a membranous sheath filled with small worms. These young filariæ are, according to Duncan, the 57th of an inch in length.

The *filaria medinensis* is found in the tropical regions of the Old World, in Arabia, on the Ganges, on the Caspian Sea, in Upper Egypt and Abyssinia, but especially in the Dutch and English possessions of Guinea, where it is so prevalent that it has received the name of *guinea-worm;* it likewise occurs in some districts of the West Indies and of America, and upon the island of Curaçoa (where it was probably introduced by negroes). It exists in the subcutaneous cellular tissue of the human subject, most frequently upon the extremities, especially the inferior; but it occasionally occurs in the scrotum and other parts of the body. A man has sometimes only one, sometimes several (4, 5, 6—15) worms at the same time. The symptoms which accompany the presence of this parasite in the human subject are very various, being sometimes unimportant, while they are sometimes so violent that a dangerous disease, or even death itself results. These are diminished, or totally disappear, if the worm is removed by cautious extraction. If it should be ruptured during the process, the masses of young contained in its interior are discharged into the wound, and occasion unhealthy suppuration.

Although some celebrated authors are of opinion that these worms are spontaneously developed, yet it appears to me far more probable that they have passed into the body from without; either from the stomach or intestinal canal, into which the almost microscopic young have been introduced with water, or, which is more probable, that they have made their way into the body through the integument, and have there further developed themselves. The worm may, apparently, dwell for a long time in the body without being remarked, and not excite attention until after its perfect development, when it becomes filled with young, which quit the parent animal, and by their great number, and active movements, excite irritation in the surrounding parts; or until it spontaneously endeavours to quit the body in order to deposit its young externally. This slow process of development also explains those cases in which the disease has broken out in persons who had quitted, eight or even twelve months previously, the countries in which this worm is endemic.

The representation of the worm by Bremser is incorrect, and inferior to that given by Birkmeyer in his Treatise, de filaria medinensis comment. propriis observat. illustr. Onoldi, 1838. The older literature is very complete in Bremser, p. 194, &c., and some more modern papers are referred to in Dujardin, p. 44; I may also refer to Bruce and Paton, in the Edin. Med. and Surg. Journ. 1806, p. 145, &c.; to Duncan, in the Transactions of the Med. and Phys. Soc. of Calcutta, vol. VII. p. 273; and to Forbes, in the Transactions of the Med. and Phy. Soc. of Bombay, vol. I. p. 216. Duncan and Forbes bring forward many reasons in favour of the transference of the worm: it appears to be communicated from the patient to the attendants, to dogs, and to horses. Forbes has kept the young alive in moist earth from fifteen to twenty days. In the countries where it is endemic, the mud of the pools contains numerous animals resembling the young of the worm. It is worthy of remark, that as yet only female filariæ have been found in the human body. Do females alone, while still young, after their impregnation enter the human body because they there find conditions favourable to their further development? Or does the male also penetrate into the body, but, on account of its smaller size, and because it furnishes no young, give rise to no evil effects, and therefore escape observation? The reply to this and to many other questions respecting the origin and indication of this worm, must be left to future researches.

According to observations collected by Pallas,* it appears that even in our latitudes thread-worms (the *gordius aquaticus?* which is common in stagnant water and moist ground) can in certain cases infest the human subject.

I may here mention the fabulous *furia infernalis*, which, in northern Sweden and Lapland, is stated by Solander† to fall down from trees upon men and animals, and generate a fatal disease.

2. *The filaria oculi humani* has on several occasions been observed by A. v. Nordmann‡ in the human eye. In one of his cases, Nordmann discovered in the *Liquor Morgagni* of a cataractic lens (extracted by Graefe), which he examined half an hour after extraction, two small, delicate filariæ, coiled in the form of a ring. Under the microscope,

* De infestis viventibus intra viventia, p. 11.

† Nova acta Upsal. Vol. I. p. 44.

‡ Mikrograph. Beiträge zur Naturgesch. d. wirbell. Thiere, Berlin, 1832, Part 1, p. 7, Part 2, Preface p. ix.

one of these worms presented in the middle of its body a rupture (occasioned probably by the operating needle), through which the intestinal canal protruded; the other was uninjured, and was three-quarters of a line in length. It had a simple mouth, without distinct papillæ, and a straight intestinal canal, which glistened through the transparent skin, and was observed to be surrounded by the convolutions of the oviducts, and terminating at an incurved anal extremity.

In another case, one opaque crystalline lens of an old woman (*cataracta lenticularis viridis*, extracted by Jüngken), contained a living filaria five and a half lines in length, in the act of casting its skin; whilst in the other lens of the same person no foreign animal body could be detected.

Gescheidt* likewise discovered in an opaque lens extracted by Ammon, three filariæ, of which the largest was about two lines long. In relation to their length, the animalculæ were remarkably thin and delicate; the body was of almost equal thickness throughout, but tapering a little towards the head; the tail somewhat club-shaped, and furnished with a short, slender, curved point. The mouth was small, almost circular, and without papillæ; the intestinal canal was of a yellow colour, and ran without curvature or dilatation as far as the tail, where it terminated in a round opening, which received at the same time the excretory duct of the ovaries. The ovaries appeared as extremely delicate spiral cylinders, whose convolutions accompanied the course of the intestinal canal.

Whether these filariæ occur only in the human eye, and form a distinct species, or whether, as seems to me more probable, they can also live elsewhere, must be decided by future researches. An explanation of their origin is at present impossible from want of experience; yet, in elucidation of it, the circumstance that filariæ have also been found in the blood of living animals, appears to me to be important.

3. *The filaria bronchialis*, Rud. (*hamularia lymphatica*, Treutler) has as yet been found only once (by Treutler) in

* v. Ammon's Zeitschr. f. Ophthalmologie, vol. III. p. 436.

the enlarged bronchial glands of a cachectic young man. They were about an inch long, roundish, blackish brown, sometimes spotted white; at one extremity there were two projecting hooks (the external genital organs of the male?)

Figured by Bremser, Pl. IV. fig. 2. Most probably these worms are allied to those which are not unfrequently found in the bronchi and lungs of animals belonging to the genus *mustela*.

4. *The trichina spiralis*, Owen, is a microscopic worm which has hitherto been only found in the voluntary (striated) muscles, and then usually in very great numbers. In such cases the muscles appear dotted with minute white spots which, under the microscope, represent elliptic cysts, commonly elongated at their extremities; the long diameter being always parallel to that of the primitive fasciculus. These cysts, whose long and short diameters are about the 50th, and the 100th of a line respectively, constitute the habitation of the worm. They are usually so transparent that, under the microscope, even without opening them, the animal may be recognised in the interior. It occupies about the third part of the cavity of the cyst, appears coiled up into a spiral of two or two and a half turns, is round and filamentous, presents a somewhat truncated appearance at both sides, and slightly tapers towards one end. When extended, its length varies from one half to one third of a line; its diameter from the 60th to the 80th of a line. Internal organs cannot be perceived in it. In general only one worm is contained in one cyst, rarely two, and still more rarely three. The cysts frequently contain in addition to the worm, depositions of calcareous salts, so as to form small granulations which grate under the knife. These often conceal the worm, which in this case frequently, but not always is dead; if, however, the calcareous salts are removed by acetic acid, the worm becomes apparent.

With the exception of the heart, these animals occur in all striated muscles. They have been found in persons who have died of very different diseases; moreover, even in some who, whilst in perfect health and vigour, had been suddenly destroyed by mechanical injuries (fracture of the scull). Their pathological importance seem, therefore, to be not very great. The occurrence of this worm has been, even recently, regarded as affording an important support to the theory of spontaneous generation; although I believe, that ultimately also in this case, a transference from without will be successfully proved.

The *trichina* was first discovered in England, and described by Owen.* It has been since observed by others, (Farre,† Henle,‡ Kobelt,‖ Bischoff,§ Bowman, &c.) Farre states that he has observed in it an intestinal canal with evident walls. On account of its symmetrical form, I hold the investing capsule of the worm not to be a secondary cyst produced, as in the case of hydatids, by reaction of the organism which harbours it, but believe that it pertains to the worm itself, and is the result of a kind of metamorphosis of the animals. This view is supported by the regular form characterising these cysts, which are elongated and terminate in pestle-like extremities. Most trichinæ, before they can escape from their cysts, undergo the calcareous incrustation already noticed. What becomes of those which quit the cysts is unknown. The trichinæ which Bowman has observed in the interior of the primitive muscular fasciculi should be probably here noticed; possibly the animal afterwards becomes larger, and attains to a more developed form of the nematoidea. In favour of the origin of a trichinæ by transference, it may be mentioned that they (probably the same species) have been observed also in animals. Diesing has found them in the horse; Siebold in several of the mammalia and birds: I have found perfectly similar animals in the peritoneum of an owl, and a few days ago, through the kindness of my colleague, Professor Herbst, I observed trichinæ, completely resembling those occurring in the human subject, in nearly all the muscles of a cat. The detection by several recent observers of filaria-like worms in the blood of different animals, is suggestive of their mode of origin. See Rayer, Archives de méd. comparée, 1843, t. I. p. 40 et seq.; Vogt in Müller's Archiv. 1842, p. 189; and Gruby and Delafond in Froriep's N. Notizen, Febr. 1843, p. 231.

* Transact. of Zoological Soc. vol. I. London, 1835, p. 315 et seq.

† Medical Gazette, Dec. 1835.

‡ Müller's Archiv. 1836, Jahresber. p. 227.

‖ Froriep's N. Notizen, 1840, vol. XIII. p. 309, vol. XIV. p. 235.

§ Medicinische Annalen, vol. VI. p. 232 and 485.

5. *The trichocephalus dispar*, (*trichuris*, Roed. and Wagl.) or *long thread-worm* is a thin, filiform animal, varying in length from an inch and a half to two inches. It consists of a very delicate, capillary anterior portion, which includes about two thirds of the length of the worm, and then passes rather suddenly into a strikingly thicker posterior extremity. It is usually white, although occasionally somewhat coloured. The worm has separate sexes, the males and females being essentially different; and hence the name *dispar*. The male is rather smaller than the female; its capillary anterior part is pointed, the thicker posterior portion is spirally coiled, and exhibits on its extremity a long penis (spiculum), invested with a proper sheath. In the female the capillary anterior portion is longer; the thicker posterior part being straight, and only a little inverted at the extremity; the penis with its sheath is absent. The eggs are oval, with resisting shells, and when mature, measure the 40th of a line in length.

The *trichocephalus dispar* is of very frequent occurrence in the large intestines, particularly in the human cæcum; it sometimes occurs in nearly half the subjects examined. Sometimes it is found alone, at other times in great numbers. It firmly adheres by its capillary head to the mucous membrane.

The pathological importance of this worm appears slight, since it is frequently found in great quantities in persons, who during life did not exhibit any symptoms of its presence.

Bremser, p. 76, Pl. 1, fig. 1 to 5. On the anatomy of the trichocephalus, see Meyer, Beitr. zur Anatomie der Entozoen, p. 4 to 14. A similar trichocephalus, apparently the same species, is found in swine.

6. *The trichocephalus affinis*, Rud. a species otherwise occurring only in the ruminantia (of the genera cervus, antilope, ovis and bos) is stated to have been once found in the human subject, on a soldier who had died in Fort Pitt from angina tonsillaris; this worm was found in the left tonsil,* which was tumid and gangrenous.

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* Monthly Journal of Medical Science, 1842, May.

7. *The spiroptera hominis*, Rud. is a small, delicate, spirally coiled worm of white colour, and with separate sexes. The two sexes differ in their form and size. The male measures eight, the female ten lines in length. The head ends obtusely and has one or two papillæ, and an orbicular mouth. The body is round, tapering towards both extremities, especially towards the anterior. In the female the tail is thick with a short, blunted point; in the male, thin, with a tube—probably the sheath of the penis. An aliform appendix towards the tail is characteristic of this animal.

The *spiroptera hominis* has hitherto been only found in one instance, by Barnett of London, and is stated to have been discharged with the urine by a woman. It possesses at all events no great importance.

Figured by Bremser (Pl. IV. fig. 6 to 10) who regards these worms as young strongyli.

8. *The strongylus gigas*, Rud. is a very large, round worm, varying from five inches to three feet in length, and from two to six lines in thickness, and, when recent, of a blood-red colour. The sexes are separate, and differ in form. The male is smaller than the female, and tapers somewhat towards both ends. The head is obtuse, the mouth orbicular, and surrounded by six minute papillæ. The body is marked by circular striæ, and presents several shallow longitudinal furrows. At the posterior extremity, the male presents an infundibuliform pouch, from which a very slender penis protrudes. The female is larger and has a straightly extended and obtuse tail, on which may be seen the oblong anus. Its vulva is one or more inches distant from the extremity of the tail, according to the size of the individual. The ova are almost globular.

The *strongylus gigas* inhabits the kidneys, and the cellular tissue surrounding them. It is highly dangerous, and by its presence may occasion a total destruction of this organ, or even cause death. This species occurs also in several animals—the horse, dog, wolf, marten, &c.

See representations in Bremser, Pl. 4, fig. 3 to 5; Gurlt, Lehrb. der patholog. Anat. der Haussäugethiere, Pl. 8. fig. 25 to 28, and Rayer, Maladies des reins.

9. *The round worm, ascaris lumbricoides*, Linné, is

of common occurrence, and of considerable size, varying from six to ten, or even fifteen inches in length, although occasionally, however, smaller, as from one to two inches long. It is usually of a whitish or brownish red colour, and occasionally blood-red. Its body is round, cylindrical, and pointed at both ends, but more decidedly at the anterior than at the posterior extremity. A delicate furrow runs along the body upon both sides. If the worm is examined under the microscope, it is perceived that the head is separated from the body by a kind of circular constriction, and presents three tubercles or peculiar valves, which can open and shut themselves, and have between them the proper opening of the mouth. In the interior of the body we may recognise the brownish intestinal canal which terminates in the anus, a little anterior to the extremity of the tail. This worm has the sexes distinct. The male is somewhat smaller, and has a more curved tail, from which, at intervals, the double penis is seen protruding. In the female, again, we may recognise the sexual organs, ovaries and oviduct, as white, partly thread-, partly riband-like organs which, when the worm breaks, readily fall out, and having become detached are frequently mistaken for individual worms. The ova measure the 25th of a line in length, and have a thin smooth shell.

The round worm is of very frequent occurrence in the small intestines of the human subject, especially in children. Its presence is not so injurious as is commonly supposed, for it is often found in great numbers without the slightest disturbance of the health. Yet it may certainly become troublesome and even injurious, either by reason of its accumulating in great numbers, and exciting mechanical irritation in the intestinal canal, or even closing it up,* and thus producing

* Haller observed an instance in which a girl aged ten years, died from the accumulation of ascarides in the fauces, mouth, trachea and bronchi.

gangrene, or by entering into the stomach. In certain cases it appears to be capable of even perforating the intestine, by thrusting asunder with its head the fibres of the intestinal coats: it thus passes into the cavity of the abdomen, where it gives rise to inflammation, suppuration and abscess. Sometimes it even escapes externally through the abdominal walls.* These cases are, however, very rare. This subject will be continued in the special part.† That round worms are not generated spontaneously, but pass into the body from without, is scarcely questionable, although the manner in which this takes place cannot be, at present, demonstrated.

See representations by Bremser, Pl. I. fig. 13 to 17. Respecting its internal structure, vide Jules Cloquet, Anatomie des vers intestinaux ascaride lombricoide et échinorhynque géant, Paris, 1824.

10. *The ascaris alata,* Bellingham, is a species once found in the human subject, namely in Ireland, by Bellingham; the extremity of the head is furnished with membranous, semi-transparent alæ, similar to those occurring in the ascaris of the cat, (*ascaris mystax*) but so far different that, in *a. mystax,* this appendix is broader in front than behind, while in *a. alata,* on the contrary, it is broader behind than in front.

Vide Dujardin, op. cit. p. 156.

11. *The thread worm,* (*oxyuris vermicularis,* Brems. *ascaris verm.* Rud. is a thin white worm even smaller than the trichocephalus. These worms are of separate sex, and the male and female have a very dissimilar appearance. The male which is far the rarer of the two, is much smaller, varying in length from a line to a line and half, spirally coiled at the tail, and often completely assuming the form of a ring. The head is not much thinner than the tail, and under the microscope, shows a transparent tuberosity apparently forming lateral alæ. The female is not annulated, but extends in a straight line, or at most slightly undulates. Its cephalic extremity corresponds to that of the male, and bears a

* See Oesterr. medic. Wochenschrift, 1843, p. 661.

† See Siebold, op. cit. p. 667.

similar vesicular tuberosity. From its head to its anterior third, the worm increases somewhat in thickness; it then contracts in diameter, and terminates in the tapering awl-shaped tail, of which the extreme point is so fine, that it is totally invisible to the unaided eye. The eggs are not symmetrical, being more convex upon one side than upon the other: they measure the 36th of a line in length, and the 62nd in breadth.

These worms occur very frequently, and in great numbers in the large intestines—particularly the rectum—of the human subject; they are especially common in children; and in the female sex, sometimes pass into the vagina. They are not particularly injurious, but frequently excite an intolerable itching of the anus, and in this way become very troublesome. In the vagina they occasion still more violent irritation.

See figures in Bremser, Pl. I. fig. 6 to 12.

SECOND ORDER.

TREMATODA.

1. *The liver-fluke*, (*distoma hepaticum*, Abilgaard; and *dist. lanceolatum*, Mehlis). These two species of *distoma*, resemble each other very closely. They are flat, ovo-lancet-shaped worms, of yellowish colour, and somewhat truncated at both ends. With the aid of a lens, we perceive upon them, two round suckers, of which the anterior, situated on the head, forms an actual mouth. Between it and the body lies a short, scarcely distinct round neck, which merges very gradually in the body. The second sucker is situated upon the abdomen; it is roundish or oval, rather larger than the anterior, and instead of being perforated, forms only a blind sac. Between these two mouths, may be detected a third opening—the excretory duct of the sexual organs. The distomata are hermaphrodites.

It is only very recently, and mainly through the labours of Mehlis, that we have acquired a knowledge of the distinction between the two species.

The distoma hepaticum is larger, the young being four lines long, and one and a half line broad; while the full grown animal varies from eight to fourteen lines in length, and from one and three quarters to six lines in breadth; its intestinal canal is ramified; the eggs are brownish, the 17th of a line long, and half that breadth.

The distoma lanceolatum is smaller; from two to four lines in length, and scarcely one line broad; its intestinal canal is bifurcated; the eggs range from the 77th to the 48th of a line in length.

These two species of distoma occur but rarely in the human subject. They have been found in the gall-bladder, in the biliary ducts, and once even in the vena portæ and its hepatic ramifications, (Duval).* In animals, especially in sheep, these entozoa are of much more frequent occurrence. Although the nature and mode of their transference have not yet been clearly shown, it can scarcely be doubted that these animals enter the system from without, and do not originate in it.

For representations and descriptions, see Bremser, Pl. IV, fig. 11 and 12; Mehlis, Observ. anat. de distom. hepat. et lanceolat. Götting. 1825; Gurlt, Lehrbuch der pathol. Anat. der Haussäugeth. Pl. VIII, fig. 29 to 35. Respecting the metamorphoses which the distomata undergo, which are highly interesting in a zoological point of view, see Steenstrup,† über den Generationswechsel, Copenhagen, 1842, (or Busk's translation, published by the Ray Society).

2. *The distoma oculi humani*, Gescheidt, has been found only once (by Gescheidt); it was observed in a child aged five months, who had suffered from *cataracta lenticularis cum partiali capsulæ suffusione*, and had died of *atrophia meseraica*. Four lancet-shaped distomata ranging from a quarter to half a line in length, and with dichotomously ramifying intestinal canals (*dist. lanceolatum ?*) were present between the lens and the anterior portion of the capsule.‡

* Gazette, Médic. de Paris, 1842, No. 49.

† See Siebold, op. cit. p. 669.

‡ Ammon's Zeitschr. f. Ophthalmologie, vol. III. p. 434.

To the trematoda also belong the eight portions of monostoma (*monostoma lentis*), discovered by Nordmann in the opaque lens of a woman.*

3. *The polystoma pinguicola*, Rud. and Bremser; *hexathyridium pinguic.* Treutl., has been found only once, and possesses no great value in relation to pathology. It was discovered in the human ovary by Treutler. The animal lay free in a cavity formed by fat, was about an inch in length, and from two to three lines in thickness. Its form was a longish oval, above slightly arched, beneath somewhat hollowed out, pointed behind; the anterior portion was obtuse, and behind the head somewhat constricted; it presented upon its underside, six minute openings (suckers) arranged in a semilunar form. An additional larger sucker was observed on the abdomen at its point of junction with the tail.

The nature and mode of origin of this animal is involved in perfect darkness. See representations in Bremser, Pl. IV, fig. 15 to 17.

Treutler has observed another worm of this kind (*hexathyridium venarum, polystoma ven.*); it was found in a young man's tibial vein (which had been lacerated whilst bathing), and he conceives it had dwelt in the blood-vessels. This explanation, however, is unquestionably incorrect, and the worm (perhaps a *planaria*) most likely, during the bath, entered the vein from without. Compare Bremser, p. 265.

THIRD ORDER.

TAPE WORM, CESTOIDEA.

1. *The common tape worm*, (*taenia solium, t. vulgaris, t. cucurbitina*), is a riband shaped, very long worm of milk white or yellowish colour. Its length may exceed twenty feet (and may reach even twenty ells); its breadth at the extremity of the head is small, scarcely a quarter or third of a line; but in passing backwards, gradually increases to three, four, or even six lines. The thickness ranges from a quarter of a line to a line. The worm is jointed; the individual joints are flat, more or less quadrangular, frequently of the form of a gourd seed with a blunted point, and commonly longer than they are broad. They are characterized by the circumstance, that all or at least the greatest number, present upon the margin a mam-

* Mikrographische Beitr. Part 2, p. 9.

millary projection with a distinct opening in the centre. These projections form the orifices of the sexual organs, and are situated without fixed order, sometimes on the left, sometimes on the right margin of the joint; occasionally, however, their position on the separate joints varies according to rule. The head of the worm occupies the anterior thin extremity, and is very minute, commonly hemispherical, broader than it is long, and often appears as if curtailed in front. Its essential character only becomes evident upon the application of magnifying glasses. It then exhibits four lateral mammillary suckers, and between these, in the middle of the head, an arched eminence upon which is always remarked a circle, in whose centre a minute, scarcely perceptible opening exists. Upon this circle are sometimes seated small hooks in double rows. This double circle of hooks may, however, be absent; indeed, it appears, that with advancing age the worm always loses it. The head merges into a flat, unarticulated neck, which varies in length and is followed by the articulated body. The first joints are very short, the following almost square, while the more posterior are longer than they are broad; the joints are narrower in front, thicker and broader behind, so that the posterior extremity of each, projects over the commencement of the following; the last joints are sometimes twice or three times as long as they are broad. The growth of the worm takes place in this manner: from the neck, new joints are continually evolved, which push those behind still further back, and develop themselves in proportion as they regress. The hindmost joints are, therefore, the oldest, and at the same time, the most perfect. Yet it appears that new joints are developed not only from the neck, but may be introduced between the perfectly developed articulations, even at the posterior end of the animal. The increase of the worm is, however, not unlimited; when the last joints have attained to their perfect development, and are filled with mature ova they detach themselves, and, either uninjured, or in a state of decomposition, are evacuated by stool. Since the joints which are thus thrown off, are continually being replaced by new ones, it is absolutely necessary, in order that the annoyance caused by the worm shall cease, that the whole animal, including even the extremity of its head, should be evacuated.

The *taenia solium* inhabits the small intestines of the human subject, but only in certain districts; it occurs ordinarily—indeed, almost exclusively—in Germany, England, Holland, Egypt, and the Levant. Commonly there is found but one tape-worm in the intestinal canal; sometimes, however, several are simultaneously present. It is pretty well ascertained that the innumerable ova which a single individual of this class may produce in a short time, cannot develop themselves in the intestinal canal of the patient, but must quit him in order to experience unknown changes out of his body. The manner in which this worm finds its way into the intestinal canal, cannot yet be pointed out; but numerous reasons entitle us resolutely to reject the opinion, that it may have spontaneously originated. We must, therefore, assume a transference of it from without.

It cannot be denied that the tape worm, by its presence in the intestinal canal, may cause derangement of the organism; nevertheless its pathological importance is commonly overestimated. It often remains in the body for a long time without its presence being revealed by the slightest symptom; sometimes, particularly when of great size, its movements become annoying and unpleasant.

See representations in Bremser, Pl. III. The disorders occasioned by it will engage our further attention in the special part. See Wawruch, Monographie der Bandwurmkrankheit, Wien, 1844, in which, however, the description of the worm and of its physiological relations, (p. 34, et seq.) do not perfectly correspond with the present state of our knowledge.—Th. v. Siebold, on the escape of a tape worm through the umbilicus, Oesterr. medic. Wochenschr. 1843, p. 660.

2. *The broad tape worm*, (*bothriocephalus latus*, *taenia lata*, in many respects, so closely resembles the preceding, that we may shorten its description, and content

ourselves with noticing their distinguishing characters. Like the *taenia vulgaris,* it is a flat, usually distinctly articulated worm, which can attain to a length of from one foot to twenty, or even forty or more feet, and likewise at the cephalic extremity, is not more than a quarter or half a line broad; posteriorly it acquires a breadth of four, six, or twelve lines. Its colour is whitish or light gray; its thickness from the sixth to half of a line. The individual joints of the worm are quadrangular, in general, broader than long; their length, however, increases in proportion as they become distant from the cephalic extremity. The well developed joints want the mammillary projection on the margin, but in the place of it have, each in its centre, a distinct depression—the genital opening—surrounded by an elevated ring. On the larger joints may sometimes be remarked, behind this opening, a second smaller one. The head of the worm, as in the case of *taenia vulg.* is very minute; but, the application of the microscope reveals well-marked differences. It has no suckers, but instead of them, two (not always evident) depressions, or furrows running longitudinally.

The neck is very short, often entirely absent. The discrimination of this worm from the *taenia vulg.* is easy, and is to be accomplished—partly through the well-developed joints, which are thrown off not singly, as in the *taenia vulg.*, but in connected rows, and which are characterized with certainty as of the family *bothriocephalus*, by the presence of the above mentioned cavity in the *centre*, and not on the *border* of the joint—and partly through the examination of the cephalic extremity, when that is possible.

The *bothriocephalus* likewise inhabits the small intestines of man, but only in certain countries—in Switzerland, in Middle and Southern France, Russia, Poland and Eastern Prussia, where the Vistula forms the boundary between its territory and that of the *taenia vulgaris.** When it occurs

* See Siebold, op. cit. p. 652.

in other districts, where the *taenia* prevails, we may be assured that the patient is a native of one of the above-named countries, or at least has caught it there.

With respect to its origin and pathological importance, there is nothing to add beyond what has been stated of the *taenia vulgaris*.

See representations in Bremser, Pl. II. See also the very interesting paper by D. F. Eschricht, anat. physiol. Untersuchungen über die Bothriocephalen, (Nova acta acad. Caes. Leop. vol. XIX. suppl. 2), which also contains some general remarks well worthy of consideration, against the view of the spontaneous origin of intestinal worms.

FOURTH ORDER.

CYSTICA.

1. *The cysticercus cellulosa*, (*hydatis finna*, Blumenb.) consists of an oval vesicle varying in length from three to eight lines: it possesses an extensible neck, terminating in a head, which together with the neck can be protruded and retracted, and in the latter case may be entirely overlooked by a superficial observer. The head when protruded is quadrangular, and has, at each of its four corners, a sucker; on the fore part of the head, situated at the base of a conical proboscis, is a double circle of hooks, amounting in number to about thirty-two. Extended to its full length the animal may measure from half an inch to an inch; its breadth at the cephalic extremity amounts to about one line; at the vesicular portion, to about six lines.

As in the case of the *trichina*, this worm is found in the muscles of the human subject—most frequently in the *psoas*, the *glutæi*, *iliacus internus*, the extensors of the thigh, and in the heart; also, however, in the cellular tissue, in the brain and *pia mater*, and sometimes, but very rarely in the eye. We sometimes observe a solitary worm; sometimes they occur in great numbers. It is almost invariably, at least when occurring in parenchymatous parts, surrounded by an enclosed capsule, which, however, is not essential to it, but is a product of the part in which it dwells. It owes its origin to fibrinous effusion, of which the fibrin coagulates, and is organized according to the mode formerly explained (p. 242). It appears that this capsule, as in the case of the *trichina*, may sometimes become filled with calcareous salts, and after the death of the worm become converted into a concretion.

The pathological importance of this worm is entirely dependant on the tissue or organ it attacks. Whilst in many instances, as for example, in the brain, it may occasion serious accidents, or even death, the presence of a small number in the muscles or cellular tissue, often excites no symptoms of any sort.

It is figured in Bremser, Pl. IV, fig. 18 to 26, who has collected a number of the early cases in which it was observed in man, (p. 241). See also Tschudi, die Blasenwürmer, Freiburg, 1837. An excellent microscopic representation is given by Gulliver, in his Observations on the structure of the entozoa, belonging to the genus Cysticerus. Medico-chirurg. transactions, 1841, p. 1 et seq. The following cases have been recently described: Fournier mentions an instance in which seven or eight *cysticerci* occurred in a boil upon a child aged six years.* It has been observed in the eye by Sömmering, Mackenzie,† Hering‡ and Logan.‖ It is extremely probable that the *cysticerci* are abortive and dropsical *tæniæ*,§ which have entered the body from without; but chancing to establish themselves in a spot unfavourable to their development, gradually degenerate without leaving issue; ova are never found in them; the roundish bodies with the property of refracting light, which are perceived in their structures by the microscope are not ova, but calcareous deposits, which dissolve with effervescence in acids. In the brain the *cysticercus* may produce dangerous symptoms. I examined a dog, which for some time had been completely blind, and in the

* Journ. des connaiss. méd. chirurg. Juin, 1841.

† Gescheidt, in Ammon's Zeitschr. f. Ophthalm. vol. III. p. 416.

‡ Dublin Journal of Medical Science, Jan. 1841, p. 500. Other cases are recorded in Mediz. Vereinszeit. 1838; Froriep, N. Notiz. 1838, No. 170; Annales d'oculistique, Mars, 1842; Oesterr. mediz. Wochenschr. 1843, No. 11; and Rayer, Archives de pathol. comparée, t. I. p. 125.

‖ Todd's Cyclopædia, art. Entozoa, p. 119.

§ Dujardin, Histoire des Helminthes, p. 633.

highest degree apathetic. Upon dissection I found the whole substance of the brain interspersed with *cysticerci.*

The existence of the *cysticercus visceralis* described by some as a human entozoon is extremely problematical. See Bremser, p. 244.

2. *The echinococcus hominis*, consists in the first place of an external vesicle, which, as in the case of the *cysticercus*, is formed by, and is firmly united to the part of the body in which the entozoon is situated. It owes its origin to coagulated fibrin, which, however, becomes gradually organised, and even intersected with vessels. It generally consists of fibrous tissue, which on its inner surface is coated with a more or less perfect epithelium. This membrane is sometimes thick, and has the cartilaginous condition not unfrequently shown by amorphous fibrous tissue generally (see p. 218). Within this membrane which does not pertain to the worm, there lies, perfectly loose and free from all organic connection with it, a second membrane which forms a completely shut sac, filled with fluid. This second membrane presents a jelly-like transparency, but is sometimes milk-white; under the microscope it appears perfectly structureless, and may commonly be split into a very great (but indefinite) number of laminæ; this appearance is very obvious on placing a section of it under the microscope, when it is seen to resemble the leaves of a book. With chemical reagents this membrane behaves like coagulated fibrin. In the interior of this cyst, there exists a fluid which either encloses smaller vesicles of varying size, or on standing for some time, deposits a finely granular matter, which almost resembles pus, or more closely approximates in appearance to fine white sand. Under the microscope this granular matter resolves itself into a number of animalcules which present some resemblance to the diminished head of a cysticercus. Like this, they usually bear on the one extremity a series of hooks, behind which there are several (usually four) suckers; the body usually contracts to an obtuse conical tail, which is sometimes separated from the fore part by a kind of constriction. This is the ordinary form of the ani-

malcule; other forms, however, sometimes occur. They may present a double cordiform shape (like two contiguous hearts, as they are depicted on playing cards, with their apices cut off), or they may appear circular when the animalcule is viewed from above—in which case the ring of hooks appears in the centre. It seems to be able to retract the cephalic extremity with the circle of hooks; for the latter sometimes occupies the interior of the body. Sometimes the posterior extremity is drawn out to a pedicle, and presents a distinct opening. Sometimes the circle of hooks is absent, being apparently thrown off. Isolated hooks are then seen in the fluid. With higher powers, clear, vitreous globules of varying size, which entirely correspond with those described in the *cysticercus*, and consist of calcareous salts, are seen in their interior. The animalcules vary from the 8th to the 20th of a line in length, and from the 10th to the 30th of a line in breadth. Sometimes they are free in the interior of the cyst, and in this case form, with the fluid contained in it, a kind of emulsion; sometimes they seem adherent to the internal wall, which then presents the appearance as if it had been sprinkled over with fine white sand. Sometimes these animalcules are enclosed in small vesicles varying from the size of a pea to that of a nut, which lie free in the interior of the cyst, or are attached to its walls, or there is found within the common parenchymatous cyst, instead of one simple vesicle, a large number of various sizes. In certain cases the animalcules have died, and disappeared without leaving even a trace; on a microscopical examination a large quantity of isolated hooks are then perceived in the fluid, or at least in its sediment, besides indefinite detritus and crystals of cholesterin. *Wherever these are absent, we have no right whatever to regard the structure as the remains of an echinococcus.* Sometimes after the death of the animalcule, the cyst becomes metamorphosed into a concretion; protein-compounds and calcareous salts are deposited within it, and it then closely resembles a cretaceous tubercle.

The *echinococci* are found by far the most frequently in the parenchyma of the liver, but occasionally also in that of other organs, as the spleen, kidneys, brain, and lungs. Their pathological importance is principally a mechanical one; since, like other tumours, they exercise an injurious pressure on the tissues which invest them, or give rise to suppuration, abscesses, or fistula, in the neighbouring parts. The means by which they gain access to the body is still altogether problematical; yet I entertain no doubt, that they do not arise spontaneously, but that they owe their origin to an animal introduced from without, whose other states and grades of development are either still unknown, or are so widely different from the *echinococcus*, that their connection with it has hitherto escaped observation.

Representations and literature. Good representations of the *echinococcus* are still wanting. I cannot but question whether those of Bremser in Pl. IV, fig. 27 to 32, represent this animal. But the representations of the *echinococcus veterinorum* of the dromedary, given by the same author in his Icones Helminthum, Vienna, 1824, Pl. XVIII. fig. 3 to 13, afford a tolerably correct idea of the human parasite, except that in the *echinococci* depicted in fig. 6, the circle of hooks is not distinct, and the isolated hooks there represented do not accord with reality. Tschudi, (die Blasenwürme, Freiburg, 1837), has copied Bremser's figures, and added a few very defective ones. Curling's Plate in the Medico-chirurg. trans. 1840, p. 385, Pl. II, fig. 3, is nothing remarkable. Two years ago I had an opportunity of examining a highly interesting case of *echinococcus* in the liver, and am indebted to the kindness of my friend Dr. Kohlrausch, of Hanover, for the details and representation of another case occurring in the same organ. A case, likewise in the liver, is also described by Lebert.* J. Müller has observed an instance in which *echinococci*, no doubt proceeding from the kidneys, were discharged with the urine.† Gescheidt has found this animal in the eye, between the choroid and retina.‡ See also Gluge, Abhandlungen zu Physiol. und Path. Jena, 1841, p. 196; Roozeboom, Dissert. de hydatidibus, Schoonhoviæ, 1836, in which there is a tolerably copious bibliography, from which I will here only quote the very labo-

* Müller's Archiv. 1843, p. 217.

† Müller's Archiv. 1836, Jahresber. p. 107.

‡ v. Ammon's Zeitsch. für Opthalmologie, vol. III. p. 437.

rious dissertation by Lüdersen, de hydatidibus, Gottingæ, 1808, 4. These latter treatises refer partly to this, partly to the following section.* After the interesting researches of Siebold (Burdach's Physiologie, 2, 183), we must suppose their growth to take place in the following manner; upon the interior of the primitive cyst minute points spring forth; these gradually form *echinococcus-animalcules* which afterwards detach themselves from the parent cyst. Instead, however, of isolated *echinococci*, secondary cysts may be developed from the parent cyst, which then give origin to isolated *echinococci*; from these secondary cysts, tertiary cysts may perhaps be developed, and so on. We might, accordingly, regard the *echinococcus-vesicles* as nurses (*ammenthiere*), probably performing their office in the same way which Steenstrup has shown to occur in the case of the *distomata*. Our knowledge on this point is, moreover, still deficient, and further researches are very desirable. I conceive it to be possible that the vesicle lying within the parenchymatous cyst, is in many instances, the product not of the animal, but of the organism; see the description of Plate v. fig. 5.

3. *Acephalocysts—hydatids*. Whilst the true *echinococci* which have been just described, are undoubtedly animals, there are other structures closely resembling them, whose animal nature is, at least, very questionable. These are the *acephalocysts* of Laennec. They, like the *echinococci*, consist of an external cyst, arising from the parenchyma, usually exhibiting evidence of organization, and doubtless a product of the organism. Within this is a second cyst perfectly similar to that of the *echinococci*, containing in its interior a clear fluid which, again, includes smaller vesicles. Sometimes these smaller vesicles are attached to the inner wall of the parent cyst. In certain cases the parenchymatous cyst contains, not merely one simple vesicle, but several of various sizes. These *acephalocysts* are thus essentially distinguished from the *echinococci*, by their containing neither *echinococcus-animalcules*, nor the *rejected hooks* which might lead us to infer the presence of dead and disintegrated *echinococcus-animalcules*. The *acephalocysts* may, like the *echinococci*, assume a tubercular appearance, or be converted into concretions; they likewise occupy the same localities,

* See also Siebold, op. cit. 678.

exist under the same relations and in pathological importance, resemble them in every respect.

With regard to their origin, there are two opposite views. According to the one, maintained by Laennec, Owen, Lallemand, and others, they are animals either specifically distinct from *echinococci* or identical with them—nurses (*ammenthiere*) which never attain to the development of *echinococcus-animalcules*. According to the other, they are no animals at all, but morbid products of the human organism, which are perfectly analogous to the hydatids, formerly noticed, and arising in the same manner (see p. 242). Many structures considered as *acephalocysts*—as for instance, the vesicular hydatids of the peritoneum and other serous membranes, the cystic moles of the uterus, and the greater number of the encysted dropsies—are to be ranged, no doubt, in the latter category; and if the first mode of origin of the *acephalocysts*—their animal principle — should become positively established, (which future researches must decide, but which seems to me very improbable,) it will certainly prove that only a very small number of the so named *acephalocysts*, are of an animal nature.

The literature respecting *acephalocysts* is exceedingly abundant. I shall here notice only the most important Memoirs: Diction. de méd. art. Acephalocysts; H. Cloquet, Dict. des sciences méd. t. XXII. p. 156; Phöbus, Encycl. Wörterbuch d. mediz. Wissensch. Berlin, 1834, v. X. p. 62; Tschudi, die Blasenwürmer; Kuhn, Recherches sur les acephalocystes et sur la manière dont ces productions parasites peuvent donner lieu à des tubercles, Strasbourg, 1832, avec planches; also in Annales des Sciences natur. t. XXIX. 1829, p. 275; Jaeger in Meckel's Archiv. 1820, vol. VI. p. 495 et seq.; Michea, Archives générales de méd. Mars. 1841, p. 341; Aran in ditto, Sept. 1841, p. 76. In a chemical point of view, the contents of most *acephalocysts* correspond with the fluid of serous dropsy, whilst the cyst-membrane possesses all the characters of coagulated fibrin. The transition of hydatids into deposits resembling tubercle and into concretions, long since attracted so much attention, that some inconsiderately have regarded all tubercles and concretions as proceeding from hydatids. See Ruysch, Dilucid. valv. vas. lymph. Obs. 25, p. 25. Lallemand avers that he has perceived voluntary motion in the *acephalocysts* of the human subject.* Yet in such observations deception is so easily possible, that I do not attach any great weight to them. Klenke has communicated numerous observations respecting hydatids, and states that he has very frequently propagated them to animals by inoculation.† But most of his statements are impressed, in so high a degree, with the character of improbability and exaggeration, that I cannot resolve in this place to avail myself of his communications, which if true would possess a high interest.‡

PSEUDOPARASITES.

The animals which have been described in the preceding pages are the only parasites which hitherto have been certainly recognised as inhabitants of man, although we may anticipate that more extended researches in foreign countries and different climates will disclose many others. Moreover, many incidental parasites have been observed which in part have been already mentioned, and in part will be considered, with their effects and with the pathological alterations to which they give rise, in the special department of the work.

If, however, we glance at the annals of science, we find exhibited a great number of cases, in which other parasites than those described are stated to have been observed, and new instances of the kind daily appear, in which physicians affirm that they have observed parasites on man, but where, in fact, no parasite was present. These cases may be reduced to two classes:

1. Cases in which various animals are stated to have been evacuated from the human subject, by stool, urine, or vomiting. Here there can be no doubt respecting the animal nature of the object in question, but physicians err in supposing that these animals were parasites. They did not exist in the body, and only appeared incidentally in the excretions; thus worms, larvæ, acari, and even beetles, are sometimes

* Annales des sciences natur. t. xv. p. 292.

† Ueber die Contagiosität der Eingeweidewürmer, &c., Jena, 1844.

‡ See also Siebold's critique on these views, op. cit. p. 651.

found in the urine; these, however, were not discharged with the urine, but previously existed in the utensil; the like occurs in the fæcal evacuations, in vomited matters and in sputa. In some of these cases the deception is intentional, and proceeds from the patients who assert that they have discharged these animals, when they have previously cast them into the utensil; sometimes this is done with a view to excite interest, and often from totally inexplicable psychological motives, the patients having even previously swallowed them, in order more effectually to deceive the physician.

2. The substances supposed to be parasites may indeed have been actually discharged, but are, however, no animals, but other foreign bodies of the most varying description, as seeds and other vegetable matter, morbid products (fibrinous coagula, &c.) In order to escape such errors which even in modern times, occur sufficiently often, whenever the physician entertains a doubt respecting the nature of an evacuated body, he should always consult an experienced naturalist.

It is not our intention to enumerate all the pseudoparasites hitherto met with, but merely, once for all, to caution the physician to be on his guard in such matters, and neither to fall spontaneously into error, nor allow himself to be deceived by others.

A series of pseudoparasites, which might be easily augmented by some more recent examples, has been described by Bremser, and figured in the vignette on the title page of his work.*

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* Siebold's remarks on this subject are well deserving of the attentive perusal of every practical physician, op. cit. p. 683.

CHAPTER IX.

CONGENITAL MODIFICATIONS OF THE HUMAN BODY—(MALFORMATIONS).

A SPECIAL consideration must be devoted to those morbid changes which originate not, as is for the most part the case with those hitherto described, after birth, but during fœtal life, and which, consequently, the infant brings with it into the world.

These congenital changes may be reduced to two divisions, which, however, are not strictly separable from one another. Those belonging to the first division differ in no respect from the morbid changes already considered; indeed, it has been already frequently mentioned, that certain tumours are occasionally formed in the fœtus in exactly the same manner as they arise after birth. This, for instance, was stated in relation to congenital telengiectasies, lipomata, encysted tumours, &c. These congenital changes, accordingly, present little or nothing peculiar; we shall, therefore, only briefly notice them at the conclusion of this chapter.

In addition to these there are, however, other morbid changes, which occur only in the fœtus, and of which it has never yet been observed, that they have originated in the same way after birth. These latter are termed *malformations—vitia primæ conformationis.*

The peculiarity of these malformations, and their essential difference from ordinary morbid changes, are explained by the following considerations:—immediately after birth almost all the organs exist in a condition which, with slight modifications of form, they retain throughout life. All organs, indeed, grow until they are perfectly developed; but this growth is, for the most part, merely a simple augmentation of bulk. A few organs only, as the sexual apparatus and the thymus gland, undergo at a later period comparatively important modifications, either developing themselves more highly, or, on the other hand, disappearing. Indeed, in adults the changes of the body are, in the normal state, almost solely confined to renewal of material (metamorphosis of tissues), whilst the form of the organs, with very trivial modifications, remains unaltered. The case is different with the embryo and fœtus. Here, as the laws of development teach us, the various parts and organs of the body are gradually developed from the simple stroma of the ovum. During fœtal life we have, therefore, not merely *nutrition*, as afterwards, but also *development*; and whilst, after birth, pathological influences only affect existing structures, or, at most, give rise to the introduction of heterogeneous matters, previous to birth morbid influences extend their operation even to the development, so that pathological structures are generated, which differ considerably from those occurring after birth.

This appears to me to be the best mode of expressing the essential nature of malformations, and their distinction from those pathological changes, which occur not merely in individuals after birth, but occasionally in the fœtus. The relation of malformations to pathological anatomy, spontaneously results from it. If the latter, in the sense in which we here receive it, is allowed to include all cognizable pathological changes occurring in the human subject, then malformations must be included in it. Whilst, however, the study of ordinary pathological changes pre-supposes, in addition to an acquaintance with pathology and physiology, merely a knowledge of normal anatomy, the study of malformations, if it is to lead to the comprehension of their origin, demands a profound knowledge of the history of development; indeed, these two latter subjects are in immediate relation. And hence I do not object to the view of those who, like Isidore Geoffroy St. Hilaire,* desire to form of the doctrine of malformations a special science, under the name of *Teratology*. Malformations have much less practical interest than other pathological changes, since the greater number of them can neither be prevented, nor, having once arisen, can be removed by remedial measures. For this reason, and because the number of malformations is exceedingly great, I cannot here enter into the details of this subject with the fulness with which it has been treated in various other works on pathological anatomy. I shall content myself with a superficial exhibition of the various malformations; and, for a complete study of the individual forms, must refer partly to the special department of this work, and partly to the works and memoirs quoted in the separate cases, and to the special treatises on malformations; of which the following deserve particular recommendation:

A. v. Haller, de monstris, in oper. minor, t. III. Lausanne, 1768, where the best scientific collection of the older literature is to be found; J. F. Meckel, Handbuch der pathologischen Anatomie, vol. I. 1812, vol. II. 1816; Isidore Geoffroy St. Hilaire, Histoire des anomalies de l'organisation, t. I. Paris, 1832, t. II. and III. 1836; W. Vrolik, Handboek der zicktekundige Ontleedkunde, vols. I. and II. 1840—1842, also under the title: de menschelijke Vrucht beschouwd in hare regelmatige en onregelmatige Ontwikkeling;† Otto, Monstrorum sexcentorum descriptio anatomica. Vratislav. 1841, fol.—a splendid work, with thirty plates; F. A. Ammon, die angebornen chirurgischen Krankheiten des Menschen. Berlin, 1840—1841; Gurlt, pathologische Anatomie der Haussäugethiere, vol. II., treating of the malformations occurring in domestic animals—a subject which, in a comprehensive study of this department, must not be disregarded.

An excellent sketch of the general relations of malformations, with especial regard to the history of development, may be found in the Article "Entwicklungsgeschichte, mit besonderer Berücksichtigung der Missbildungen," by Bischoff, in Wagner's Handwörterbuch der Physiol. vol. I.

The fabulous malformations of the ancients have been collected by Berger de Xivrey, traditions tératologiques. Paris, 1836.

* Histoire des anomalies de l'organisation, vol. III. p. 447, &c.

† As, in consequence of the language in which it is written, this interesting work is accessible to comparatively few readers, I may refer to a very copious review of it by v. d. Busch in the Hannov. Annalen. für die gesammte Heilk. 1843, No. VI., and 1844, Nos. I. II. and III.

The causes of most malformations are, undoubtedly, pathological influences, perfectly analogous to those which occasion morbid changes in the body after birth. Probably, like the latter, these also are very manifold; and it appears to me a limited mode of viewing the question to endeavour, as is not unfrequently done in pathology in relation to different diseases, to trace all malformations to one, or to only a few causes. Experience, as well as analogy, leads to the inference that the causes not merely of different, but even of the same kinds of malformation, may be very dissimilar. However, at present we unfortunately know very little respecting these causes. The following propositions represent the actual state of our knowledge on this subject: The human embryo is formed by the co-operation of the male and female generative matter—the semen and the ovum. By means of a fruitful coition, an impulse to further development is communicated to the ovum. A normal development, therefore, primarily assumes normal generative matter in both sexes. In order, however, that a normal fœtus may be produced, it is further essential that the maternal organism should supply all the conditions necessary to the development of the embryo, and that the development should in no way be disturbed by external influences, or by diseases of the fœtus.

Accordingly, we may regard as causes of malformations:

1. *Abnormalities of the generative matter of one or both parents.* Numerous phenomena in man and animals lead to the conclusion that the condition of the father exercises an influence upon the condition of the offspring, which in many cases at least, can be effected only through the intervention of the generative matter, and that this influence may be extended even to the production of malformations. Thus we frequently see that children exhibit the peculiarities of the parents. Malformations are transmitted from the parents to the children; and if, in the case of the mother, the two causes, which will be presently noticed, possibly co-operate, this, at least, does

not hold good in relation to the father. In this class we may also include the cases in which several children, whose parents present no peculiarity, suffer from the same malformations.

Cases of this kind are by no means unfrequent, and may be daily observed. A large number has been collected by Meckel.* See, also Gurlt,† and Henle.‡

The great majority of these cases admit of no other explanation than that the malformation had its origin in an original abnormality of the generative matter. But in what this abnormality consists, and how it operates, are points upon which really nothing is known, although, in solitary instances, an abnormal condition of the semen, (of the seminal animalcules,) or of the ovum (of the yelk) has been observed.§

2. As a second series of causes which, after impregnation has been effected, possibly take a part in the production of malformations, may be considered, *abnormalities of the maternal organism*:—pathological alterations in the fallopian tubes and the uterus, bodily diseases and psychical affections of the mother. Of all these causes it may, with probability, be conjectured that they exercise a disturbing influence upon development, but we are still very far from knowing in what this consists, and what share it exerts in the production of malformations. It is probable that these causes operate by arresting and interrupting development, and consequently giving rise to various malformations by *arrest of structure.* We must here also notice the opinion that some malformations owe their origin to an influence on the imagination of the mother during pregnancy—a psychical affection, in consequence of which the fœtus is stated to bear upon it

* Op. cit. vol. I. p. 15—59.

† Op cit. vol. II. p. 5—172.

‡ Zeitschr. f. rat. Mediz. v. Henle u. Pfeufer, vol. II. p. 7.

§ See Bischoff. Op. cit. p. 884.

certain characters which resemble the object that acted on the maternal imagination. This theory is in the highest degree improbable, if it cannot be positively denounced as false.*

3. *Diseases and abnormal states of the placenta, of the membranes of the ovum, and of the umbilical cord,* may be regarded as causes of malformations. These generally induce an arrest of formation, by disturbing the process of development, and we may point out individual deviations from a normal state, which can with much probability be regarded as causes of certain malformations. Thus shortness of the funis and deficient union of the vessels forming it into one common cord, favour the origin of abdominal fissures, and of congenital umbilical hernia; or if the funis be of disproportionate length, it may coil around the extremities, constrict them, and thus render their nutrition defective, or even cause their amputation. Union of the fœtus with the amnion may likewise give rise to malformations, through pressure or tension.†

4. Amongst the most frequent causes of malformations, we must undoubtedly consider various morbid influences acting directly on the fœtus, as *mechanical injuries,* and *diseases affecting it.* From the experiments of Geoffroy St. Hilaire and Valentin,‡ it appears that by various mechanical influences to which hen's eggs are submitted during incubation, the development of the embryo is partly interrupted and partly modified in such a manner as to give rise to malformations. Many observations tend to the conclusion that by means of mechanical influences (ill treatment by kicks, blows, or falls,) affecting the womb in the early months of pregnancy, certain malformations by arrest may be produced, as *hemicephalia.* The experience that malformations, such as *acephalia,* which depend upon a very decided arrest of

* See Bischoff, Op. cit. p. 885; and G. Rubner, über das sogenannte Versehen der Schwangern. Dissert. Erlangen, 1839.

† Several cases of this nature have been collected by Henle, in his Zeitschrift f. ration. Mediz. vol. II. p. 11, &c.

‡ Repertorium, vol. II. p. 168.

development, usually occur in twin or triplet pregnancies, is favourable to the view that pressure and confined space are to be regarded as causes of certain monstrosities; for the objection which has been made, that twins and triplets are also born perfectly normal, only shows that, notwithstanding the limited space, a normal development is possible; but not that, under specially unfavourable relations, the presence of a second embryo cannot exercise an interrupting influence upon the development of the other. Of diseases of the fœtus which are capable of causing malformations, we at present recognize *dropsical accumulations of water in its various cavities*—no doubt one of the most frequent causes of *hemicephalia, spina bifida, abdominal fissures*, and *hernia umbilicalis congenita; inflammation of certain organs* at an early period, which through the agency of fibrinous dropsy may give rise to union, or even destruction and atrophy of certain parts; and *nervous diseases*, inasmuch as they cause spasmodic contractions of individual muscles or muscular groups, and in this way give rise to deformities of the trunk and extremities (curvatures).*

The influences alluded to in the preceding observations are, doubtless, those which must be regarded as the most frequent and most important causes of malformations. But it is only rarely that we are able to point out in more minute detail the manner in which these causes operate. By mere general terms, as "increased or diminished energy of the formative power," such as were frequently employed by earlier authors, and which usually are nothing more than an abstract expression of that which the most superficial consideration of a malformation teaches, we must not hope to be able to explain the complicated causes of these changes, or to comprehend their origin. There is here much untrodden ground for scientific investigators, and the most important results may be expected from their labours.

* Several cases of this nature are collected by Henle, Op. cit. p. 9.

A perfect knowledge of the history of development is essential to the clear comprehension of the manner in which a certain cause, by exerting a disturbing influence upon the development, effects a certain malformation. This especially holds good in relation to the numerous forms of malformation in which, by arrest of development at an early stage, some parts of the fœtus exhibit forms which correspond more or less closely with those of an earlier grade of development (arrest of formation).*

Since malformations may affect the most different parts and organs of the body—sometimes one alone, sometimes several in connection with each other—their number becomes very great; and, in order to regard them in a general point of view, it appears absolutely necessary to arrange them in certain classes. I regard the following classification as the most conformable to the objects of pathological anatomy:

1*st Class.* Malformations, in which certain parts of the normal body are entirely absent, or are too small.—Monstra deficientia.

2*nd Class.* Malformations produced by fusion or coalescence of organs. Coalitio partium—Symphysis.

3*rd Class.* Malformations, in which parts in the normal state united—as for instance, in the mesial line of the body—are separated from each other—Clefts, fissures.

4*th Class.* Malformations, in which normal openings are occluded—Atresia.

5*th Class.* Malformations of excess, or in which certain parts have attained a disproportionate size—Monstra abundantia.

6*th Class.* Malformations, in which one or many parts have an abnormal position—Situs mutatus.

7*th Class.* Malformations of the sexual organs—Hermaphroditism.

To these true malformations I append also:

* See Bischoff, Op cit. p. 892.

8*th*. Diseases of the fœtus, and abnormal states of its envelopes.

A classification of malformations presents numerous difficulties, and, in whatever manner it is attempted, must necessarily be very imperfect. In an anatomico-pathological point of view, it should, in my opinion, only claim to be in some degree a methodical register, affording an idea of the forms not merely actually occurring, but of all that can possibly occur, and thus enabling us to class a newly discovered malformation with known allied forms. This appears to me to be accomplished by the above classification. I regard the objection which may be brought against it, that it is not perfectly logical, because the malformations of the genital organs form in it a class of their own, as unimportant; for there are strong reasons in favour of their collection into a special class. For other objects other classifications may be more fitting, as, for example, that based on the causes of malformations, or on the influence which malformations exercise upon life, health, and on the civil usefulness of the individual affected—a basis of classification which might be of more service to the medical jurist, but is of no value to us in this place. Accounts of other classifications, and critiques on them, may be seen in Geoffroy St. Hilaire and Bischoff. Op. cit.

FIRST CLASS.

MALFORMATIONS, IN WHICH CERTAIN PARTS ARE ENTIRELY ABSENT, OR ARE TOO SMALL—Monstra deficientia.

FIRST ORDER.

DEFICIENCIES, IN THE STRICT SENSE OF THE WORD.

We must here notice those cases in which certain parts of the body are altogether absent. This order comprises a great number of forms, of which the following constitute the best marked groups:

1. *Completely shapeless malformations* (*amorphus*, Gurlt; *anideus*,* Geoffroy St. Hilaire.) The monster presents the appearance of a more or less shapeless lump, with no indication of definite organs; it consists merely of integument, cellular tissue, serous fluid, fat, rudimentary bone, and vascular ramifications, with an umbilical cord. It has been hitherto

* From α and εἶδος form; hence, synonymous with *amorphous*.

rarely observed, and then usually co-existing with a normal twin; hence it is probable that through the presence of the twin, the other germ has been at a very early period so much injured that this anomalous formation, void of every external and internal organ, has alone been developed from it; of course, these monsters are not viable.

See representations of these forms occurring in animals, in Gurlt, op. cit. Pl. I. fig. 1., Pl. XVI. fig. 1 to 4.; Geoffroy St. Hilaire, op. cit. Pl. XIII. fig. 1 and 2, vol. II. p. 528.—A case occurring in the human subject is described by Bland, in the Philosophical Transactions, 1781, vol. LXXI. p. 363, in a note.

2. Malformations, which consist of only *a more or less rudimentary trunk*, while no signs of head or extremities exist. Like those belonging to the preceding group, they form externally a shapeless mass, which, however, in the interior, besides fat, cellular tissue, rudimentary bone (vertebræ) and vessels, contains more or less decided traces of viscera. Malformations of this group are not viable.

This form constitutes a division of the genus *mylacephalus** of Geoffroy St. Hilaire.† In the human subject only one solitary case, observed by Vallisneri, appears to have been observed. Otto‡ has figured and briefly described a case of this nature occurring in a calf. The monster co-existed with a well-formed twin, to whose secundines it was attached. Its origin therefore is, no doubt, to be explained in the same way as that of the first group.

3. Malformations, in which the *inferior half of the body is wanting*, and only some parts of the upper half—as, for instance, the head—are present—*trunkless monsters* (*acormus*, Gurlt). The malformations belonging to this group consist of little else than a more or less rudimentary head, which, instead of neck and trunk, is furnished with a pouch-like appendage, containing rudimentary viscera, and

* μύλη, a mole in the womb, and ἀκέφαλος.

† Vol. II. p. 488.

‡ Op. cit. p. 3, Pl. XXX.

pieces of bone of indefinite form. They are very rare, and are invariably accompanied by one or two well-developed children, so that, as in the case of the preceding groups, these are also to be explained by injury of the germ. These also are not viable.

Cases of this kind are recorded in Meckel, vol. I. p. 57 ; Lycosthenes, chronicon prodigiorum ac ostentorum. Basil, 1557, p. 542 ; Delamarre, Journ. de méd., chir., pharmac., t. XXXIII. 1770, p. 174 ; Rudolphi, in the transactions of the Berlin Akademie der Wissench. 1816, p. 99 ; Nockher, medicin. Zeitung des Preuss. Vereins f. Heilkunde, 1837, No. 3 ; and Nicholson, de monstro humano sine trunco nato. Diss. Berol. 1837.

4. Malformations, in which *the head*, and sometimes a part of the *upper half of the body is wanting*, whilst more or less of the inferior half of the body is present—*acephalic monsters* (*acephalus*). Numerous cases of *acephalia* have been observed in the human subject. They form a complete descending series of varieties. In the most perfect *acephali* the head alone is absent; indeed, rudiments of this organ exist, but they are concealed under the skin, and are only recognizable on an anatomical examination. The trunk is deficient to a certain extent; the viscera are more or less developed; the heart is commonly, but not always, absent, and the same may be said regarding the lungs. In other cases the superior extremities are wanting. In more defective formations of the kind, the greater part of the trunk is also absent, and the two inferior extremities, with the rudiment of a pelvis, alone exist. Indeed, there are instances recorded in which the *acephalus* has consisted of only a lower extremity (as in the case of a goat, described by Hayn). *Acephali* almost always occur in company with one or two perfect or less defective twins, whence it appears that in this case also the probable cause of the malformation is an injury of the germ, effected by the co-existing twin; or sometimes, perhaps, hydrocephalus, in a very early period of pregnancy. The *acephali* are not viable.

The literature relating to *acephali* is very abundant, and the number of cases of this malformation which have been observed in the human subject may, perhaps, amount to 100; in animals they are less frequent. The most important information may be found in Meckel, vol. I. p. 140, &c.; Fr. Tiedmann, Anatomie der kopflosen Missgeburten. Landshut, 1813, with plates; E. Elben, de acephalis s. monstris corde carentibus. Berol, 1821 c. tab. (which contains an enumeration of most of the cases on record); and Geoffroy St. Hilaire, vol. II. p. 464. More recent cases are described by Pfotenhauer, de monstro acephalo humano. Berol. 1835; Hildreth and Houston, in Valentin's Repertorium, 1837, p. 170; P. J. Gergens, Anat. Beschreib, eines merkw. Acephalus. Giessen, 1830; J. H. Kalck, Monstr. acephal. hum. expos. anat. Berol, 1825; Herholdt, Beschreibung sechs menschl. Missgeburten. Kopenhagen, 1830, p. 21 and 38; Otto, op. cit. p. 4, &c. On the circulation in the *acardiac acephali*, see Holland, "on the circulation in the acardiac fœtus." Edin. Med. and Surg. Journal, 1845, vol. LXII. p. 156, &c.

Geoffroy St. Hilaire subdivides the *acephali* into three genera: 1. *True acephali*, with perfect, or almost perfect thorax, which supports both upper extremities, or at least one of them. 3. *Peracephali*, without upper extremities. 3. *Mylacephali*, with very anomalous body, and either with very defective, rudimentary extremities, or with no limbs at all.

5. *Malformations* in which *not the whole head*, but some of its *component parts are wanting—monsters with defective head* (*perocephalus*).* Malformations of this kind are very frequent in the human subject. They may be reduced to several subdivisions, some of which form well-characterized groups.

a. The head may be present, but only as a mere rudiment. This group (*paracephalus*, *pseudacephalus*) is immediately allied to the *acephali*, and similar observations apply to it.

Plates of this somewhat rare form are given in Gurlt, op. cit. Pl. I. fig. 4, and in Geoffroy St. Hilaire, Pl. XI., who (vol. II. p. 437, &c.) has also given the literature of the subject. He separates this group into three species: 1. *Paracephalus*, with malformed, but voluminous head; face distinct, with mouth, and rudimentary organs of sense; the upper extremities present. 2. *Omacephalus*, with the head as in the preceding class, but the upper extremities absent. 3. *Hemiacephalus*,

* From πηρός, deficient.

head very imperfect, formed by a shapeless tuberosity, with certain membranous appendages; upper extremities present.

b. The brain and greater part of the cranium may be absent. *Brainless monsters* (*anencephalus*, *hemicephalus*, *microcephalus*). *Hemicephalia* is comparatively frequent and presents different degrees: in the highest, not only the brain, but also the spinal cord is absent, and at the same time there exists a breach of continuity in the spinal canal (*spina bifida*); in a lower grade of malformation the spinal cord is present. In a still smaller degree, the malformation passes into the *cranial fissure*, presently to be noticed. Of the cranial bones, the *os frontis*, *ossa temporum*, *parietalia* and the greatest part of the *os occipitis* are commonly absent. Sometimes malformations of the trunk, or of the extremities are at the same time present.

The cause of this malformation is commonly dropsy of the head; in many cases, alarms, diseases and ill-treatment of the mother have preceded it, and Geoffroy St. Hilaire regards these as its exciting causes. *Hemicephali* notwithstanding the absence of brain are usually born alive; some have survived several hours, a few several days.

Owing to the great frequency of these malformations (they form more than the third part of all cases of human monstrosities) their literature is very copious. We may especially refer to Meckel, op. cit. vol. I. p. 195, et seq.; Geoffroy St. Hilaire, vol. II. p. 317, et seq. Pl. 8 and 9; Otto, op. cit. (who describes upwards of fifty cases, and has figured several); Sömmering, Abbildung und Beschreibung einiger Missgeburten, 1791; E. Sandifort, Anatomia infantis cerebro destituti, Lugd. Batav. 1784, with six beautiful plates; Cerutti, rarioris monstri, in mus. anat. Lipsiensi adservati descr. anat. c. tab. 2. Lipsiæ, 1827; H. Mattersdorf, de anencephalia c. rariss. casus anenceph. post part. vivi exposit. Berol. 1836; Krieg in Casper's Wochenschr. 1843, p. 543. Cases where the child lived for some time after birth, and was submitted to experiments, are described by Spessa, Gaz. méd. Janv. 1833, and Müller's Archiv. 1834, p. 168, and by Panizza (Giornale del R. Instituto Lombardo, 1841, fasc. 3, and Oesterr. medicin. Wochenschr. 1843, No. 9). See also Marshall Hall on the history of *anencephali*.

Geoffroy St. Hilaire separates this group into two families with several species, whose characteristics I shall notice, since they afford an excellent view of the most important forms which occur.

A. *Pseudencephali*, containing in place of the brain, a soft, reddish, vascular protuberance. They may be divided into: 1. *Nosencephali*,* in which the skull is open only in the frontal and parietal regions, and the posterior fontanelle is distinctly present. 2. *Thlipsencephali*,† when the skull is opened not merely in the frontal and parietal, but also in the occipital region, and a distinct posterior fontanelle does not exist. And 3. *Pseudencephali* in the strict sense of the term; in which there is not merely the fissure of the skull, but the medullary canal is also widely cleft, and the spinal cord is absent.

B. *Anencephali*, in which the brain is totally absent, without, as in the case of *pseudencephali*, being replaced by a foreign substance; they are reduced into: 1. *Derencephali*,‡ in which not only the brain, but the spinal cord in the cervical region is also wanting; the skull and upper part of the spinal canal being widely cleft. And 2. *Anencephali* in the strict sense of the word; in which the brain and the whole of the spinal cord are wanting; the skull and the spinal canal being widely opened.

Some of these forms, as already mentioned, constitute the transition to the fissures which will be presently considered.

c. *Portions of the face*—as the nose, eyes, facial bones, and at the same time more or less of the cranium—*may be absent* (*aprosopus, microprosopus*). This class is reducible into many sub-orders, which are rare in man, but are frequent and comparatively abundant in animals.

We must here place absence of the lower jaw, of the nose, of the eyes, of the mouth, &c., resulting from an extensive arrest of development. See Meckel, vol. I. p. 393, et seq.; Sömmering, Abb. und Beschreib. einiger Missgeburten, Pl. 9; Otto, op. cit. No. 88, et seq. and Gurlt, op. cit. vol. II. p. 68, et seq. The deficiency of these organs individually, as absence of the eyes, of the eyelids, of the iris, of the ears, &c., whether occasioned by imperfect development or subsequent destruction, is noticed in the special department.

These malformations also stand in the most intimate relation to some fissures and fusions, as for instance, with *cyclopia*.

6. Malformations in which *the whole body* appears more or less defective, some parts being absent and others too

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* νόσος, disease. † θλίψις, pressure, destruction.

‡ δέρη, the neck.

small or unshapely (*perosomus*, Gurlt): an indistinctly characterised group, whose occurrence is rare in man, but more frequent in animals. They are not viable.

Figures are given in Gurlt, op. cit. Pl. III. fig. 5 and 6; Pl. IV. fig. 1 and 2.

7. Malformations in which the *trunk is defective*, and too short, from the absence of one or more vertebræ; the head and limbs being normal (*perocormus—oligospondylus*, Gurlt). They arise either from an original defect in the formation of the vertebræ or from fusion of several into one. In man they are never observed, and only rarely in animals. These malformations do not affect life.

Gurlt, op. cit. Pl. II. fig. 4; Otto, op. cit. No. 213, et seq. Absence of the tail in animals belongs to this group.

8. *The extremities may be deficient;* all the limbs may be absent, or two or only one, or merely portions of the extremities may be wanting. The head and trunk may in this case, be either normal or abnormal (*peromelus*, Gurlt). This group may be reduced to several subdivisions; the forms included in it arise partly through original abnormalities of formation—the germinal elements for the extremities being either not evolved at all, or experiencing an arrest at some stage of the development; and partly through mechanical agencies—the extremities when perfected or in the act of forming, becoming atrophied from mechanical causes, as for instance, constriction by the funis. Such malformations are not unfrequently hereditary. The subjects of them are viable.

For the literature and illustrations of this group, we may refer to Meckel, vol. I. p. 748 et seq. where most of the earlier cases are collected; Otto, op. cit. p. 134; Herholdt, Beschreibung sechs menschl. Missgeb. p. 59; and Cruveilhier, Anat. pathol. livr. 28, Plate I.

Geoffroy St. Hilaire names the higher grade of these malformations *Ectromeles*,* (vol. II. p. 307 et seq.) and reduces them into 3 genera.

* ἐκτρώειν, to cause to abort.

1. *Phocomeles,** in which hands and feet appear to exist independently of arms and legs, and to be inserted immediately into the trunk. 2. *Hemimeles,* in which the upper or lower extremities are very defective—mere stumps—and the fingers and toes are entirely wanting or are very imperfect. 3. *Ectromeles* in the strict signification of the term; in which the extremities are nearly or altogether absent. The slighter degree of the malformation, where only one or more fingers or toes are wanting is named by Geoffroy St. Hilaire *Ectrodactylie* (vol. I. p. 676). It is sometimes hereditary and may be referred to a defective development; since the germs for the hand and foot are at first simple, and do not until a later date become divided into the individual fingers and toes.

The cases in which certain internal organs or parts of them are absent—a class of malformations which are commonly first discovered by anatomical examination—will be found in the special part.

SECOND ORDER.

ABNORMAL DIMINUTIVENESS OF PARTS—DWARFISH STRUCTURE.

Here we have all the organs of the body present, but some of them too small. This arises either from a primitive tendency of the germ or from a subsequent arrest of the development of parts which are in process of forming, or from atrophy of parts already perfected. The individuals affected with it are, in general, viable.

1. *General dwarfishness* (*nanosomus,*† Gurlt.) If the entire body with all its parts is smaller than common, the individual constitutes a *dwarf,* whose component parts are more or less proportionate. This state, (as is well known) is not unfrequent, and the individuals affected with it are always viable; it is often hereditary, or, at least, is extended to several children of the same parents.

For cases see Otto, patholog. Anatomie, vol. I. p. 19, or South's translation, p. 21, and Geoffroy St. Hilaire, vol. I. p. 140, et seq.

* φώκη, a seal; in consequence of the similarity of the extremities to those of that animal.

† νάνος, a dwarf.

where many instances are collected, and a few described in detail. An account of a family of dwarfs may be seen in Casper's Wochenschr. 1842, p. 705.

2. *Dwarfish head*, (*nanocephalus*, Gurlt). The whole head or certain parts of it being too small, while the trunk and extremities are normal. The higher grades of this group are allied to the *perocephali*, namely to the *microprosopi.* In man they are rare, but are almost always viable.

To this group we must refer arrested development of the lower jaw, Geoffroy St. Hilaire, vol. I. p. 259.

3. *Dwarfish trunk*, (*nanocormus*, Gurlt). The trunk, with or without extremities, being two small, whilst the head possesses its normal size.

4. *Dwarfish limbs*, (*nanomelus*, Gurlt). Some or other part of an extremity being too small, and the whole limb being therefore too short, but yet no part of it being absent. Head and trunk are generally normal. This form is allied, as a lower degree, to the *peromeli.*

Cases belonging to the preceding groups are given in Geoffroy St. Hilaire, vol. I. p. 251, et seq.

SECOND CLASS.

MALFORMATION FROM COALESCENCE OF ORGANS.

Coalitio partium—Symphysis.

Parts which normally lie together unconnected, (usually in the mesial line of the body), may approximate more closely than in the normal state, and form a coalition; there thus arises a new and peculiar formation. In many cases this coalescence is only possible in consequence of the atrophy or total absence of parts, which in the normal state separate the organs here united. In this way many of the cases included here are in the closest alliance with the preceding class. We have the following well characterized groups.

1. *Malformations by coalescence on the head.* These

reduce themselves into two subdivisions according as the upper part of the face with the eyes, or the lower part of it (the mouth), is the seat of the malformation.

a. Coalescence of the eyes (*cyclopia, monophthalmus*). The eyes are very nearly approximated or even amalgamated in the mesial line of the face. The nasal cavities and some of the bones of the superior half of the face are more or less deficient. Moreover, a proboscis frequently exists above the eyes. The mouth is large and irregular, or altogether absent. The varieties of this malformation are very numerous.

Cyclopia may be regarded as an interruption in development; the special explanation of its origin, however, differs according to the different view which is taken of the normal development of the eyes. If we assume with Huschke, that the two eyes originate from *one* primitive rudiment, which only at a later period becomes divided by the intrusion of the nose and face, the deficient development of the last named parts, is the cause of the non-separation of the eyes. If, on the contrary, we assume with Bischoff that the two eyes are originally distinct, then the development of *cyclopia*, appears to require an amalgamation of the germinal elements of the two eyes. Whichever of these views we advocate, *cyclopia*, in an anatomical point of view, always appears as a coalescence of organs, which in the normal condition are apart from each other; and so far belongs to this place, although, at the same time, it is most intimately allied to the *monstra deficientia.*

Cyclopic malformations in the human subject are not very rare; and in many animals, for instance in swine, they are frequent. Although usually born alive these monsters are not viable.

Illustrations and descriptions are given in Cruveilhier, Anat. pathol. livr. 33, Pl. VI.; Otto, op. cit. p. 83 et seq.; Knape, Monstri hum maxime notabil. descr. anat. Berol. 1823. See also J. F. Meckel, über die Verschmelzungsbildungen, in his Archiv. vol. I. 1826, p. 238; Seiler, über Cyclopie, Dresden, 1833; Vrolik, over den Aard en oorsprong der Cyclopie, Amsterd. 1834, (or the abstract in Müller's

Archiv. 1836, Jahresber. p. 177, et seq.); and Geoffroy St. Hilaire, Pl. VII. and vol. II. p. 375, &c., and who names the whole group *Cyclocephaliens*, and makes the following subdivisions, which, at the same time, serve as a view of the principal forms:

A. There may be *two orbits* which, however, are very closely approximated. 1. *Ethmocephalus*,* with two eyes distinctly apart, but very close; the organ of smell atrophied, and occurring only in a rudimentary form, which appears externally as a proboscis above the orbits. 2. *Cebocephalus*,† with two very closely approximating, but yet decidedy separated eyes; the organ of smell atrophied, no proboscis.

B. *Or there may be one orbit.* 3. *Rhinocephalus*, with two adjacent eyes, or one double eye in the mesial line; the organ of smell being atrophied, and forming a proboscis. 4. *Cyclocephalus*, with two adjacent eyes, or one double eye in the mesial line; the organ of smell atrophied, but forming no proboscis. 5. *Stomocephalus*, with two adjacent eyes or one double eye in the mesial line; the organ of smell atrophied, and forming a proboscis; the jaw rudimentary, and the mouth very imperfect or entirely wanting.

In reference to the coalescence of the eyes, we may distinguish the following forms: 1. The eyes may be double, completely asunder, and each with its own eyelid, but closely approximating. 2. Two perfectly developed eyeballs may be in contact, and included within one common upper and lower eyelid. 3. The two eyeballs may be more or less amalgamated, but contain several internal parts doubled. 4. Only one eyeball may be apparent externally. 5. The eye may not be apparent externally; indeed sometimes it is absent altogether.

b. The coalescence may be chiefly limited to *the inferior half of the face*, (*monotia*, *agnathus*, *otocephalus*). The inferior, and more or less of the superior maxilla, with the bones in immediate connection with them may be wanting. The mouth is then very small or altogether absent, the ears approach each other under the face or perhaps even unite. This group is closely allied with that of *cyclopia*, and the two malformations are not unfrequently combined; consequently many cases belonging to this are referred by some to *cyclopia*. There can be no doubt that the cause of this malformation is to be sought in a deficient development of the parts of the

* ἠθμός, the root of the nose.

† κῆβος, an ape.

face, namely of those which form the commencement of the alimentary canal.

Some of the literature cited in reference to *cyclopia* is equally applicable here; we may also mention, Otto, op. cit. p. 112, et seq. and Geoffroy St. Hilaire, vol. II. p. 420 et seq. The latter arranges this group, which he names *Otocephaliens*, under the following subdivisions:

A. *With two distinctly separated eyes.* 1. *Sphenocephalus*, the ears approximating under the face and uniting; jaw and mouth evident.

B. *With only one eye or two united in one socket.* 2. *Otocephalus*, the ears approaching each other under the face or uniting; jaw and mouth obvious; no proboscis. 3. *Aedocephalus*,* the ears approximating under the face or uniting; the jaw atrophied; no mouth; a proboscis over the eye. 4. *Opocephalus*,† the ears approaching each other under the face or uniting; the jaw atrophied; no mouth; no proboscis.

C. *The eyes absent.* 5. *Triocephalus*,‡ the ears uniting under the face or approximating; jaw atrophied; no mouth; no proboscis. The latter in its higher grade forms the transition to the *acephali.*

2. *Coalescence of the inferior half of the body, namely of the lower extremities,* (*monopodia, sympodia*). The pelvis and the organs lying within it, are here incompletely developed; the lower extremities coalescing, and at the same time more or less atrophied. There are different degrees of this condition. In the lowest the two inferior extremities coalesce into one common limb which supports two feet; in a higher, they are united to one limb and one foot; finally, in the highest, they form together only an undefined caudiform mass. This malformation depends upon a deficient development of the lower end of the trunk, whereby the germs of the inferior extremities approximate too closely, and thus become amalgamated. The subjects of this malformation are not viable.

* *αἰδοῖα*, the organs of generation; the proboscis having been regarded by some of the early observers as a penis.

† *ὤψ*, the eye; since the eye with its appendages here forms nearly the whole head.

‡ Since three principal parts of the head—the mouth, nose, and eyes—are absent or deficient.

From the rather copious literature of this subject, I may especially notice: Cruveilhier, Anat. pathol. liv. 33, Pl. v and vi, and liv. 40, Pl. vi; Otto, op. cit. p. 153 et seq.; idem, Monstr. hum. sex anat. et path. disquis. Francofurt, 1811; A. Kaw Boerhaave, Hist. anat. infantis, cujus pars corpor. infer. monstrosa. Petropol. 1754; Rossi, Diss. Jenens. 1800; Köhler, Diss. Jenens. 1831; Maier, Dissert. Tubingens, 1837; M.M. Levy, de sympodia. Diss. Havniæ, 1833; and Huesker, de vitiis syngeneticis, adjecta monstri sireniformis descr. Gryphiæ, 1841.

Geoffroy St. Hilaire (Pl. v, and vol. ii. p. 237), names these malformations, *Symeliens*, and arranges them, according to the degree of the deformity, into three subdivisions: 1. *Symeles*, with the limbs amalgamated, but otherwise almost perfect, terminating in a double foot, whose sole is directed anteriorly. 2. *Uromeles*, with the limbs amalgamated, very imperfect, terminating in a simple foot which is almost always imperfect, and has the sole directed anteriorly. 3. *Sirenomeles*, when the two lower extremities are completely fused together, and are in the highest degree imperfect, terminating in a stump or point, without evident foot.

3. To these we may add certain other amalgamations, whose existence, however, does not affect viability. The principal and most frequent of these are:

Coalescence of the fingers and toes (*syndactylus*, Gurlt). This form occurs in two degrees: in the lower degree, merely the soft parts—muscles, cellular tissue, and skin, or the latter alone—are united, and the bones are double: in the higher degree, the phalanges are also amalgamated. This malformation is sometimes complete on both hands and feet at the same time, but more frequently it is confined to certain pairs of fingers or toes.* It is to be viewed merely as an anatomical, not as a physiological coalescence, since the germinal matter of the hands and feet is simple, and only at a comparatively advanced period of development is divided into individual fingers and toes.

The congenital fusion of those viscera which normally occur in pairs, as the kidneys and ovaries, are, for the sake of avoiding repetition, noticed in the special part.

* Cases with illustrative plates are given in Otto, op. cit. p. 312, et seq.

THIRD CLASS.

MALFORMATIONS, IN WHICH PARTS NORMALLY UNITED ARE SEPARATED FROM EACH OTHER—FISSURES.

In this class of malformations, parts which normally are united appear cleft at some spot in the mesial line. The manner in which these malformations originate, can be very clearly shown by the history of development, although the causes giving rise to them are not very obvious. The cavities for the brain and spinal cord on the one hand, and of the chest and abdomen on the other, are known to be produced in the following manner; the parts of the embryo, at first forming laminæ, rise on each side, and gradually approach each other, uniting in the mesial line of the body. If this union does not take place, or if, having already occurred, separation through any cause (as, for instance, the excessive accumulation of water in a cavity of the body) ensues, a fissure arises. It is usually accompanied with a protrusion of those viscera which normally lie within the fissured cavity, or if the cleft involves only a part of the structures (muscles and bones) forming the wall, whilst the external skin or internal serous coat remains undivided, a rupture (hernia) occurs. In a similar manner we have smaller orifices as congenital malformations; openings, as the *foramen ovale* of the heart, the *ductus botalli*, and the *urachus*, which in the normal state become closed at a later period of fœtal life, or immediately after birth, do not close, but remain patent. The higher grades of the fissures are closely allied to some groups of the first class of malformations.

On fissures generally, and their individual forms, the reader may consult C. Meyer, de fissuris hominis mammaliumque congenitis. Dissert. Berol. 1835; and E. A. W. Himly, Darstellung des Duaslismus am normalen und abnormen menschlichen Körper. Hannover, 1829.

1. *Fissures on the head* (*schistocephalus*,* Gurlt), are

* σχιστός cleft.

resolvable into distinct groups, which occur in part singly, and in part in connection with each other.

a. Fissure of the cranium. The higher degrees, where the skin, bones, and membranes of the brain are divided, and the brain, in a more or less atrophied condition, is exposed, are allied to *hemicephalia*. In the lower degrees, the fissure is limited to the cranial bones; the integument of the head being present, and forming a hernial sac, in which the brain lies externally to the skull; this sac commonly contains also a large quantity of serous fluid (*hydrencephalocele*, Otto). In these cases we frequently observe a union of the placenta with the head.

The cause of cranial fissure is certainly, in the majority of cases, hydrocephalus. Individuals with cranial fissure are not viable; even those affected with a slighter degree of the malformation die shortly after birth.

For cases, consult Meckel, vol. I. p. 301, &c.; Otto, op. cit. p. 38; G. Frederici, Monstr. human. rariss. Lipsiae, 1737. c. tab.; Sömmering, Abbildung u. Beschreibung, &c. Pl. II.; and C. E. Rudolphi, Monstror. trium praeter natur. cum secundinis coalitor. disquis. Berol. Geoffroy St. Hilaire* names the whole group *Exencephaliens*, and reduces them to the following subdivisions: 1. *Notencephalus;* when the cranial fissure exists in the occipital region, the greater part of the brain lying exteriorly, and occupying a position posterior to the skull upon the back. 2. *Proencephalus;* when the fissure is in the frontal region, the greater part of the brain lying anterior to the skull. 3. *Podencephalus;*† when the skull is incomplete on its upper wall, and the greater part of the brain is exterior, in a position superior to the skull. 4. *Hyperencephalus;* when the roof of the skull is entirely absent, and the brain projects to a great extent; this is the highest degree, and is immediately allied to *hemicephalia*. Geoffroy St. Hilaire adds two other species, which are characterized by the co-existence of a cleft in the spinal canal. 5. *Iniencephalus;*‡ when the greater part of the brain lies within the cranial cavity, but in part also exterior to it, behind, and somewhat beneath the skull, which is fissured in the posterior region of the head. 6. *Exen-*

* Vol. II. p. 291, &c. and Pl. x.

† ποῦς, a foot; the brain being connected to the cranial cavity by a species of pedicle.

‡ ἰνίον, the back of the head.

cephalus; when the greater part of the brain is out of the cranial cavity, and lies behind the skull, most of whose upper wall is wanting.

b. Fissures in the facial part of the head occur in different degrees, such as fissures of the whole face, of the nose, of the upper lip, and of the palate. On account of their more frequent occurrence, and their importance in relation to surgery, the two latter malformations possess an especial interest, since those affected with them are not only viable, but their condition admits of amelioration.

In the lowest degree, the *cleft or hare-lip*, the upper lip is divided either singly in or beside the mesial line (constituting a single hare-lip), or on both sides of the raphé, so that between the two fissures there intervenes an atrophied and usually conical central portion (the double hare-lip). In the higher degrees, the alveolar portion of the upper jaw also takes part in the fissure. In *cleft-palate or wolf's-jaw* (*rictus lupinus*) there is a fissure of the hard or soft palate, or of both together, either singly in, or on one side of the mesial line, or, as in double hare-lip, on both sides. Hare-lip is not unfrequently combined with cleft-palate.

The origin of these malformations is referable to an arrest of structure. At an early fœtal period, the palate and superior maxillary bones are separated by the *os intermaxillare*. If the development remains stationary, at a condition corresponding to this stage of evolution, and the normal union is not established, there arises double cleft-palate or double hare-lip; if, again, union takes place on one side only, single cleft-palate or hare-lip results. The occurrence of the latter in the mesial line is, therefore, always only apparent.

For cases, consult Meckel, vol. I. p. 521; Geoffroy St. Hilaire, vol. I. p. 581; Otto, op. cit. p. 288, &c.; Caspar, de labio leporino. Götting. 1837; Leuckart, Untersuch. über das Zwischenkieferbein des Menschen in s. norm. und abnormen. Metamorphos. Stuttgart, 1840.

c. Fissures of individual organs and parts of the head, as extensive separation of the lips, splitting of the cheeks, of the eustachian tubes, of the cavity of the tympanum, of the tongue, division of the iris and choroid coat of the eye (coloboma iridis), are described in the special part.

2. *Fissures on the trunk and neck* (*schistocormus*, Gurlt), appear under very different forms, according as the cleft occurs on the neck, thorax, abdomen, the pelvis, or the arches of the vertebræ. As in the fissures on the skull, so in these cases, the viscera are frequently protruded, and, according as they lie exposed, or are still covered with a part of the membranous investments, form either a prolapse or a hernia.

a. Fissures on the neck (*fistula colli congenita*). Their origin is due to an arrest of formation; the respiratory or visceral clefts, which during the formation of the embryo appear on the cervical region, not uniting at an early stage, as in the normal condition, but remaining open at certain spots.

Literature. Fr. M. Ascherson, de fistulis colli congenitis. Berol. 1832; Kersten, de fist. c. c. Magdeb. 1836; Zeis in v. Ammon's Monatschr., vol. II. part 4; J. Heine, de fist. colli congen. Diss. Halens. Hamburg, 1840; Münchmeyer, in the Hannover. Annal. 1844. part I.

b. Fissures of the spinal column, i. e. of the vertebral arches, (*spina bifida*), occur in very different degrees, from splitting of the entire spinal canal, which commonly exists in connection with *hemicephalia*, to the division of the arch of one or more vertebræ, in which case the fissure frequently remains covered by the membranes and skin. It is either an original arrest of structure, or the effect of dropsy of the vertebral canal (*hydrorhachis*).

The literature of this subject is very abundant; we may especially notice Meckel, vol. I. p. 347, and Geoffroy St. Hilaire, vol. I. p. 615. The reader may also consult Sandifort, Mus. anat. vol. IV. pl. 65 and 66; Otto, op. cit. p. 282; Cruveilhier, liv. VI. pl. 3; and liv. XVI. pl. 4; Küster, de spina bifida. Gryphiæ 1842; and Anderseck, exercit. anat. circa monstra duo hum. spina bifid. aff. Vratislaviæ 1842.

c. Fissures of the thorax and abdomen occur either alone or together.

Thoracic fissures (*fissura sterni*) resolve themselves into those in which, besides the sternum, the skin is also separated—in which case the thoracic viscera are exposed, and form a prolapsus (*prolapse of the heart or lungs*); and into those in which the integument is not cleft, and where the protruded thoracic viscera are covered by it (*hernia pectoralis*).

The same holds good regarding *abdominal fissures*. In the lowest degree, the umbilicus alone is open and the abdominal viscera, to a greater or less degree, protrude through it (*congenital umbilical hernia—exomphalus*); in the highest degree the abdominal walls are completely cleft, and the viscera are more or less exposed and protruded, forming a *prolapsus*.

In some instances the fissure is limited to the lower part of the abdomen, and especially affects the bladder (*prolapsus vel inversio vesicæ urinariæ*). It generally happens in this case, that the urethra is also cleft on its *upper* side (*epispadias*).

The higher degrees of this malformation are incompatible with viability.

The literature of this subject is given in Meckel, vol. I. p. 93; Geoffroy St. Hilaire* names the whole group *Celosomiens*,† and reduces them to the following subdivisions:

A. *The cleft limited to the abdomen.* 1. *Aspalosomus*,‡ the fissure and eventration extending chiefly upon the *lower* part of the abdomen; the urinary apparatus, genitals, and rectum, opening externally by three distinct orifices. 2. *Agenosomus*,§ the fissure and eventration chiefly in the lower part of the abdomen; urinary and sexual apparatus absent or very rudimentary. 3. *Cyllosmus*,‖ the fissure and eventration lateral, chiefly in the lower part of the abdomen; the inferior extremity of the side affected with the fissure, absent or very little developed. 4. *Schistosomus*, the

* Vol. II. p. 264, &c. Pl. VI.

† κήλη, a hernia.

‡ ἀσπάλαξ, a mole.

§ ἀ and γεννάω, without generative organs.

‖ κυλλός, crooked.

fissure and eventration extending over the entire length of the abdomen; the lower extremities absent, or very little developed, so that the body appears as if truncated inferiorly.

B. *The fissure extending also to the thorax.* 5. *Pleurosomus*, the fissure somewhat lateral, with eventration extending chiefly upon the upper part of the abdomen, and upon the chest; the upper extremity of the fissured side being more or less atrophied. 6. *Celosomus*, complete fissure on one side, or in the mesial line, with atrophy or total absence of the sternum, and prolapse of the heart. Plates and descriptions of *hernia umbilicalis congenita* are given in Cruveilhier, Anat. pathol. livr. XXXI. pl. 5, and Otto, op. cit. p. 294. On *ectopia* of the heart, see Cerutti, Rarior. monstr. descr. anat. Lips. 1827; C. Weese, de cordis ectopia. Diss. Berol. 1818; and H. J. Haan, de ectopia cordis. Diss. Bonn. 1825. On *prolapsus vesicæ urinariæ*, see Sandifort, Mus. anat. vol. IV. pl. 67, fig. 2; J. Schneider, der angeborne Vorfall der umgekehrten Urinblase, with plates. Franc. a. M. 1832. (Reprinted from Siebold's Journ. f. Geburtshülfe) with copious literature; and Garvens, Inversio vesicæ urinariæ. Dissert. Halens. 1841.

d. Fissure of the urethra inferiorly (*hypospadias*), usually accompanied *with fissure of the scrotum*, together with the formation of a *cloaca*, in which the orifices of the urinary and sexual organs and of the rectum meet in a common receptacle, is discussed under the head of *Hermaphroditism*.

All or the greater number of the above fissures sometimes occur to the same person.*

3. In this class we must include other fissures, which at first sight are scarcely, or not at all, perceptible, and are only to be recognised by a careful anatomical examination—fissure of the lungs, spleen, liver, thymus gland, kidneys, or pancreas; also the abnormal patency of certain canals or orifices, which in the normal state are closed—as of the *urachus*, the *ductus venosus Arantii*, the *duct. arteriosus Botalli*, and the *foramen ovale* of the heart. These will engage our consideration in the special part.

* Tiedemann, Anatomie der Kopflosen Missgeb. Pl. IV.

FOURTH CLASS.

MALFORMATIONS IN WHICH NORMAL OPENINGS ARE CLOSED.—Atresia.*

Since most of the malformations belonging to this class stand in relation to individual organs, and will hence be more particularly described in the special part, we shall here content ourselves with a specification of the principal forms. Their origin can usually be referred to an arrest of structure.† The higher grades alone are incompatible with life.

1. *Atresia on the head* (*atretocephalus* Gurlt). These include congenital occlusion of the mouth, of the nostrils, of the external auditory foramen, of the palpebral fissure, and of the pupils.

Cases are recorded in Meckel, vol. I. pp. 396, 401, 407; in Geoffroy St. Hilaire, vol. I. p. 525, et seq.; and in Otto, p. 315.

2. *Atresia on the trunk* (*atretocormus* Gurlt) are, chiefly, imperforate conditions of the anus, of the urethra, and of the vagina. Their higher grades are always combined with malformations of internal organs—of the intestinal canal, or of the generative system.

Meckel, vol. I. pp. 591, 655, 662: Geoffroy St. Hilaire, vol. I. pp. 521, 533; Otto, p. 316; Cas. de Chonski, de vitio quod primæ form. infer. potiss. tubi intest. partem et vesic. urin. spectat. Diss. Berol. 1837.

FIFTH CLASS.

MALFORMATIONS OF EXCESS, OR IN WHICH CERTAIN PARTS HAVE A DISPROPORTIONATE SIZE.—Monstra abundantia.

This class may be arranged in two divisions according as certain parts are too large, or there are supernumerary organs.

* ἄτρητος, imperforate.

† Bischoff in Wagner's Handwörterbuch, vol. I. p. 905.

FIRST ORDER.

ONE OR MORE PARTS DISPROPORTIONATELY LARGE.

In many cases the whole body is too large, but the parts are more or less proportionate. These cases present themselves under very different forms: in some instances, the individual, even at birth, is larger than usual; in others he becomes prematurely developed after birth; and again in others he attains to an abnormal size, and becomes *a giant*, or excessively corpulent (polysarcia).

The greater number of these abnormalities do not properly belong to congenital malformations, and consequently demand merely a passing notice. The tallest men, respecting whose heights we possess trustworthy statements, measured eight and a half feet, or perhaps a little more. Cases have been observed in which the growth of the beard and other indications of almost full development have occurred in children seven years of age, and even younger. Excessive corpulence has been chiefly observed in England; cases are recorded in which individuals have attained a weight of six hundred and fifty pounds. For further details on this subject we must refer to Meckel, op. cit. vol. II. part I. p. 2, et seq.; and Geoffroy St. Hilaire, vol. I. p. 168.

In a similar manner, individual parts of the body may be too large; this, however, is rarely a congenital malformation, but more commonly local hypertrophy acquired after birth.

The most frequent of the congenital malformations belonging to this class is a disproportionate size of the head, from the accumulation of fluid in the cranium—*hydrocephalus congenitus*. For cases see Geoffroy St. Hilaire, vol. I. p. 253, &c.

SECOND ORDER.

ONE OR SEVERAL SUPERNUMERARY ORGANS.

This order presents a very great number of varieties, from the simplest cases, in which a single joint of a finger is supernumerary, to those of a highly complicated nature, where two, or even three bodies are united by some one point—twin or triplet monsters.

Great difference of opinion has prevailed respecting the causes and mode of origin of these malformations with supernumerary parts.

According to some, they arise by a *coalescence of two separate germs*, while according to others, they depend on a *furcation of a single germ.*

Although, at present, it is impossible to decide with certainty on either of these views, yet in the majority of cases, (with certain exceptions to be presently mentioned,) the latter appears to me by far the more probable.

The chief arguments in favour of the latter view are the following:

1. The organs that are united are always similar organs: head with head, thorax with thorax, &c.; a fact that can only be explained in a very forced manner by the assumption of a coalescence of two germs.

2. There is a complete transition from the cases where two almost perfect individuals are attached at only a circumscribed spot of the body, to those where one individual bears only some trivial supernumerary parts, or other malformation, as, for example, fissure of the skull; in short, to cases whose origin no one would ascribe to a coalescence of two germs.*

3. Finally, it is totally incomprehensible, how, in the case of two separated germs or ova, of which each must have its own membranes, a union of two embryos can take place; and it is just as little to be comprehended how, in such a union, often more than the halves of the two systems can be so intimately fused together, as we sometimes find to be the case. These are the principal reasons which lead me to agree in the opinion, that all twin and triplet monsters, with the exception of the cases of *fœtus in fœtu*, proceed from a simple germ, or ovum.

The question: how and from what causes does it happen that a malformation with supernumerary parts is produced from one ovum? can only be answered by experience, and the materials necessary to this reply will doubtless be furnished to us by future observers. At present, little more than the following can be said upon the subject. In some cases the ovum or the germ is malformed *ab origine* (the yolk of abnormal form—*ovum in ovo*), in others it becomes, after impregnation, so affected by causes still unknown to us, that excessive nutrition of particular portions of it ensues, and hence supernumerary parts are

* Sömmering has pointed out this fact very convincingly in certain cases. See the vignette on the title-page of his Beschreibung und Abbildung einiger Missgeburten.

formed. Sometimes, finally, the excessive number of parts is only apparent, and is founded upon an arrest of development. On these points the reader will find further details in Meckel, vol. II. part I. p. 11, &c., and in Bischoff, op. cit. p. 909, &c.

The malformations belonging to this order may be arranged in two subdivisions, according as the head and trunk are single, and only certain portions of them, or particular limbs and their parts are supernumerary; or as the head and trunk are double or even triple.

I. MALFORMATIONS IN WHICH THERE ARE SUPERNUMERARY PARTS, BUT A SINGLE HEAD AND TRUNK.

Most of the malformations belonging to this subdivision are noticed in the special part, so that in this place a mere specification of them is sufficient.

1. *Supernumerary parts on the head.* We may have multiplication of the cranial bones, as double frontal bone, *ossa wormiana* (which are properly formations of arrest); duplication of the lower jaw and of the tongue; supernumerary teeth; and in animals, supernumerary horns.

2. *Supernumerary parts on the trunk,* as an increased number of vertebræ; the formation of a tail in the human subject;* supernumerary ribs, muscles, and mammæ.

3. *Supernumerary parts on the limbs.* Supernumerary fingers and toes in the human subject are by no means rare, and sometimes appear to be hereditary.

Six fingers on one hand are not unfrequent; a case in which there were seven fingers on one hand, and eight toes on one foot is given in Geoffroy St. Hilaire, Pl. III.; several cases are also given in Otto, p. 267, &c.

Supernumerary extremities with a single head and trunk, very rarely occur in man, but are comparatively frequent in animals. These cases form the transition to the second division.

* See Meckel, vol. I. p. 385; and Geoffroy St. Hilaire, vol. I. p. 736.

Supernumerary parts in the intestines, as for instance, supplementary spleens, are noticed in the special part.

II. MALFORMATIONS WITH SUPERNUMERARY PARTS, AND MORE THAN ONE HEAD OR TRUNK.

The malformations belonging to this division form the so-called *double or twin monsters* (*monstra duplicia, m. bigemina*), and triplet monsters (*m. trigemina*). They may be regarded (anatomically, but not physiologically), as two individuals, whose bodies are adherent, and, to a greater or less extent, fused together in a very symmetrical manner, by the coalition of corresponding parts.

The literature on the general relations of these malformations is very abundant. We may especially notice Meckel, op. cit. vol. II. p. 38, &c.; Meckel, de duplicitate monstrosa, 1815; Burdach, Sechster Bericht von der anatomischen Anstalt in Königsberg, 1823; Barkow, Monstra animalium duplicia per anat. indagata, Lipsiæ, vol. I. 1826, vol. II. 1836; and Bergholz, de monstro dupl. per implantat. ac de duplicitate, Berol, 1840.

These malformations are further divisible into two groups: in the one, the united individuals are both equally developed, *double monsters by coalition* (*autositaires*, Geoffroy St. Hilaire); in the other, only one individual is especially developed, the second being more or less atrophied, and forming, in a manner, a parasitic appendage to the first, *double monsters by implantation*, (*per implantationem—parasitaires*, Geoffroy St. Hilaire.)

A. DOUBLE MONSTERS BY COALITION.

These double monsters may be separated into a great number of forms, of which we must here give only a brief sketch, without entering deeply into their anatomy. They form a connected series from a single individual with a few doubled parts, to two bodies almost completely separated, and only attached at a very circumscribed spot.

1. The duplication may be so inconsiderable, that externally it can be scarcely or not at all perceived, while internal

parts, viscera, or the upper portion of the vertebral column, with a corresponding part of the brain and skull, are doubled.

All the forms of this duplication are very rare, and have hitherto been observed only in animals. The forms hitherto noticed are:

a. Partial duplication of the vertex (*dicoryphus** Barkow—*dicranus*, Gurlt). The cranium is doubled, the face not so, or only partially. The upper end of the vertebral column is also doubled, but there are present only two rows of ribs. Sometimes the superior extremities are also doubled. The brain and upper part of the spinal cord are more or less doubled.

Heusner, descript. monstror. avium, &c. Diss. Berol. 1824; Gurlt, op, cit. p. 256.

b. Partial duplication of the face (*monocranus*, Gurlt). The face may be partially doubled, the eyes, nose, tongue, and the cerebrum being especially implicated in the duplication; the cranium being single.

Gurlt, vol. II. p. 216, &c.

2. *The duplication may affect the upper half of the body.* This may be more or less doubled, while the lower half of the body is single. The cases which belong to this class form a perfect transition-series from the simple cranial fissure to two almost completely separated bodies. The following are the principal forms:

a. Duplication of the face (*diprosopus*, Barkow and Gurlt). The face is more or less doubled; the separation of the two faces commences anteriorly, and either does not extend at all, or only partially upon the skull.

For the literature of this class see Barkow, vol. II. p. 36; and Otto, op. cit. p. 223, 225, &c. Geoffroy St. Hilaire,† divides this group into

* κορυφή, the top of the head.

† Vol. III. p. 195, &c.

two genera: 1. *Iniodymus** (*diprosopus sejunctus*, Gurlt), which forms the higher grade. The two heads are united at the occiput, and consequently all the cranial bones as far as the os occipitis are doubled; also the organs of sense and the cerebrum; 2. *Opodymus*† (*dipros. distans*, Gurlt), in which the face only as far as the zygoma is doubled, the skull is simple; the cerebrum, however, being commonly doubled.

b. Duplication of the whole head (*dicephalus*, Barkow and Gurlt). The whole head is doubled, and the upper part of the vertebral column is double. On the contrary, the thorax and abdomen are, at least externally, single.

For the literature, see Barkow, vol. II. p. 37, &c.; and Otto, p. 221, plate XXIV. figs. 2 and 3. Geoffroy St. Hilaire‡ distinguishes the following forms: 1. *Atlodymus*, in which the two heads are seated upon one neck, and the duplication descends as far as the atlas. 2. *Derodymus*,§ in which the duplication extends to the neck; the thorax, externally simple, presenting one sternum and a double vertebral column.

c. The head, neck, and upper extremities may be doubled, while the chest and abdomen are single, or at least fused into one another, in the two bodies. *Thoracico-abdominal duplication*, (*didymus symphyothoracogastrius*, Barkow—*thoraco-gastrodidymus*, Gurlt).

Barkow, vol. II. p. 39, and vol. I. pl. III. fig. 1. Geoffroy St. Hilaire‖ names this form *Xyphodymus*.¶ In this division we must place the twin monster known under the name of Rita Cristina, who was born on the 12th of March, 1829, at Possari (in Sardinia), and was brought alive to Paris, but died there in the November of the same year, after it had been subjected to some interesting physiological experiments. Other cases are given in Otto, p. 217, &c., and W. Grüber, Anatomie eines Monstrum bicorporium. Prag. 1844, with six plates.

d. The duplication may extend to the thorax, while the *abdomina* coalesce, (*didymus symphyogastrius*, Barkow—

* ἰνίον, the nape of the neck.

† ὤψ, the face.

‡ Vol. III. p. 191.

§ δέρη, the neck.

‖ Plate XV. fig. 1, and vol. III. p. 161, &c.

¶ From the coalescence of the ensiform cartilages.

gastrodidymus, Gurlt). The lower extremities may in this case be single or doubled.

Barkow, vol. II. p. 39. Geoffroy St. Hilaire* names this from *Psodymus*.† A case recently described in Froriep's N. Notiz. vol. v. p. 152, of a double monster, born at Stammsried (Bavaria), in January, 1838, should probably be placed in this division.

e. The duplication may extend as far as the centre of the abdomen, while the lower halves of the body, from the umbilicus downwards, coalesce, (*didymus symphyohypogastrius*, Barkow—*hypogastrodidymus*, Gurlt). The lower extremities are likewise sometimes doubled.

Barkow, vol. II. p. 40. Geoffroy St. Hilaire,‡ names this form *Ischiopages;* while Dubreuil assigns to it the term *Ischiadelphus*. The following recent cases have been recorded: J. A. Pereira, in Edin. Med. and Surg. Journ. 1844, vol. LXI. p. 58; Montgomery, in Todd's Cyclopædia of Anatomy and Physiology, "Abnormal Anatomy of the Fœtus," p. 317.

f. The duplication may be *almost complete*, and the two bodies amalgamated at only a circumscribed spot, at the perineum, the sacrum, or coccyx, (*didymus symphyoperinæus*, Barkow—*pygodidymus*, Gurlt).

Barkow, vol. II. p. 40. Geoffroy St. Hilaire§ names this form *Pygopages*. The Hungarian sisters, Helen and Judith, who were born at Szony, in Hungary, in the year 1701, and after being exhibited for a long time throughout Europe, died in their twenty-second year, afford a good illustration of this form.

3. *The duplication may extend to the inferior half of the body, while the superior half is more or less single.*

a. The duplication may be limited to the *organs of generation*, and the *urinary bladder*, and consequently to the anterior part of the pelvic region (*diædæus*,‖ Barkow). This form is rare, and hitherto has been observed only in animals. For the literature, see Barkow, vol. II. p. 40.

* Vol. III. p. 157.
† ψόα, the loins.
‡ Plate xx. fig. 1, and vol. III. p. 69, &c.
§ Plate XIV. fig. 2, and vol. III. p. 50.
‖ *αἰδοῖον*, the generative apparatus.

b. The duplication may be confined to the posterior part of the lower end of the trunk, the *coccygeal region* (*dipygus*, Barkow). It is, however, questionable if this form actually occurs; at present, no instance of it is known.

c. The pelvis may be completely doubled, together with a portion of the abdomen, (*dihypogastrius*, Barkow). This group separates into different subdivisions, according as the duplication extends, more or less, upon the upper part of the body.

Cases are recorded by Barkow, vol. 2. p. 41, &c.; and Otto, p. 179, pl. XXIV. fig. 1. The forms into which this group has been subdivided, are as follows: 1. The head always single, and only the lower (hinder) part of the body, as far as the umbilicus, doubled, (*monocephalus* s. *dipygus*, Gurlt—*thoradelphus*, Geoffroy St. Hilaire); this has been hitherto observed only in animals. See Gurlt, op. cit. vol. II. p. 257, &c.; Gurlt and Hertwig, Magazin f. ges. Thierheilkde, vol. II. p. 2 & 180; and Geoffroy St. Hilaire, vol. III. p. 146, &c. 2. The upper jaw double, but amalgamated, and only the doubled lower part of the body, from the umbilicus downwards, separated, (*octopus*, Gurlt). This is again separable into various sub-forms: *a.* There may be present two more or less perfect faces (*octopus Janus*, Gurlt), a group which Geoffroy St. Hilaire has again divided into two genera, *Janiceps* and *Iniops*: both occur in the human subject. *b.* There may be only one face, and opposite to it two ears united at the base, as the rudiment of a second, (*octopus quadriauritus*, Gurlt—*synotus*, Geoffroy St. Hilaire, vol. III. p. 126): this also is not unfrequent in the human subject. *c.* Only the posterior parts of the head, the occipital and sphenoid bones may be double, the rest simple, (*octopus biauritus*, Gurlt—*deradelphus*, Geoffroy St. Hilaire, vol. III. p. 142): in man this is very rare, but not very unfrequent in animals.

d. The duplication may be almost complete, and the two bodies connected at only a circumscribed spot on the head, (*didymus symphyocephalus*, Barkow).

For cases, see Barkow, vol. II. p. 43; and Otto, p. 179. The forms belonging to this group have been further reduced to several subdivisions: 1. The two bodies may be attached at the occiput, *didymus symphyopistocephalus*, Barkow). 2. They may be connected at the vertex, (*didymus symphyocoryphus*, Barkow). These two forms are comprised by Geoffroy St. Hilaire in the genus *Cephalopages*.*

* Pl. XIX. fig. 1 & 2, and vol. III. p. 60, &c.

3. They may be attached at the forehead (*didymus symphyometopus*, Barkow—*metopages*, Geoffroy St. Hilaire, vol. III. p. 56). Cases belonging to this group are very rare in man.

4. *The duplication may simultaneously affect the upper and lower ends of the body, the two bodies being amalgamated in the middle.*

a. The duplication may affect, superiorly, the *face*, and inferiorly, the *anterior pelvic region* (*diprosopus diædæus*, Barkow; *tetrascelus* in part, Gurlt). It does not occur in the human subject: cases which have occurred in animals have been collected by Barkow, vol. II. p. 43.

b. The duplication may affect, superiorly, the *face*, and inferiorly, the *lower part of the body* (*diprosopus dihypogastrius*, Barkow; *tetrascelus* in part, Gurlt); *four lower extremities are here always present.*

Frequently observed in man. See Barkow, vol. II. p. 43.

c. The duplication and separation may affect, superiorly, *the vertex*, and inferiorly, the parts from the *umbilicus downwards* (*dicoryphus dihypogastrius*, Barkow—*octopus synapteocephalus*, Gurlt).

Barkow, vol. II. p. 44; vol. I. pl. II. fig. 1. Geoffroy St. Hilaire terms this form, *hemipages* (vol. III. p. 104).

d. *The head and neck superiorly, and the lower half of the body from the umbilicus downwards*, may be doubled and separated; the amalgamation taking place on the thorax and upper part of the abdomen, either on the anterior surfaces of the bodies, or more laterally (*thoracodidymus*, Gurlt; *dicephalus dihypogastrius*, and, as a higher degree, *didymus symphyothoracœpigastrius*, Barkow.

Both, but especially Barkow's second form, are not unfrequent in the human subject. See cases in Barkow, vol. II. p. 44, &c.; Cruveilhier, Anat. pathol. livr. XXV. pl. V.; Otto, p. 170, &c.; and in Geoffroy St. Hilaire, who separates these cases into two genera: 1. *Sternopages*, with anterior amalgamation (vol. III. p. 93, &c.) 2. *Ectopages*, with lateral amalgamation (vol. III. p. 98, &c.)

e. There may be almost complete duplication, with separation of the two bodies, which are amalgamated only in the upper region of the abdomen (*didymus symphyoepigastrius*, Barkow).

Cases of this nature are rare; several are collected in Barkow, vol. II. p. 45, and in Geoffroy St. Hilaire,* who names this form *Xiphopages*. We must here include the celebrated case of the Siamese twins; also a case described by Fanzago (*Storia del mostro di due corpi, etc.* Padova, 1803), with a beautiful illustration; see also Otto, p. 169, &c.

B. PARASITIC DOUBLE MONSTERS.—MONSTERS BY IMPLANTATION.

The amalgamated bodies are here not equally developed, one being more or less atrophied, and either apparent externally on the more perfect individual, or so concealed under the skin or inclosed within the cavities of the body, that it is not outwardly visible.

The cases belonging to this division arise either like perfect double malformation, by splitting of one germ, of which, however, half becomes atrophied, or, compared to the other, is backward in its development—or two germs exist from the first (an ovum with two germinal vesicles, or two ova), which unite together, or of which the more developed one encloses within itself that which is less perfect. We may distinguish the following forms of these malformations:

1. A perfect individual may bear on its head, not like the *didymus symphyocephalus* or *cephalopages*, a fully developed second individual, but only a head with traces of the rest of the body. It is very rare.

Geoffroy St. Hilaire, who has collected several of these cases (vol. III. p. 239. &c., and pl. xx. fig. 3), names the form, *epicoma*.

2. On the head of a more or less perfectly developed fœtus, attached either to the palate or the lower jaw, there may be very imperfect rudiments of a second head.

Geoffroy St. Hilaire arranges (vol. III. p. 250, &c., pl. xx. fig. 3,) these rare cases in three genera; 1. *Epignathus*; where an accessory very defective, and, in all its parts, very malformed head is attached to the palate

* Vol. III. p. 80, &c.

of the developed individual. (We should here probably place a case described by J. C. L. Haack, in his Diss. sistens. descr. anat. et del. fœtus parasitici. Kiliae, 1826). 2. *Hypognatus;* where a very defective second head is situated nor the lower jaw of the developed individual. 3. *Augnathus;* where a very rudimentary head, which is almost limited to a lower jaw, is seated on the lower jaw of the developed individual.

3. On a well developed, or more or less normal body, a second, smaller and more or less defective one may be situated, which, after birth, does not increase in size. It is generally attached to the thorax, or upper part of the abdomen (*heterodidymus*, Gurlt).

Geoffroy St. Hilaire* places these cases in three subdivisions: 1. *Heteropages;* where the undeveloped second individual possesses an evident head, and at least rudiments of lower extremities, and is, therefore, almost complete. 2. *Heteradelphus;* where the parasite consists of only a lower half of a body—its head and sometimes also its thorax being wanting. 3. *Heterodymus;* where the parasite consists of only an imperfect upper half of a body (head, neck, and thorax); the lower half being wanting. Additional cases are described by J. Wirtensohn, Duor. monstror. dupl. human. descript. Berol. 1825; and by J. Faesebeck, in Müller's Archiv. 1842, p. 61.

4. In a more or less perfectly developed individual there may be concealed under the skin, in a tumour or in a cavity of the body—commonly in the abdomen—parts of a second individual, which, however, are not amalgamated with the corresponding parts of the first, but are more or less isolated. This condition has received the name of *fœtus in fœtu.* It is most probably caused by the inclusion of one germ by another; not, as Meckel believed, by generative-like multiplication.

With this condition we must not confound extra-uterine pregnancy with ossification of the child (lithopädion) nor the bony particles formerly mentioned, which, with teeth and hair, sometimes occur in encysted tumours, and by some are maintained to be parts of a fœtus. Cases of this nature are given in Meckel, vol. II. p. 69, &c.; Geoffroy St. Hilaire, vol. III. p. 291, &c., who names these malformations *endocymiens;* also

* Pl. XVIII. and vol. III. p. 211, &c.

in Fattori, whose work, *de' feti che racchiudono feti detti volgarmente gravidi*. Pavia, 1815, besides enumerating the earlier literature, contains the description of an interesting case, with exceedingly beautiful illustrations. More recent cases may be found in Schaumann, diss. sistens cas. rarior. fœtus in fœtu. Berol. 1839; and Schönfeld, Annales de Gynécolog. et Pédiatrique. Septbre. 1841; or Froriep's N. Notizen, vol. xx. 1841. p. 137.

TRIPLET MONSTERS (MONSTRA TRIPLICA S. TRIGEMINA).

Some portions of the body are here not merely doubled, as in the case of twin monsters, but tripled. Triplet monsters are, indeed, very rare; but latterly, even in man, their existence has been positively shown.

See the cases in Geoffroy St. Hilaire, vol. III. p. 327, where one of especial interest is communicated—a child with three heads, observed in 1832, by Drs. Reina and Galvagni, in Catania.

SIXTH CLASS.

MALFORMATIONS IN WHICH ONE OR MANY PARTS HAVE AN ABNORMAL SITUATION (SITUS MUTATUS).

The malformations belonging to this class may be brought into the following subdivisions:

1. *Congenital abnormalities in the situation of the viscera.* The highest degree is seen in the complete reversing of all internal organs, in which the heart and spleen lie upon the right, the liver and cæcum upon the left side, without the viability being in any way impaired. Of this anomaly, which has its origin in an abnormal development, the causes are quite unknown.

For cases, see Meckel, vol. II. p. 183, &c.; and Geoffroy St. Hilaire, vol. II. p. 6, &c. More recent cases are given in Herholdt, Beschreibung sechs menschlicher Missgeburten. Copenhagen, 1830. Case I. and p. 65; and Valentin's Repertorium, 1837, p. 173.

2. Anomalies in the course of *individual vessels* (arteries, veins, and lymphatics). They are very numerous and diversified. Their mode of origin cannot be

explained without entering deeply into the history of development.*

3. Changes in the arrangement of the bones, curvature of the vertebral column, club-foot, club-hand, &c., are for the most part the consequences of abnormal contractions of the muscles during fœtal life.

For cases of this nature see Cruveilhier, Anat. pathol. livr. II. pl. II., III., IV.; and Otto, pp. 281, 284, 317, 322.

SEVENTH CLASS.

MALFORMATIONS OF THE GENERATIVE ORGANS—HERMAPHRODITISM.

In this class we must place the cases where, in consequence of abnormal development, the generative organs of one sex approximate to those of the other, or where on one and the same individual both male and female generative organs occur—in short, all malformations affecting the generative apparatus, whereby the sex is made at all doubtful.

For the general literature, see Meckel, vol. II. Part 1, p. 196, et seq.; Geoffroy St. Hilaire, vol. II. p. 30 et seq.; Simpson's article, Hermaphroditism in Todd's Cyclopædia of Anatomy and Physiology, p. 684; J. F. Ackermann, Infantis androgyni historia. Jenæ, 1805; and G. Steglehner, de hermaphroditorum natura, 1817.

This class is usually arranged in two divisions:

1. *False hermaphroditism*, where the occurrence of double sexual organs is only apparent.

2. *True hermaphroditism*, where male and female organs of generation actually occur in the same individual.

1. FALSE HERMAPHRODITISM.

All cases belonging to this division, are characterized by the sexual organs of an individual, or at least the external parts of generation approximating, in consequence of malformation, more or less closely to those of the opposite sex, so as to render the sex doubtful.

* See Bischoff, op. cit. p. 918.

These malformations occur in females and in males.

a. IN FEMALES.

In this case the resemblance to the male sex may be occasioned:

1. By disproportionate size of the clitoris, so that it may be mistaken for a penis. This mistaking of the clitoris for a penis may, in infants, occur the more easily, since in the fœtus, almost until birth, the clitoris is not much smaller than the penis. In many cases, again, the clitoris grows remarkably after birth, and often attains a very considerable size (from two to five, or even seven inches in length, with proportionate thickness). In addition to this the clitoris is sometimes furnished at its anterior termination with an orifice, which resembles that of the urethra of the male, or has, inferiorly, a channel which corresponds to the male urethra; sometimes also the prepuce is much developed. Now if, at the same time, as is frequently the case, there is constriction of the vagina, considerable development of the hymen, tumefaction of the labia pudendi, approximation of the total *habitus* to the male sex by deep voice, traces of beard, and slightly developed mammæ; such individuals may be easily mistaken for men.

2. The apparent approximation of the female generative organs to those of the male, may be caused by prolapse of the uterus. However improbable this sounds, yet cases are known where by reason of such a prolapse the sex became in the highest degree doubtful; indeed, when females have even married as men.

For cases see Meckel, vol. II. p. 200 et seq.; Nega. de congenitis genital. fœmineor. deformitat. Vratisl. 1837, (only a small portion of it, however, refers to this subject); Becker, de hermaphroditismo, Jenæ, 1842; and Oesterr. mediz. Wochenschr. 1843, p. 701.

b. IN MALES.

A resemblance to the female sex is produced by several malformations.

1. By fissure and eversion of the urinary bladder with prolapse of its posterior wall, a condition already treated of under the head of *fissures*. This fissured bladder, although situated above the pubis, has been repeatedly mistaken for the vagina, especially in the cases where the intestinal canal has opened into it (cloacal structure), and where at the same time the male generative organs have been much atrophied. The latter is, indeed, usually the case in this condition; that is to say, the penis is nearly always imperfectly developed and cleft upon its upper side (*epispadias*).

2. In rare cases, the approximation of the male genitals to the female *habitus*, is produced by the penis of the infant being attached to the scrotum by false ligaments and adhesions; it is thus drawn downwards and appears to have vanished; the deception is further favoured when the testicles do not descend.

3. Most frequently false hermaphroditism in the male sex, arises from the urethra being fissured beneath and atrophied, (*hypospadias*) while, at the same time, also, the scrotum and even the perineum are cleft, so that the fissure resembles the female vulva; the resemblance being increased by the circumstance that like the latter, it is lined with a soft, red, mucous membrane.

Generally, also, in such cases the testicles have not descended (*cryptorchismus*), which adds to the deception, so that such individuals have been frequently taken for girls until the period of puberty, when they have suddenly changed into men.

For cases see Meckel, vol. II. p. 207; Th. Brand, the case of a boy who had been mistaken for a girl, London, 1787, with illustrations; H. A. Wrisberg, comment. de singul. genit. deform. in puero hermaphrodit. ment. Gœtting, 1796; F. H. Martens, Beschreib. und Abbild. einen sonderbaren Missgestaltung der Männl. Geschlechtstheile, Leipz. 1802; Rapp in Casper's Wochensch. 1843, No. 32, p. 522; and Otto, op. cit. p. 205.

On *cloacal structure* generally, see Wedel, Diss. monstri human rar. descr. cont. Jenæ, 1830, c. tab.; Ulrich, Diss. Marburg. 1833, c. tab.; Otto, p. 308, et seq.

The origin of these malformations is explained by the history of the development of the genital organs, and chiefly depends on arrest of structure. At first there exists in both sexes a common orifice for the urinary apparatus, generative organs, and intestinal canal: an arrest of development at this stage causes cloacal malformation. At an after period the termination of the rectum is separated from the urino-generative aperture; in the male sex the latter becomes closed as far as the orifice of the urethra; in the female, on the contrary, it remains divided. Now, if an arrest of formation interferes anterior to the period of this change, the external genital organs of a male fœtus bear a close resemblance to those of a female; the penis remains small, undeveloped, and is not perforated by the urethra, and consequently is very similar to the clitoris.

II. TRUE HERMAPHRODITISM.

This comprises the cases where male and female organs of generation actually occur together in one individual. In the human subject few cases are at present known which can be regarded as pertaining to true hermaphroditism, and even some of these are in the highest degree questionable. It is, for instance, very difficult, sometimes, indeed, almost impossible to distinguish with certainty, the different corresponding generative organs of the two sexes from each other, as testicle and ovary, or vas deferens and fallopian tube, when they are malformed or atrophied. Moreover, all these individuals are incapable of propagation, and consequently a practical determination of their true sex is impossible.

For these reasons the occurrence of true hermaphroditism in the human subject is totally denied by some, and all cases of this nature, referred, as merely apparent, to false hermaphroditism.* I shall, therefore, content myself with giving a brief sketch of the forms which have been hitherto observed of true hermaphroditism, without desiring to be held responsible for the accuracy of the individual observations.

The cases which have been observed may be brought into the following groups:

1. The internal sexual organs may differ on the two sides,

* See Bischoff, op. cit. vol. I. p. 919.

being on the one side male, and on the other female (*hermaphrodismus lateralis*). On one side of the body is an ovary, on the other a testicle.

For cases see Meckel, vol. II. Part 1, p. 213; Rudolphi, Abhandlungen der Berlinen Akademie der Wissenschaften, 1825; J. C. Meyer, Caspar's Wochenschr. 1835, No. 7; Berthold, über seitliche Zwitterbildung, Göttingen, 1844, (reprinted from vol. II. of Abhandlungen der Königl. Gesellsch. der Wissenschaften zu Göttingen).

2. The external genital organs may differ from the internal; the external being female, the internal male; and less frequently the converse. Most of these cases are probably founded on deception, and belong to false hermaphroditism.

3. Hermaphrodites with *increased* number of parts; certain male sexual organs are present with a perfect female system, and the converse.

A few cases are given in Meckel, vol. II. p. 215, et seq. All these and some other more recent cases are, however, in the highest degree questionable, and are probably founded upon a false interpretation of the supernumerary parts.

Additional matter on congenital malformations of the sexual organs will be found in the special part.

As an appendix we may add certain pathological changes of the fœtus, which are not commonly classed with congenital malformations—as tumours and other morbid products; also the alterations which the fœtus undergoes when retained in the abdominal cavity in extra-uterine gestation (lithopadion); and various pathological changes of the placenta and membranes of the ovum.

Most of these pathological changes are as yet very imperfectly understood, and, as in the case of the malformations, a profound consideration of them is impossible without entering deeply into the history of development. I am, therefore, content in this place, to refer to a few works which contain more special statements respecting certain of these morbid alterations.

On diseases of the fœtus, consult J. Grätzer, die Krankheiten des Fœtus, Breslau, 1837; Cruveilhier, Anat. pathol. liv. 15, Pl. II.; Otto, op. cit. p. 317, et seq.

On Lithopædia, see Cruveilhier, op. cit. liv. 15, Pl. VI.

On pathological changes of the placenta, and membranes of the ovum, see Ruysch, Observat. cent. Obs. 58. Molarum origo et natura; Meckel, vol. I. p. 82 et seq.; Cruveilhier, op. cit. liv. 1, Pl. I. and II. liv. 6, Pl. VI. liv. 16, Pl. I.; Valentin, on the minute structure of a disorganization of the human ovum which is of frequent occurrence, and leads to abortion, in his Repertorium, vol. I. 1836, p. 126, et seq.; W. Vrolik, Handboek, &c., and Hannoversche Annalen, 1843, p. 723, et seq.; and Pappenheim, Neue Zeitschrift für Geburtskunde v. Busch, d'Outrepont und Ritgen, 1841, p. 300.

CHAPTER X.

CHANGES OCCURRING IN THE BODY AFTER DEATH—POST MORTEM CHANGES.

It is only in occasional cases that we have the opportunity in the human subject of examining diseased parts of the body whilst perfectly fresh, such as extirpated tumours or amputated extremities. In general, a shorter or longer period elapses between death and the examination, and during this interval, through the agency of putrefaction, changes frequently occur in the elements of the body which may be easily confounded with such alterations as, during life, were produced by disease. The study of cadaveric changes is, therefore, necessary, lest false conclusions should be drawn from the state of the corpse, with respect to existing pathological alterations.

It has, however, still another object which is of more especial importance in relation to medical jurisprudence, and consists in the reply to certain questions which are frequently put to the medical jurist. Such queries are chiefly as follows:

1. Has a person died a natural or violent death?
2. How long a period has elapsed since his death?
3. In what condition was the corpse found?

The cadaveric changes interest us here chiefly with reference to the first question. They are commonly placed in direct opposition to those which take place during life, and the two are held to be essentially different, since, as it is reasoned, the latter have arisen under the influence of the vital force, while the former, on the contrary, have resulted in accordance with totally different laws, namely, the strictly physical and chemical laws, which govern inorganic nature. This is an erroneous or at least illogical view, founded upon the fact that a false idea is commonly attached to the term 'vital force.' This is not a simple power *sui generis*, it is rather the common result of all the different and innumerable forces operating within the human body: of these, again, the greatest number (all, with the exception of the psychical) act according to physico-chemical principles. Many of these forces certainly cease at the moment of death, some before, others shortly after—as, for instance, all operations which depend upon the mind, the united activity of the nervous system, with every voluntary or involuntary movement dependant on it, the circulation, &c. Others, on the contrary, continue in operation after death, and upon these, which certainly are greatly modified by the abstraction of the above mentioned forces, depends the occurrence of the cadaveric changes, and not upon any new agencies that may come into operation only after death. These phenomena are those of putrefaction and decomposition: even during life perfectly analogous processes are taking place at every instant and in every part of the system, but their products are being continuously carried away from their original place by the circulation, and removed from the body by means of the secretions. But as the mechanism of the circulation and of the secretions ceases with life, these products of decomposition are then no longer removed; they accumulate, and perhaps experience chemical modifications which could not occur during life; and peculiar results may be manifested, which on a superficial consideration of their mode of origin seem to be very different from the changes occurring during life. Such is, however, in reality, not the case, since, for example, in gangrene, changes sometimes occur during life, perfectly analogous to the phenomena of putrefaction, as seen after death.

The cadaveric changes no less than the metamorphoses during life, are the products of a very great number of agents, and it is, therefore, difficult, and, indeed, impossible to lay down general laws for their establishment. We may consider the following as amongst the most important agencies which exercise an influence upon cadaveric changes.

1. The state of the constituents of the body at the moment of death. The condition of the blood is here of great importance, since this fluid is not only generally the first of all parts of the corpse to suffer further changes and decomposition, but also, by means of these, gives rise to metamorphoses in many other elements of the body. We must here take into consideration the quantity and quality of this fluid, and its distribution, also the condition of the other parts of the body, the amount of fat they contain, and other characters, as, for instance, their vascularity.

2. The state of the temperature, the degree of warmth of the body at the moment of death, the rapidity or slowness with which this warmth escapes, the humidity of the atmosphere, and the other ordinary relations which either retard or accelerate the course of the chemical changes previously going on in the body. To these may be added, as important in many respects, the situation of the body after death; including the circumstances whether the body lay exposed to the atmosphere, whether it had been buried, or had been lying in water.

3. In the critical examination of the cadaveric changes, *the time* which has elapsed since death, is a point of very great importance.

Upon these influences depend partly the quality of the changes, and partly their quicker or slower occurrence, and their greater or less intensity. At present, unfortunately, we are unable accurately to establish the influence of the individual agents, and thus, conversely, from a change in a corpse, to conclude with certainty upon its cause.

Since, with a view to pathological anatomy, it is our especial object to draw a conclusion regarding the state of the body at the moment of death, from the changes presented by the corpse, it is advisable always to make the examination with as little delay as possible; examinations after the lapse of a considerable period have little or no value for pathological anatomy. It often happens, however, that the dissection cannot be immediately made, and it becomes, therefore, necessary to be acquainted with those cadaveric changes which, under ordinary relations, generally occur within a day or two after death, in order to conclude from them whether the alterations which present themselves are really of a morbid character.

The most important cadaveric changes are those which take place in the *blood* and *vascular system*. They are intitimately allied to the formerly detailed modifications of the blood, and have been in part already described (see pp. 59—98, 391, and 403).

The blood coagulates first in the larger vessels, namely, in the heart and the large venous trunks, and to a less degree in the arteries, which are often contracted after death, having expelled the greater part of their contents. When they afterwards again relax, the blood has coagulated and does not return into them. The blood does not, however, always coagulate: in many cases, where its fibrin is modified and has lost its characteristic coagulability, it remains more or less fluid.

Considerable alterations commonly ensue in the distribution of the blood.

Capillary hyperæmia may diminish or totally disappear, since, by the contraction of the arteries and capillaries occuring after death, the blood is more or less expelled from them. Hence, capillary hyperæmia which existed during life cannot always be discovered in the dead body, unless the examination has been made at a very early period. This morbid change is most frequently and beautifully observed in hot climates, where the examination is generally made a few hours after death.

On the other hand, *venous hyperæmia* may increase or originate after death, since the blood contained during life in the arteries and capillaries leaves them with the post mortem contraction of these vessels, and passes into the veins furnished with more yielding walls.

To cases of hyperæmia which arise after death (cadaveric hyperæmia, hypostases) also belong those compounded of capillary and venous hyperæmia, which, after the cessation of the circulation, arise according to the laws of gravity; since the blood of a part whose capillaries are connected, gravitates to the lowest portions of it, and there gorges the capillaries and veins. Such a cadaveric hyperæmia, like venous hyperaæmia occurring during life, may when of long continuance result in serous dropsy.

Cadaveric hyperæmia arises with the greatest facility in organs whose capillary vessels are very large, and therefore present the most favourable conditions for a subsidence of the blood within them according to the laws of gravitation and capillarity. It must be also presumed that the capillaries are open, and connected at very many points. Consequently this species of hyperæmia occur by far most frequently in the lungs, whose capillaries not only anastomose abundantly together, but are also very large; cadaveric hyperæmia combined with more or less serous dropsy (œdema) is found in the majority of subjects, either in the posterior or lower part of the lungs, according to the position of the body. Cadaveric hyperæmia is found in a less degree in the skin, (some of what are termed *death spots* belong to this class), and in the intestinal canal, where the capillary vessels are connected throughout the whole organ, although not with such numerous and extensive anastomoses as in the lungs. Between parts which are not directly connected by capillary vessels, but only by means of larger vascular trunks, as between the heart and the lungs, the lungs and costal pleura, &c., cadaveric hyperæmia never occurs.

In cadaveric hyperæmia, it is moreover presupposed that the blood is fluid: the more liquid it is, the more easily does it take place. The intensity depends on the quantity of blood which the organ contains at the moment of death. It is, accordingly, more considerable in a hyperæmic, slighter or quite absent in an anæmic part. It is possible that such cadaveric hyperæmia may commence in the last moments of life, when the force of the circulation has become generally and locally so weakened that it can no longer counteract the influence of gravitation upon the blood: this especially applies to the lungs.

To these changes in the distribution of the blood are allied various modifications of the blood itself, which are at present very little understood, with respect to their chemical nature. The most important of them may at present be characterised as *a solution of the blood-corpuscles*, (that is of their colouring matter), which is observed in rare cases during life (see p. 97). In consequence of this, a *red plasma* is conveyed into the tissues whence is frequently produced the semblance of a capillary hyperæmia (constituting another division of the *death spots*). The precise chemical changes of the blood which effect the solution are unknown, for although, as commonly happens, they are properly referred to decomposition or putrefaction, yet this is in reality no explanation of the change.

A true explanation would consist in a demonstration of the special chemical cause which produces the solution of the blood-corpuscles. This proof is still wanting, although in many cases the solution can be referred with great probability to the generation of carbonate of ammonia in the blood. The diagnosis of this state, as was formerly mentioned, rests on microscopic examination, which shows that the blood-corpuscles have disappeared and their pigment been dissolved in the liquor sanguinis.

As a second change of the blood, which is accustomed to take place in the dead body, although not until a later period, we must mention a re-solution of the blood which had coagulated after death: this, likewise, is probably due to the formation of carbonate of ammonia.

To these may be added other changes (commonly called putrefactive phenomena) that usually commence in the blood, but are not confined to it, extending to other parts of the body. Such are various phenomena which, for the most part, have been already described in their appropriate sections, as *evolution of gas* and *softening* in different parts of the body, *increase of volume* of certain parts from gaseous distension or infiltration of fluids, *changes of colour* independent of the above mentioned imbibition of hæmatin, namely pseudo-melanosis from decomposition of hæmatin or the formation of sulphuret of iron, and green colorations, depending partly on imbibition of the colouring matter of the bile, and partly upon other unknown causes active in putrefaction.

We must also here include the *rigor mortis*, or *death-stiffening*, which as the animal heat disappears, invades all contractile parts of the body—the muscles of voluntary and involuntary motion, fibrous tissues, &c.

Parasitic plants and animals may also appear in the body after death, and are therefore so far to be noticed amongst cadaveric changes.

From these statements it will be perceived how cadaveric changes may partly efface certain pathological alterations, and partly simulate them; and consequently how important it is to be upon our guard against being deceived by them in the examination of the dead body.

The cadaveric changes above described are the most important of those which usually ensue during the first days after death. At a later period they are so considerable that the examination of the body is of no use in leading to a correct recognition of pathological relations. The alterations which then occur, fall within the province of forensic medicine, and do not require any further explanation in this place.

Some of the changes subsequently occurring, and which are of the greatest importance to forensic medicine, are fully discussed in the following works:

A. Devergie, médicine légale, and

Orfila, traité sur les exhumations juridiques, to which I therefore refer.

EXPLANATION OF THE PLATES.

PLATE I.

Contains illustrations of the different forms of cells occurring in the development of morbid epigeneses.

FIG. 1. Is an ideal figure, illustrating the formation of a cell. In an amorphous substance (A A), the *cytoblastema,* lie three ideal cells, (B, C, D). The cell B appears oval; we distinguish in it a clear ring with a very distinct external and internal contour (x x), the *cell-wall;* in the interior of the ring, an elliptical body (z) the *nucleus* or *cytoblast;* and in it, two round dark corpuscles, the *nucleoli.* The space between the cell-wall and nucleus, the *cavity of the cell,* is filled with a fluid which escapes observation.

The cell C is round; here we observe an evidently distinct cell-wall, and an equally clear nucleus, with a single nucleolus in the centre; the cavity is filled with dark granular matter.

The cell D is likewise round, and exhibits a clear cell-wall, with a more evident internal and external contour. The nucleus does not lie in the centre of the cavity, but on its circumference, on the inner surface of the wall, and contains distinct nucleoli. The contents of this cell are granular in the vicinity of the nucleus, but fluid and invisible in the remainder of the cavity.

FIG. 2. A. Is a cell from encephaloid, occurring in the knee-joint.
B. Cells from pulmonary tubercles. Magnified 220 diameters.

These cells are perfectly round, and we distinguish in them a tolerably thick transparent cell-wall, and dark granular contents. Here there can be no doubt as to the granular mass being actually in the interior of the cell, in the cell-cavity. At A there are also separate granules on the outer circumference of the cell-wall; we see an undoubted pale nucleus with a nucleolus in the upper part of the cell-cavity; in the cells B, the nuclei are not evident.

FIG. 3. A. Are cells from the substance of pulmonary tubercle.
B. Cells from the expectoration in pneumonia. Magnified 220 diameters.

These cells also appear granular, but we cannot decide with certainty whether the granular mass is in the interior of the cells, or whether it is situated on the exterior of the cell-wall.

FIG. 4. Very pale non-nucleated cells (?) of an indefinitely oval form, from the contents of an encysted tumour. Magnified 220 diameters.

Fig. 5. Cells with two nuclei, magnified 220 diameters. *a*. an oval cell from encephaloid affecting the knee-joint. *b*. a cell of irregular form from the liver (normal hepatic cell).

Fig. 6. Cells containing many nuclei in their interior, from encephaloid of the uterus. Magnified 220 diameters.

Fig. 7. Large cells, in the interior of which there are smaller but perfect cells, (parent-cells with young cells,) from encephaloid of the bladder. Magnified 220 diameters. The cell A is complete; B is the mere outline.

Fig. 8. Cells containing yellow pigment (bile-pigment) from a diseased liver. Magnified 220 diameters.

Fig. 9. Cells containing fat, from a fatty liver. Magnified 220 diameters. The fat-globules are very small in some; in others they are larger and more distinct.

Fig. 10. Cells containing black granular pigment from a lung compressed by empyema. Magnified 220 diameters.

Fig. 11. Nucleated cells of very irregular form, from encephaloid of the stomach. Magnified 220 diameters.

Fig. 12. Very elongated caudate nucleated cells. A, from a semi-organized exudation in the pulmonary pleura. B, from a newly formed sac, attached to the pulmonary and costal pleura, and containing a fluid of the same chemical composition as the serum of the blood. Magnified 220 diameters.

In A and B the cell becomes gradually thinner and is finally elongated to a mere thread; in B *b*, several such cells are united by their pointed extremities, and form a single varicose fibre.

Fig. 13 and 14 demonstrate the origin and growth of cells in morbid products. Magnified 220 diameters.

Fig. 13. Represents different parts of a tuberculous lung. At A we perceive the earliest perceptible stage of the disease; many nuclei with or without nucleoli, in an amorphous cystoblastema. At B the cytoblastema is consumed, and we can only trace a mass of nuclei lying closely on one another. C represents nuclei around which a pale soft cell-wall is already formed. At D there are wholly developed cells.

Fig. 14. Shows portions of a scirrhous testicle. At A we see a firm amorphous cytoblastema, in which distinct cells are being developed; most of these exhibit an evident nucleus, while in some, the cell-wall merging into the cytoblastema, appears like a broad, clear ring. At B the cells are more evident, and more distinctly separated from the cytoblastema.

PLATE II.

INFLAMMATION, FIBRINOUS EXUDATION, AND THEIR DEVELOPMENT.

FIG. 1. A piece of inflamed mucous membrane from the trachea of a young man who died from *febris mucosa*. The respiratory mucous membrane was especially attacked by the disease; during life there had been difficult respiration, *rhonchus sibilans* in both lungs, and moderate expectoration, containing pus and mucus streaked with blood.

On dissection, the mucous membrane of the trachea was found to be much reddened; the colour passing into a violet tint, but on exposure to air soon changing to a clear red. (A) exhibits a piece of this mucous membrane, as it appeared to the naked eye.

Seen under a power of 220 diameters, normal ciliated epithelium was visible, the separate cells being for the most part rubbed off, so that the surface of the mucous membrane appeared free. (B) shews the free surface of the mucous membrane after the epithelium had been removed. Magnified 220 diameters. We saw a very thick vascular network, the vessels having a larger diameter than usual, and being entirely filled with stagnant blood, which was, however, still fluid, and flowed from them on pressure. On examining this expelled blood, the blood-corpuscles were seen to be little changed in their form; they were more globular than usual, and had lost the cup-like depression in their centre (Fig. 1, **). The vascular reticulations were so close, that they in some places entirely covered the parenchyma of the mucous membrane; and where the latter is visible, it was colourless, or of a faintly brown tint, and had the usual appearaace of normal mucous membrane.

FIG. 2—5 illustrate different stages of development of effused and coagulated fibrin. Magnified 220 diameters.

FIG. 2. Fibrinous exudation after bronchitis, in the earliest stage of organization.

A strong and otherwise healthy man, aged forty-one years, was attacked with acute bronchitis in consequence of exposure to severe cold and wet. There was cough, sharp pain on inspiration, hoarseness, and expectoration, at first moderate, but afterwards very copious, forming a thin yellowish fluid, which shewed under the microscope an immense number of pus-corpuscles; on auscultation little respiratory murmur was heard, but general mucous *rales*. Membraneo-gelatinous masses were mixed with the expectoration, which was copiously charged with pus, and thrown off to the amount of five or six ounces in the twenty-four hours.

A mass of this kind of the size of a hazel nut appeared entirely homogeneous, yellowish, and in places of a rusty tint: it resembled stiffening glue, but admitted of being drawn asunder, and divided into membranous layers. These layers formed perfect membranes and appeared entirely structureless and like coagulated fibrin—shewing neither granules or fibres (Fig. 2 A). The mass was opaque in the centre, and of a bluish yellow tint; but transparent and almost colourless at the edges.

Acetic acid rendered it more transparent; nitric acid, and ammonia did not affect it; but caustic potash rendered it more transparent, and softer, without entirely dissolving it. It did not dissolve when boiled with concentrated hydrochloric acid, the colour of the acid as well as that of the membrane remaining unchanged even after prolonged ebullition.

In some places this amorphous mass contained roundish, very pale, colourless bodies (Fig. 2. B, cells ?) They varied from the 100th to the 60th of a line, and contained no nuclei—the first traces of cellular formation.

Fig. 3. An unorganized coagulum of fibrin from the heart of a man aged fifty-six years—constituting false polypus of the heart.

Both ventricles contained thick coagula of a white colour, which were closely combined with the *columnæ carneæ*, and could only be separated piecemeal with great difficulty. The observation of the progress of the disease rendered it probable that these coagula had been formed about ten days before death, while the patient remained for several hours in a state of syncope, without any evidence of a pulse. The coagulum in the left ventricle was very thick and firm, of a faint red colour; in the interior it was soft, being saturated with a yellowish white fluid, which was declared to be pus by the physicians in attendance.

Under the microscope the coagulum appeared as a perfectly structureless mass, which was covered by a large number of globules and granules of fat: it contained no trace of cells. On the application of acetic acid, the amorphous mass became very pale, and so translucent as almost entirely to escape observation; but even then no traces of nuclei or of commencing organization were visible. The fatty parts were not changed by the acid. The supposed pus in the interior contained no pus-corpuscles, but simply many globules and granules of fat in a colourless fluid.

The same was the case with the coagulum in the right ventricle.

FIG. 4. Exhibits fibrinous exudation in the act of development, from the *arcus aortæ* of a man who had died from inflammatory hypertrophy of the heart with deficient action of the valves.

The *arcus aortæ* was externally reddened and covered with coagulated exudation, which was of a yellowish white colour, soft, saturated with a yellowish white thickish fluid smooth and fatty to the touch, and formed irregular portions of tolerable thickness.

Under the microscope the exudation appeared like an amorphous mass of an indefinite fibrous character (FIG. 4. A). It became paler and more transparent on the application of ammonia, as well as of acetic acid.

This amorphous mass contained a large number of cells of round, or roundish shape, varying from the 200th to the 100th of a line in diameter, and, for the most part, pale and without evident nuclei. There were, however, a tolerable number of little roundish granules, but it was impossible to determine with certainty, whether they were contained in the interior of the cells, or whether they were situated on their exterior. These granules were not affected by water, common spirit of wine, caustic ammonia, caustic potash, or acetic acid, but dissolved in ether, in which they united and formed large fatty globules: they consisted, therefore, of fat.

The cells became paler and gradually disappeared on the addition of ammonia, which also rendered the amorphous exudation paler, and, by prolonged application, softer, and more fibrous. In some parts of the exudation the cells preponderated, in others, on the contrary, the amorphous stroma. No free fat appeared in the exudation.

The pus-like fluid expressed from the mass showed under the microscope many isolated cells B, which were precisely similar to those contained in the exudation; behaving in the same manner towards chemical agents.

FIG. 5. Fibrinous exudation in the act of development, from an inflamed lung.

The patient, a coachman aged forty years, addicted to drinking, entered the hospital at Munich, with all the symptoms of inflammation of the right lung. Fever with hard full pulse, severe pain on breathing, oppression at the chest, and cough with sanguineous expectoration. In the lower part of the right lung the respiratory sounds could not be heard, but crepitation was distinctly audible. On the seventh day of the disease the local symptoms yielded to an antiphlogistic treatment—venesection and the internal use of large doses of tartarized antimony. The sounds on percussion continued to be dull, but instead of the crepitation there was a loud mucous rattle, and the expectoration became more copious. This was succeeded by a general prostration of strength, the pulse was more frequent—small and weak; there was great distension in the region of the stomach, vomiting, and death.

On dissection there was fatty degeneration of the liver in an advanced stage.

The lower part of the right lung (the middle and lower lobes) was thickened, of a grayish red colour, which gradually became of a bright red on exposure to the air, and exhibited a granular appearance, when cut: it did not crepitate, and sank in water.

The fluid from the thickened part of the pulmonary tissue was not frothy: it exhibited no air under the microscope, but a good many unchanged blood-corpuscles, and numerous pale cells varying from the 200th to the 100th of a line, some of which contained nuclei with or without nucleoli, and others a granular mass in a larger or smaller quantity, (Fig. 5. A B). The cells appeared sometimes isolated as at A, sometimes united, in groups as at B. By the cells, fibrinous coagula of grape-like, or simply globular shape were seen, which in form and size corresponded with the air-cells of the lung. These coagula, when examined under the microscope, were seen to consist of an amorphous mass (C) which contained cells filled with granules, and likewise isolated granules. The fibrin was here in the act of being converted into granular cells.

Larger portions of the thickened tissue of the lung appeared under the microscope (Fig. 5. D) as an indistinct granular mass with very many small granules, and roundish granular heaps from the 200th to the 100th of a line in diameter—granular cells. In some parts of the pulmonary tissue, the amorphous fibrinous exudation preponderated, while in others it was almost entirely converted into granular cells.

PLATE III.

PUS AND GRANULAR CELLS.

The three first figures exhibit normal pus from abscesses of the cellular tissue. Magnified 410 diameters.

Fig. 1. Shows pus-corpuscles (*a*) dark and compact, and covered with numerous granules. Besides the pus-corpuscles, we see many smaller granules (*b*) partly isolated, partly united. They consist of fat—a mixture of olein and margarin.

Fig. 2. Also normal pus, showing very soft, pale pus-corpuscles, which do not appear perfectly round, and are only covered by a few granules. At (*b*) we see the nucleus appearing through the delicate capsule. This pus contains no fat granules.

Fig. 3. Pus-corpuscles treated with acetic acid.

The acid has more or less completely dissolved the walls, and only left the nucleus remaining. At *a* we see a triple, at *b* a single nucleus, still surrounded by the faint remains of a wall. At *c* and *d* the wall is quite dissolved and the mere nuclei remain. The cup-like form of the nucleus on treating it with acetic acid, is the one common to normal pus-corpuscles.

Fig. 4. Supposed pus (magnified 220 diameters) from the pelvis of the kidney of a patient, who died of empyema.

The pelvis of each kidney was completely filled with a yellowish white creamy fluid, which bore a perfect resemblance to pus: but on examination under the microscope nothing could be seen but portions of epithelium mixed with a colourless fluid (urine); *a*, a portion of epithelium varying between the cylindrical and pavement forms; *b* a single epithelial cell of this kind; *c* cylindrical epithelium seen from one side; *d* a portion seen from above.

Fig. 5. Exudation in the act of conversion into pus: from the pleural sac of a patient who died from empyema.

In the pus discharged from the pleural sac, there were several concretions varying from the size of a pea to that of a nut, of a whitish colour and admitting of being easily torn. When examined under the microscope, they were found to consist of an indefinite fibrous mass, enclosing numerous pus-corpuscles. These fibres were observed crossing each other in every possible direction. On the addition of acetic acid the fibrous mass entirely disappeared, leaving nothing but the nuclei of the pus-corpuscles. The whole substance, including the corpuscles, was entirely soluble in caustic potash. Magnified 220 diameters.

Fig. 6. Exhibits the formation of pus in mucous membranes. In the fluid cytoblastema which is secreted, we observe the nuclei first produced, and around them the capsules gradually forming. Magnified 220 diameters.

A girl suffering from empyema, suddenly commenced to expectorate very abundantly—in fact, to the amount of several pounds daily. It was perfectly fluid, creamy in appearance, and of a whitish yellow colour. Under the microscope there were seen (A) a very few perfect pus-corpuscles (*a. a*), which were very delicate and pale, while there was an increased quantity of nuclei of pus-corpuscles—single, double, and triple (*b. b. b*). On the addition of acetic acid there was a slight coagulation of mucus (see the lower portion of fig 6); the nuclei of the pus-corpuscles underwent no change, but in those corpuscles which were perfectly formed, the capsules became, as usual, transparent, and the nuclei became visible(**). They had not the ordinary cup-formed shape, but had an indefinite roundish appearance.

Similar appearances present themselves in all mucous membranes, in which there is a copious secretion of pus.

Fig. 7—11. Various forms of abnormal pus.

Fig. 7. Scrofulous pus, magnified 410 diameters.

The pus was obtained from a swollen cervical gland of a young man, with a well-marked scrofulous diathesis. It had a viscid appearance, was white, and, as is generally the case with scrofulous pus, contained numerous whitish clots. The corpuscles of this pus (A) deviated from the normal form; they were smaller than usual, (averaging from the 400th to the 300th of a line,) irregularly roundish, rough, pointed, and almost angular. They disappeared on the addition of acetic acid, but the characteristic nuclei (B) did not make their appearance. The acetic acid coagulated a considerable amount of a viscid matter (pyin ?) which enclosed the corpuscles, and formed clumps of them (C). A solution of alum acted in a similar manner. The clotted, caseous matter in this pus, exhibited, in addition to pus-corpuscles, stellar or striped portions of amorphous appearance, which were rendered transparent by acetic acid, and could no longer be detected by the eye (exudation not yet organized).

Fig. 8 and 9. Pus from abscesses in the cutaneous glands. Magnified 220 diameters.

Fig. 8. Pus from a small abscess on the inner surface of the root of the nail of the second toe of a healthy man.

The pus which was evacuated by a puncture amounted to only a few drops, and was very thick. When examined under the microscope, there were observed not only pus and blood-corpuscles, but also modified epithelial cells (A), which varied in diameter from the 75th to the 100th of a line, and were partly round (*a b c*), and partly oval (*d*). Some consisted of a large dark nucleus varying from the 110th to the 180th of a line, surrounded by a transparent capsule (*a*), while others exhibited a clear nucleus and nucleoli in a dark capsule (*b—d*).

On the addition of acetic acid, the pus-corpuscles underwent the ordinary change, the larger corpuscles being rendered paler and more transparent (B). There was also an abundant coagulation of mucus (pyin ?), forming a delicate membrane.

Fig. 9. Pus from a minute abscess in one of the cutaneous glands in the nose of a healthy man.

Under the microscope the fluid was seen to contain a very large number of pus-corpuscles, most of which were perfectly round, and exhibited no nuclei (*a*). They were very unequal in size, varying from the 170th to the 300th of a line in diameter; the average diameter was the 250th of a line. Many were united in a tesselated manner, forming a species of membrane; hence they were somewhat angular (*b. b*). These appeared to be extremely delicate. Amongst them were a few non-nucleated epithelial cells (?) of which some were granular (*c*), but the majority exhibited a smooth surface (*d*); these were united so as to form membranous patches. On the addition of acetic acid the pus-corpuscles underwent the ordinary change (B), while the epithelial cells were unaffected. Moreover the acid coagulated a viscid mass, which enclosed the pus-corpuscles and epithelial cells.

Fig. 10. Abnormal pus from the lung of a person who died from typhus.

The lung was very dense and hepatized; it sank in water, did not crepitate, and on making a recent section, exhibited a dark violet tint. It appeared, on making a microscopic examination, that it contained no air, but much blood; when this was removed by washing, the pulmonary tissue appeared to be everywhere filled with pus. The corpuscles of this pus (A and B) deviated in some respects from the ordinary type; their form was more irregular than usual, they were not perfectly round, many of them being elongated, and some a little angular; their margin was for the most part very sharply defined, and their surface not so granular as usual. In size they varied from the 500th to the 150th of a line. On the addition of acetic acid they underwent the ordinary change; their capsules became transparent, and as they gradually disappeared, the nuclei came in view; they did not, however, exhibit the ordinary cup-shaped form with any distinctness (C and D). Ammonia entirely dissolved both capsules and nuclei. A, B, and C are magnified 220, and D 410 diameters.

Fig. 11. Pus from what is called a cold abscess on the right shoulder of a vigorous young man. Magnified 220 diameters.

The pus which was discharged amounted to about two ounces; it consisted of a rather thin, pale yellow fluid, and delicate thready flocculi of a yellow tint; hence it differed essentially from good creamy pus. It had a strongly alkaline reaction.

The microscope revealed the presence of pus-corpuscles, almost all of which were transparent and delicate, with a distinct margin; and some slightly, others not at all granulated. In some the nucleus could be seen through the capsule (A). On the addition of acetic acid there was an abundant coagulation of an amorpho-fibrous character; and on the addition of alum there was an abundant coagulation of a granulo-amorphous character (pyin?)

The yellow filamentous flocculi which were swimming in the fluid consisted of accumulations of minute and imperfectly formed pus-corpuscles, which were connected in irregular groups by an indistinct granulo-fibrous medium of communication. On the addition of acetic acid, this combining tissue became somewhat paler, without, however, disappearing; and numerous fat-granules came in view. Ammonia produced little effect on this granular matter.

Fig. 12—15. Granular cells (Gluge's compound inflammatory globules, exudation-globules), magnified 220 diameters.

Fig. 12. Elucidates the development of granular cells. All the cells in this figure were obtained from the same inflamed lung. At first we perceive the granular cells as simple cells without granules,

with decided nuclei and nucleoli (*a. a.*) These cells are for the most part round, but sometimes elongated or even angular. Their size varies from the 300th to the 100th of a line. We afterwards observe these same cells more or less covered with minute granules, varying in size from the 800th to the 1500th of a line. At first (in *b. b.*), as long as the granules are only sparingly present, it is difficult to distinguish whether they are on the surface or in the interior of the cells.

Finally, when the whole cell is filled with granules, the nucleus cannot be discovered (*d*), and it can no longer be doubted that the whole of the interior of the cell is filled with granules. These granules appear to consist of fat.

FIG. 13. Perfectly developed granular cells from inflamed lungs. A. from the lung of a man who died from pneumonia. The lung was in a condition of red hepatization. B. from the lung of a girl who died from pleuritic effusion. The left lung was very much compressed by the effused fluid, was of a brownish colour, contained no air, did not crepitate, and sank when placed in water. Under the microscope its tissue appeared unchanged, except that an immense number of granular cells were deposited in it.

FIG. 14. Granular cells in the act of breaking up, and their remains. When the granular cells have attained their full development, the cell-wall disappears, and the granules contained in the interior are liberated, and form larger or smaller heaps.

The granular cells in this figure were obtained from the lungs of an aged woman who died from pneumonia. The right lung was dense, red, hepatized, and contained no air. Under the microscope, the whole pulmonary tissue appeared filled with these cells, in various stages of disintegration.

FIG. 15. Granular cells from an inflamed and softened liver.

FIG. 16. The *corps granuleux* or *colostrum-granules* of the milk, obtained from the duct of an extirpated scirrhous breast. Magnified 220 diameters.

They are given in this Plate, since, from their similarity, they might be mistaken for granular cells.

PLATE IV.

EPIGENESIS OF AREOLAR TISSUE AND ORGANIC MUSCULAR FIBRE.

Fig. 1. Newly formed areolar tissue, in various stages of development, from a false membrane in the pleura.

A young man was attacked with inflammation of the right pleura, which was succeeded by very considerable empyema. As the difficulty of respiration was so great as to threaten daily suffocation, *paracentesis thoracis* was had recourse to, by which a very considerable amount of fluid was discharged. The fluid coagulated spontaneously, and had the same chemical composition as the plasma of the blood. It was again formed with such rapidity, that the operation had to be twice repeated. Soon after the last operation (on which occasion the fluid did not spontaneously coagulate, but was a mere admixture of serum with a little pus), the patient died.

On dissection, the right pleura was everywhere invested with a false membrane, which formed a shut sac, containing a yellowish serum with a deposit of blood-corpuscles. This membrane varied in thickness from half a line to a line; when examined under the microscope, it was found to exhibit traces of more or less advanced organization. The most recent layer, lying next to the pleural cavity, was partially fibrous, and contained many nuclei (A), together with numerous globules and granules of fat. On the addition of ammonia it became pale and transparent, the fatty granules being the only element unaffected by this re-agent. The mass that presented itself after the removal of the most recent layers, consisted of irregular, for the most part elongated, membranous particles (cells, B), containing one or more nuclei. Some of these cells were very irregular and composite (B. *a.*), while others had the ordinary form of the caudate, fusiform, fibrous cells of areolar tissue (B. *b.*)

Acetic acid produced a paleness and transparency of the walls of all these cells without altering their nuclei.

In the older layers adjacent to the pleura, the development of the fibrous cells of areolar tissue was still further advanced. The cells were much elongated, and sharp at the two extremities, but still retaining the nucleus (C.) Other cells (D) formed parallel fasciculi of the fibres of areolar tissue, in which the nuclei were apparent. On the addition of ammonia, both the fibres and the nuclei gradually disappeared.

Fig. 2. Areolar tissue, in part fully developed, and in part immature, from a false membrane from the pleura of another man, a muscular agricultural labourer, aged thirty-three years, who was attacked with pleuritis of both sides, and after six weeks maltreatment at the hands of a quack, was brought in a moribund condition into the Munich Hospital.

On dissection, the pleural cavity on each side was invested throughout with a layer of solid exudation, varying from one to two lines in thickness.

Shreds and flocculi were attached at various spots to the inner surface; they were of a yellow colour, and their formation was obviously of the most recent date. They were soft, resembling coagulated and washed fibrin, and formed irregular patches, of varying thickness. Under the microscope they appeared perfectly amorphous, but at some spots exhibited a slightly fibrous structure. On the addition of acetic acid they softened, became transparent and gelatinous: they showed no trace of organization.

The older portion of exudation, lying directly in contact with the pulmonary and costal pleura, formed a regular layer, of tolerably equal thickness, which, with careful dissection, admitted of separation into several strata. This portion was not so soft as that previously described, but was almost cartilaginous, and did not assume a membranous form. It exhibited indications of organization in proportion as the exudation approximated to the surface of the pleura, or in other words, in proportion to its age.

The organization consisted in the formation of cells and in their conversion into fibres (Fig. 2.) The younger cells were fusiform, with a distinct nucleus (*a*.) Other cells, in a more advanced stage of development, consisted of thin parallel fibres, and formed a fasciculus of fibres of areolar tissue with nuclei (*b*.)

In the layer of exudation in contact with the pleura, these cells undergoing conversion into fibres, were compressed on one another (*c*.), and the newly formed areolar tissue could only be distinguished from the normal areolar tissue of the pleura by its less marked fibrous character, and by the presence of many nuclei. The nuclei were roundish, oval, caudate, or oat-shaped; some contained nucleoli, others were devoid of them. In no place could their elongation into fibres be observed. On the addition of acetic acid, these newly formed fibres of areolar tissue became pale, and gradually disappeared; the nuclei remained unaffected.

FIG. 3. Illustrates the epigenesis of organic (involuntary) muscular fibre. The structures depicted are primary cells from a fibrous tumour in the uterus. They represent, in all probability, the earliest stage of the development of organic muscular fibre; and it is only very rarely that we have an opportunity of observing them. The following is the history of the case.

A female servant, aged forty-four years, was admitted into the Munich Hospital on account of severe abdominal pains. Her statement was, that for several years there had been a fluctuating tumour on the right side of her abdomen, but which had never hitherto caused her further pain or uneasiness than an occasional sense of weight or bearing down, as if in labour, until just before admission, when there had suddenly occurred in it most intense pain, with tenderness on pressure. In defiance of the most energetic treatment—venesection and palliatives—this pain rapidly grew worse, and the woman died on the third day after its first occurrence.

On dissection, the following appearances presented themselves. The right side of the great omentum was considerably thickened, and inseparably united on the one hand with the walls of the abdomen, on the other with a firm tumour, which extended downwards into the cavity of the pelvis, and was of about twice the size of a man's fist. The surface of this tumour was somewhat tuberculated, and of a whitish colour. It was intimately connected with the fundus of the uterus. The upper part of this tumour had began to soften, and its substance was here and there hollowed out into irregular excavations, which were traversed by bands and shreds of tissue, soft and friable externally, but tolerably firm in their interior.

These excavations were partly empty, partly filled with small grumous masses of blood, or with a greasy, grayish-white, purulent-looking matter. The softening which was going on in this tumour had at one part approached quite to the surface, burst, and a portion of the softened matter had escaped into the cavity of the peritoneum, inducing secondary peritonitis, from which had resulted the sudden severe pain, so speedily followed by death.

The inner surface of the uterus was healthy, its mucous membrane being unaltered; but within its cavity was situated a roundish tumour, about the size of a billiard-ball, tolerably firm, of a bluish-white colour, and covered on its surface with a yellowish purulent-looking matter. It lay quite free in the cavity, having no connection, at any part, with the walls of the uterus. The parietes themselves were very thick; the degree of their thickness, however varied, being in some places as much as three inches. Imbedded within their substance were found numerous roundish tumours, of all sizes, from that of a pea, to that of a billiard-ball. These tumours, for the most part, lay free, or at least so nearly free, that they could be separated without any difficulty from the substance of the uterus, within which they were imbedded; they were of a whitish colour, very firm in texture, and of a globular form, though most of them were irregularly tuberculated and nodular. When cut into, each tumour was found to consist of a firm, compact, polished, white tissue, but with the naked eye no trace of a fibrous or other well-marked structure could be discerned. In the vaginal portion of the uterus was situated another tumour, about the size of a pigeon's egg, somewhat soft in consistence, and inseparably connected with the substance of the organ; it had a whitish colour, and when cut into was found to be made up of a fibrous net-work, the areolæ of which were large, and filled with a thick albuminous fluid.

A careful microscopic examination of the several parts described above, furnished the following results. The substance of the uterus was composed of its usual organic muscular fibres, from the 150th to the 300th of a line in diameter. Here and there, between these fibres, were scattered numerous granular cells, of a dark brownish colour such as are depicted in Plate III. fig. 12—15. The tumour, which was situated within the cavity of the uterus, presented a structure almost exactly similar to that of the uterus itself, being made up of fibres closely resembling those peculiar to organic muscle, and containing also the same dark-looking granular cells noticed between the fibres of the uterus. Similar characters were also presented by those tumours, both large and small, which were imbedded within the parietes of the uterus. The softened mass at the upper part of the large tumour, which was situated outside the uterus, contained, besides small grumous masses of blood and separate blood-corpuscles, numerous pus-corpuscles, the presence of which justified the supposition that the softening of the tumour was the result of inflammation. The usual changes were produced on these pus-corpuscles by the addition of acetic acid, namely, the gradual disappearance of the cell-wall of each, and the coming into view of its double or triple nucleus; the nuclei were left entangled in a coagulum formed by acetic acid, and consisting of a perfectly amorphous structureless mass, resembling coagulated mucus (pyin ?). The bands and shreds of tissue which traversed the excavations in this softened part, exhibited beneath the microscope the remains of areolar tissue, which had resisted the process of softening and destruction. The soft tumour situated in the vaginal portion of the uterus, seemed to be a fibrous tumour in the process of formation; for the fibrous portion consisted of organic muscular fibre and areolar tissue, and the albuminous fluid which filled up the meshes, exhibited, under the microscope, numerous roundish or oval cells, some single, others arranged in groups, containing nuclei and nucleoli, (see FIG. 3.); these were, in all probability, primary cells, which would eventually have become developed into organic muscular fibres.

Several of the other tumours contained in the substance of the uterus, were carefully removed, cut into small pieces, and after being repeatedly washed, were subjected to several chemical tests. They gradually dissolved in boiling concentrated hydrochloric acid, forming a colourless solution. In acetic acid they swelled up, became transparent and gelatinous-looking, but a complete solution was not effected even after the lapse of some weeks. Several pieces from these tumours, after being repeatedly washed and dried with blotting-paper, were weighed, then thoroughly dried in a water-bath, at a temperature of 212° F., and again weighed. Of 1000 parts of the fresh substance, there remained, when thus thoroughly dried, only 220; consequently 780 parts consisted of water and other matters, volatile at a temperature of 212° F.

FIG. 4. Newly-formed organic muscular fibre from the hypertrophied muscular coat of the intestine of a man who died from peritonitis. The muscular coat at the commencement of the cæcum was a line in thickness.

A. Is a thin section made by the double knife, as seen under the microscope. We observe parallel fibres with nuclei.

B. Are individual fibrous cells in the course of development into muscular fibres.

C. Is a very thin section treated with acetic acid; the fibres are very pale, and the nuclei are distinctly visible.

PLATE V.

EPIGENESIS OF BLOOD, BONES, NERVES, AND SEROUS MEMBRANES.

The Figures from 1 to 4 illustrate the pathological epigenesis of of blood in the adult. The following case will serve as an illustration.

A young man, aged twenty years, suffered from encephaloid of the left arm, which slowly developed itself, and finally ulcerated. Repeated hæmorrhages rendered amputation necessary. The amputated part could not be obtained for microscopical examination. About ten days after the amputation, fungoid growths, which came from the medullary cavity of the bone, appeared. When removed, they were of a whitish-yellow colour, soft, fatty, and anæmic. When examined under the microscope, they were found to consist of areolar tissue in the act of development, (granulations).

Two days subsequently, on renewing the bandage, another growth from the medullary cavity of the bone, of precisely similar appearance, was observed It was as large as a cherry, and externally brown, (being discoloured by the liniment, *ex. pulv cort. chinæ*), and shrivelled, and internally of a yellowish-white, lardaceous appearance. Its consistence was so soft and mellow, that it could easily be broken off by the finger without the assistance of any sharp instrument. It had sprouted from the medullary cavity of the bone.

Under the microscope, it appeared throughout as a granulo-amorphous mass, which, on the addition of acetic acid, became pale and transparent. It was almost wholly unorganized, only exhibiting at a few spots traces of cells, partly of indefinite form, and partly elongated, (the fibrous cells of areolar tissue).

A recent section of the mass (Fig. 1. left side) showed many small points and streaks of blood. These small portions of blood in the midst of the mass, without any connection with the vessels of the bone, must necessarily, from their place and position, have been formed there, and promised to afford some elucidation of the morphology of the formation of the blood, which can so seldom be directly observed. The result of a careful examination was as follows.

All the newly formed portions of blood were very large, and visible even to the unaided eye, as streaks or points; where the naked eye discovered no blood, none was to be seen under the microscope. It seems, therefore, that the larger and not the smallest capillary vessels are first formed.

The form of these masses of blood varied considerably, being sometimes roundish, or quite indefinite (Fig. 1.), sometimes elongated (Figs. 3 and 4), while at other times, several portions were united together in a star-like figure (Fig. 4). The masses of blood were not definitely circumscribed, and gradually lost themselves in the parenchyma; there were not as yet formed any proper vessels of uniformly equal diameter, and distinct vascular walls were still wanting. It is only in Fig. 4 that there is any indication of a distinct separation of the vessels from the parenchyma. The colour of the blood was even now red, varying from a pale yellowish red where it was thin and dispersed, to a dark red where the mass appeared more closely arranged. The blood was fluid, and could be pressed from the parenchyma; it shewed also clearly defined blood-corpuscles, which lay partly scattered separately in the parenchyma (Fig. 1), and partly collected in larger masses (Fig. 3 and 4); the former was rarely observed. There was no evidence of a development of these accumulations of blood-corpuscles in common cells, (vascular cells).

The individual newly formed blood-corpuscles (Fig. 2), were somewhat smaller than common; their diameter was the 600th, the 500th, or at most, the 400th of a line, and they had not the usual cup-like central depression, but were irregularly spherical and angular. Sometimes they appeared separate, sometimes several were united together. On the addition of water, they became pale and gradually disappeared; the same thing occurred, but more rapidly, with acetic acid. There was no trace of nuclei.

This blood had evidently originated in the interior of the parenchyma (plastic exudation), and at first in portions which corresponded with the future larger vessels. It had not been formed in vascular cells, but free in the parenchyma, and appeared earlier than the vessels. It was formed sooner and more rapidly (in less than two days), than any of the tissues, even earlier than the areolar tissue.

FIG. 1. On the left hand shows a recent section of the fungoid growth in its natural size, with distinct points and streaks of blood.

FIG. 1. On the right hand, exhibits newly formed blood-corpuscles, partly separate, and partly united in groups, scattered in the parenchyma. Magnified 220 diameters. *a.* blood-corpuscles; *b.* fat-globules.

FIG. 2. Separate, newly formed blood-corpuscles, magnified 410 diameters.

FIG. 3. Annular accumulation of blood, in which the corpuscles can be distinctly seen merging into the parenchyma. Magnified 220 diameters.

FIG. 4. Larger star-like or radiating patch of blood, magnified 67 diameters. The vascular walls can be already traced; the masses of blood are still unorganized and confused; the separate blood-corpuscles not being evident even under a strong power. At ** globules of fat are scattered in the parenchyma.

FIG. 5. and 6. Exhibit a perfect morbidly formed serous membrane with epithelium, which had been repeatedly in a state of inflammation. It likewise affords an illustration of the epigenesis of vessels. Magnified 160 diameters.

A girl, aged twenty years, died after having frequently suffered from pleurisy. The left pleural cavity contained about three quarts of a clear limpid fluid. It was inclosed in three sacs, lying within one another. The outer one was the normal pleura; the inmost one formed a structureless, perfectly amorphous mass, without any connection with the middle one, of which it was an inflammatory product. This middle sac was loosely united to the costal pleura and the diaphragm, (somewhat more firmly with the latter,) by means of areolar tissue and vessels, and was attached by adhesions to the pericardium; forming a perfectly independent membrane, which was clearly distinct from the subjacent normal pleura. It varied from half a line to a line in thickness; externally it had a glistening appearance; internally it was at spots of a bright red colour.

It showed under the microscope (FIG. 5), a very thick net-work of perfect, distended (inflamed) blood-vessels. A granular epithelium (FIG. 6) could be scraped off its inner surface. The tissue of this false membrane histologically resembled normal serous membrane. It consisted of bundles of the normal fibres of areolar tissue, which were interlaced and crossed in various directions. In many places this areolar tissue was still in the act of development; we could observe nucleated cells, which were being elongated at both extremities, and nuclei which rested upon the perfect fibrous bundles. On the external surface nearest the pleura, the tissue of the false membrane was firmer, and could not be drawn asunder into fibres. Under the microscope it exhibited fibres, which were not twisted like those of areolar tissue, but straight, stretched out, frequently divided, and even branched, and when seen *en masse*, of a darker brown colour, resembling the elastic fibre of the arterial membrane, more than that of areolar tissue.

Fig. 5. Free surface of the false membrane, with a perfect network of vessels in a state of congestion.

Fig. 6. Nucleated epithelium of the false membrane. Both figures magnified 160 diameters.

Fig. 7. to 9. Illustrate the pathological epigenesis of osseous tissue. They exhibit the internal structure of a newly formed lamina of bone, which was found in the *dura mater* of an old apoplectic soldier. The bone was flat, about the size of a fourpenny-piece, and lay in the *falx cerebri*, between the layers of the *dura mater*, at a spot corresponding with the anterior third of the commissure. All the figures are magnified 220 diameters.

Fig. 7. From the edge of the piece of bone: it seems to be the most recently formed, and still imperfectly ossified. In a still amorphous streaky blastema (*a. a.*), lie transparent fusiform corpuscles (* * *) —the future bone-corpuscles; they contain as yet no calcareous salts, and are therefore pale and transparent.

Fig. 8. Section of the piece of bone, parallel to its long diameter. At A, we see the opening of an osseous canal, the walls of which consist of concentrically disposed annular lamellæ; it has been somewhat obliquely cut. At B, the laminæ run in a straight line parallel with each other, and with the surface of the bone. * * are bone-corpuscles, which run parallel with the direction of the laminæ.

Fig. 9. A section of the piece of bone at the pointed end, cut off at right angles to the surface. Darker and lighter laminæ alternate with one another, parallel to the surface of the bone. The bone-corpuscles are not visible.

Fig. 10. and 11. Show the regeneration of primitive nerve-fibre by a morbid process. Both figures are copied from Steinrück,

(De Nervorum Regeneratione, Berol. 1833. Pl. II. Fig. 5 and 6).

FIG. 10. A piece taken from a cicatrix on the infra-orbital nerve of a rabbit, from which a portion, a line in length, had been excised ten weeks previously. Magnified 430 diameters. Primitive nerve-fibres imbedded in areolar tissue.

FIG. 11. Separate newly formed primitive nerve-fibres, precisely analogous to the normal uninjured primitive fibres of the same nerve.

PLATE VI.

TUBERCLE—ENCEPHALOID—TYPHOUS MATTER.

FIG. 1. Exhibits tubercles from different organs, in various stages of development.

FIG. 1. A—C. Tubercles from the lungs of a young man, who died of *Tuberculosis pulmonum.* A and B are nuclei in an amorphous cytoblastema; most of these nuclei contain nucleoli. At C the cytoblastema has disappeared, and the cells are in contact with each other. The cytoblastema as well as the nuclei were soluble in ammonia.

FIG. 1. D. Tubercular cells from the lungs of another young man, who died from the same malady.

Here the cytoblastema has also disappeared, and the nuclei are enclosed in a cell-wall; no nucleoli are present. The cell-wall gradually dissolved in acetic acid, the nuclei remaining unchanged.

The lungs of both subjects contained, besides the true tuberculous cells, also many granular cells; those of the first-named subject presented many vomicæ, which contained softened tubercular matter, as shewn in FIG. 6 of this Plate. Magnified 220 diameters.

FIG. 2. Tubercles from the lungs of another young man. Magnified 220 diameters.

A. Nuclei, for the most part with nucleoli, in an amorphous cytoblastema.

B. Perfect tubercular cells with a cell-wall, nucleus, and nucleoli; the former was soluble in acetic acid, which produced no effect on the latter constituents.

C. Separate cells, with granular contents.

D. Larger cells, frequently occurring in tubercle.

FIG. 3. and 4. Tubercles from the kidneys and lung of a young

woman, who died from *Phthisis tuberculosa renis dextri et pulmonum*.

FIG. 3. Tubercles from the right kidney, which had been entirely destroyed by infiltration and partial softening of tubercular matter. They constituted a white lardaceous mass, which, when magnified 220 diameters, exhibited many round corpuscles (*a*, nuclei), in an amorphous mass (cytoblastema).

Besides these, there were separate larger cells, some of indefinite form (*b*), and others much elongated, resembling the fibrous cells of areolar tissue (*c*).

FIG. 4. Tubercles from the lung of the same woman. Magnified 220 diameters.

They exhibit a very great variety in the form of the cells. *a*. nuclei in an amorphous cytoblastema. *b*. large elongated cells. *c*. large round cells, partly with and partly without granules. These variously shaped cells appeared simultaneously in all parts of the tubercle, but the nuclei (*a*) were by far the most numerous.

FIG. 5. A. Tubercles from the lungs of a soldier. Magnified 220 diameters. The cellular structure was very distinct in them; the cell-wall and nucleus with nucleoli were almost everywhere to be distinguished, and the separate cells showed less difference in form and size than usual.

FIG. 5. B. Tubercles from under the peritoneum of a woman who died from dropsy. Magnified 220 diameters. They were deposited over the whole of the abdominal parietes, and in the mesentery beneath the peritoneal investment. They were about the size of a lentil, of indefinite form, tolerably firm, and of a lardaceous consistence. Under the microscope there were seen nuclei in an amorphous cytoblastema (*a*), and perfect cells (*b*), which in form and in their chemical relations entirely resembled the cells of tubercle.

FIG. 6. Dissolved tubercular matter from the kidneys of the same woman from whom the crude tubercles in FIG. 3 were depicted.

The matter presented the appearance of a thick fluid, resembling scrofulous pus; it was not viscid, and did not form a jelly with ammonia like normal pus: under the microscope there were no pus-corpuscles to be seen, but an indistinct granular matter blended with isolated undissolved tubercular cells. Magnified 220 diameters.

FIG. 7. Encephaloid of the bladder of a man aged sixty-six years.

The bladder was entirely converted into encephaloid, and was much thickened (its walls being an inch in diameter); it was enlarged externally, whilst its cavity was diminished, rough, uneven, and tuberculated on its external and internal surfaces. Besides the bladder, the inguinal glands of the right side, and the prostate were affected by the encephaloid.

The malignant matter in the bladder was soft, brain-like, easily convertible into a pulp on pressure, and at some points had even liquefied. It was whitish, and fatty to the touch.

A microscopic examination gave the following result:

The encephaloid consisted wholly of cells of different size and form. They were partly round, partly oval, partly caudate, but no one form predominated over the rest. The roundish cells varied from the 100th to the 60th of a line in diameter, the elongated cells from the 50th to the 60th in length, and from the 100th to the 300th in breadth. The nuclei of the round ones were on an average the 200th of a line in diameter, and those of the longer cells were narrower. Some cells appeared very large (even the 30th of a line) when they generally enclosed several minute cells with nuclei (*a*). Isolated cells, although in a proportionately small number contained dark granules (*b*).

Acetic acid did not affect the nuclei, or the walls. Nitric acid caused the cells to adhere together, and to become entangled within an amorphous coagulum (albumen). Ammonia did not dissolve the cells, but rendered them paler, while the nuclei disappeared. The dark granules remained unchanged. The encephaloid contained blood-vessels. The encephaloid of the inguinal glands was in every respect similar to that in the bladder, excepting in the former case it was evident that the encephaloid had been developed between fibres of areolar tissue. Magnified 220 diameters.

The same figure serves to elucidate the appearances presented in a case of encephaloid of the stomach from an elderly woman who died from pneumonia. In the otherwise normal stomach, about two inches from the pylorus, there was in the smaller curvature, an elongated tumour three inches in length, and two in breadth. It formed a kind of roll consisting of several nodules, with an indentation in the middle; the separate nodules varied from the size of a bean to that of a walnut. The whole tumour was covered over by the unaltered mucous membrane; it was of a moderately hard consistence (somewhat like that of steatoma) and was not soft in any part. On cutting it, it was of a yellowish white colour, and exhibited no trace of blood-vessels. A microscopic examination shewed it to consist entirely of colourless nucleated cells of different forms, which were united together, as if tessellated, without any areolar tissue, and formed the tumour. These cells are depicted in the central portion of FIG. 7. The isolated cells were partly roundish or oval, and partly elongated, irregularly caudate; they varied in length from the 170th to the 60th of a line, and in breadth from the 100th to the 200th, while the diameter of the nuclei varied from the 200th to the 300th of the same standard. Neither ammonia nor acetic acid dissolved them. Magnified 220 diameters.

FIG. 8. Encephaloid of the uterus of an aged woman.

The upper part of the uterus was in a normal condition, with the exception of a fibroid tumour of the size of a musket-ball, but the vaginal portion had become entirely encephaloid. Besides this a large encephaloid mass was found upon the *psoas* muscle of the left side.

The encephaloid of the uterus was very soft and of a white colour; it exhibited different kinds of cells under the microscope—caudate cells with nuclei and nucleoli (*a a*); roundish cells also with the same (*c*); mere nuclei with nucleoli (*b b*); very large cells having in their interior many nuclei (*d d*); numerous globules and granules of olein and margarin (*e*); and crystals of cholesterin (*f*). The encephaloid covering the *psoas* muscle was precisely similar. Magnified 220 diameters.

FIG. 9. Encephaloid of the liver of a woman aged forty-eight years, in whom the bladder and the vaginal portion of the uterus had also become converted into an encephaloid mass. The liver was not enlarged, but filled in all its parts with a large number of circumscribed yellowish white tumours of sizes varying from that of a pea to that of a walnut. They were of indefinite form, spherical, reniform and knotty. They were accurately circumscribed, deposited in the normal parenchyma, and not prominent on the surface: they had a fibrous radiating structure, were tolerably firm, and exhibited no trace of softening. They contained vessels evident to the unaided eye. Under the microscope they appeared wholly composed of cells, which showed distinct nuclei with nucleoli. The cells were mostly roundish or oval, but some were caudate. Acetic acid rendered them pale and brought the nuclei plainly in view (*a*). Here and there mere nuclei were seen in an amorphous cytoblastema, (*b*). Magnified 220 diameters.

FIG. 10. A tumour supposed to be encephaloid, from the lung of an officer, who had often suffered from gonorrhœa.

The lung contained a circumscribed tumour of the size of a walnut, and of a reddish white colour. It was quite soft, could easily be reduced to a pulp, and resembled cerebral substance. From these physical characters, it was pronounced to be encephaloid of the lung.

Under the microscope the tumour showed: 1. A very evident network of capillary vessels, which were filled with blood (the lower portion of the figure.) Magnified 90 diameters. 2. The tumour consisted for the most part of little oleaginous globules varying from the 200th to the 1500th of a line in diameter (the upper portion of the figure). Magnified 220 diameters. They appeared in great quantities, and were soluble in ether and alcohol, in which they collected in large drops; ammonia did not affect them.

On the removal of these oleaginous drops by pressure and washing, the normal substance of the lung remained without showing any trace of abnormal formation. The lung in the vicinity of the tumour was in a perfectly healthy condition.

Fig. 11. Encephaloid from the inguinal glands of an aged woman.

The uterus as well as the inguinal glands on the right side were attacked by encephaloid, which was similar in its microscopic and physical characters in both organs. It was of a yellowish white colour, fatty, and of the consistence of brain. Under the microscope its chief constituents appeared to be cells of irregular form varying from the 400th to the 150th of a line in diameter (*a*). They were mostly round or oval, comparatively few being caudate. There was also much fat in minute granules and globules (*b*): the granules were heaped together in large masses in some places (*c*). A few granular cells (*d*) were also present. Magnified 220 diameters.

Fig. 12—15. Typhous matter deposited in the various organs during the progress of typhus.

Fig. 12. Typhous matter from the mesenteric glands of a girl aged fifteen years, who died of typhus.

The patient was brought to the Munich hospital, after having been ill fourteen days, with a high pulse, and suffering from excessive heat. The lungs were less affected than usual, but the abdominal organs were especially implicated, as shown by their tympanitic state, and profuse diarrhœa. Her strength failed suddenly, and death ensued on the eighth day after her admission into the hospital; and at the height of the disease.

On dissection, the brain and spinal cord were found to be normal; the lungs were sound, but somewhat congested in their lower lobes;

the spleen was rather softened; but the intestinal canal presented the most important lesions. The lower part of the small intestines was much thickened, all the glands, both those of Peyer and Brunner, being infiltrated with typhous matter. All the glands of the colon were also swollen and thickened: the mesenteric glands were much enlarged.

A few of the mesenteric glands, about the size of a bean, were carefully examined. They contained a soft medullary substance, which yielded readily to pressure. Under the microscope it appeared as an amorphous, slightly granular mass of a brownish white colour, in which an immense number of small cells were deposited (A).

These cells had an irregularly roundish form; they were mostly small, almost all under the 300th of a line in diameter; only a few measuring from the 150th to the 200th of a line. Some few of these cells exhibited a distinct nucleus. By treatment with acetic acid the amorphous mass was rendered transparent, and gradually dissolved, upon which many very minute cells (nuclei?) with a sharp outline came in view (B), being unaffected by the acid. Ammonia and caustic potash dissolved the cells as well as the cytoblastema.

The glands of the colon contained a similar mass. Magnified 220 diameters.

Fig. 13. Typhous matter from Peyer's glands.

The patient, a shoemaker's boy, aged seventeen years, was brought into the hospital in a very dangerous condition. The abdominal organs were especially affected. He had violent diarrhœa and considerable meteorism. He died on the fifth day after his admission, with the symptoms of perforation of the intestine.

On opening the body, both lungs were found externally covered with a gelatinous exudation, (serum which had become infiltrated into the tissue of the pulmonary pleura.)

The lungs themselves were tolerably healthy, but inferiorly they were in a state of congestion. The abdomen was much swollen and contained a very large quantity of sero-purulent exudation. The convolutions of the intestines were covered and partially agglutinated by a gelatinous exudation and by layers of coagulated fibrin. The mesenteric glands were much enlarged. The small intestine contained numerous ulcers; almost all the patches of Peyer's glands being in an ulcerated condition, and at one spot having given rise to perforation. At the spots where there was ulceration, the mucous membrane with its investment of epithelium was wanting, and in its place was a yellowish white lardaceous mass (typhous matter). Under the microscope this substance appeared to be indefinitely granular, amorphous, and of a brownish white colour. Both acetic acid and ammonia rendered it soft and transparent, much like coagulated fibrin. At various spots it contained irregular cells varying from the 300th to the 400th of a line in diameter (Fig. 13), and numerous fatty granules. Magnified 220 diameters.

Fig. 14. Cells from typhous matter in Peyer's glands; taken from a soldier who died whilst the disease was at its height.

All Peyer's and most of Brunner's glands were thickened and infiltrated with typhous matter. There was, however, no appearance of ulceration; the mucous membrane covering the infiltrated glands being perfectly entire, though highly reddened and vascular. The typhous matter, which was deposited between the muscular and mucous coats of the intestines, appeared to be generally amorphous, although in some places there was a distinct cell-formation. Most of these cells contained several nuclei (Fig. 14). Magnified 220 diameters.

Fig. 15. Typhous matter in the lowest stage of organization, from the lungs of a soldier.

Both lungs exhibited in almost every part tubercular-like nodules of a yellowish-white colour. Microscopic examination showed that at those spots there was an entire deficiency both of air and blood; neither was there any vestige of pulmonary tissue, but merely an amorpho-granular colourless mass covered with numerous fatty granules. It exhibited no trace of cellular structure. On the addition of acetic acid this mass became transparent, and the normal pulmonary tissue which had been enclosed by it, was brought in view. Magnified 220 diameters.

PLATE VII.

FATTY AND FIBROUS TUMOURS.

Fig. 1. A fatty tumour (lipoma or steatoma). Magnified 160 diameters.

A woman aged about forty years had several tumours on the head and neck. She had been operated on four times, but the tumours on each occasion reappeared. In September 1839, she entered the hospital at Erlangen for the purpose of being again operated on. At this period there were several tumours about her head and neck. There was one situated on the right side of the nose, extending from the root of this organ to the lower edge of the right ala, and so firmly attached to the subjacent bones that in performing the operation, it was necessary to remove the nasal bone, and the nasal process of the superior maxillary along with the tumour.

There was another tumour seated at about the middle of the lower border of the inferior maxillary bone on the right side; it was in close connection with an artery and vein, so that it was necessary to tie the former in removing the tumour. There was a third tumour situated in the middle line of the neck, about midway between the lower jaw and the larynx. Each of these tumours when extirpated, was found to be about the size of a small apple; they were irregularly spherical and lobulated, had a lardaceous consistence, and were each enclosed in a thin cyst or capsule. These tumours exactly resembled each other as regards their histological characters; they were each composed of fibres identical with those of ordinary areolar tissue (*a*), and of fat-cells (*b*), which corresponded exactly with those observed in common adipose tissue. Although there were no blood-vessels distinctly observed, yet they were undoubtedly present, though few in number, as is usually the case in adipose tissue; the fact of their being so very indistinct in the present case is explained by the great loss of blood attendant on the necessarily prolonged operation, whereby these vessels would be almost completely drained of their contents.

On examination under the microscope there were observed several drops of oil (*c*), which doubtless had been squeezed out of the fat-cells by the pressure of the glass placed over the object. These several elements of each of the tumours were disposed in the following order; the fibres (partly separate, partly arranged together in undulating fasciculi, as observed in ordinary areolar tissues), formed the ground-work of the substance of the tumours, whilst between these fibres the fat-cells were deposited. The arrangement of the fibrous fasciculi followed no regular order; they were observed crossing each other in all possible directions. Where the substance of the tumours was most firm and deep, there the fibres especially prevailed; where, on the other hand, the texture was soft and adipose, there the fat-cells were most abundant. In these latter parts, where the fat was most prevalent, the fat-cells were arranged in much the same order, as we observe to be the case with the cells of plants. At the parts where the tumours encroached upon the bone, the fat-cells were observed to be in contact with the osseous substance, which itself, however, was quite unaltered. The enclosing cyst or capsule was thin, fibrous, and made up of densely interwoven bundles of areolar tissue, crossing each other in all directions. It thus exactly resembled the structure of the membrane described as forming the cyst of a true encysted tumour. See Plate IX. Fig. 1—3.

FIG. 2. Fibrous tumour. The fibres in this case resemble those of organic muscle, constituting the variety of tumour termed *Fibroid*.

Fibroid from the stomach of a man aged forty-four years, who died from renal disease. Magnified 220 diameters.

On the lesser curvature of the stomach and towards the cardia there was a morbid product of the size and form of an almond. It lay under the mucous membrane, or more correctly speaking, in the muscular coat; was of a whitish colour, and in form and consistence resembled an extirpated tonsil. It was covered with a layer of cellular tissue, which separated it from the surrounding structures; there was, however, no definite capsule or cyst. The interior of the tumour presented the same appearance as the exterior. A recent section had a milk-white colour, and appeared perfectly homogeneous; it was very dense and unyielding, and tore on attempting to stretch it.

Under the microscope there were seen traces of vessels containing blood; on the whole, however, it was anæmic.

At the first glance the histological structure of the tumour was not very obvious. On more careful examination, however, there were seen on making a thin section, many nuclei with nucleoli (C), and some very delicate, tolerably broad, extended fibres, on many of which nuclei were apparent. (B & D). There were no fibres of areolar tissue. On the addition of acetic acid, the broad fibres became pale and gradually disappeared, leaving only the nuclei. It was ascertained, by further investigation, that these broad fibres, which were perfectly identical with those of organic muscle, and ran to a parallel direction, constituted the whole tumour (A). They were not, however, very distinctly marked; the whole structure was to the highest degree delicate, and at some spots there was an amorphous blastema not yet developed into fibres, which on the addition of acetic acid became paler and less distinct. In what direction the fibres were arranged—whether they were concentric, circular, and parallel to the surface of the tumour, or whether their course was uncontrolled by any fixed order—could not, on account of their extreme delicacy, be ascertained.

Fig. 3. & 4. Fibrous tumours, whose histological elements are identical with those of areolar tissue.

Fig. 3. Histological elements of a fibrous tumour. Magnified 220 diameters.

A man suffered from a polypus attached to the posterior portion of the nasal cavity, and projecting backward into the pharynx. It was removed by making a section through the soft palate. The portion removed was very firm, vascular, and homogeneous; when washed it had a white fibrous appearance. On microscopical examination, its tissue was seen to consist of fibres of areolar tissue, for the most part in the process of development. They appeared more or less twisted or woven together; and many of them exhibited nuclei with nucleoli. All the stages of the development of areolar tissue, which we have depicted in Plate iv. Fig. 1. & 2., were exhibited in this structure.

A, Are primary cells, with nuclei and nucleoli. B, are the same cells elongated and becoming caudate. C is an indistinct fibrous blastema on which there are nuclei. D, very elongated cells. E, the same elongated cells loosely arranged together, so as to form fasciculi of areolar tissue. F, cells which, by a sort of channelling, separate into numerous fibres. G, a portion of the mature fibres of areolar tissue.

On the addition of acetic acid, a portion of the mass became transparent; numerous isolated nuclei were then seen, as well as many unaltered fibres, in a semi-amorphous mass. The arrangement of the fibres appeared to be generally circular or spherical.

The entire polypus was invested with a normal mucous membrane, the surface of which was protected by several layers of pavement-epithelium. No ciliated epithelium could be observed.

FIG. 3*. A, represents a patch of non-nucleated epithelial cells: B, of nucleated epithelium. Both forms occurred at different parts of the surface of the tumour. All the epithelial cells had a puckered appearance. Magnified 220 diameters.

FIG. 4. Fibrous tumour of the skin (a wart). Magnified 160 diameters.

A pedunculated wart, which had been growing for the space of two years in the axilla of a young man, was excised.

After extirpation it appeared smooth, of the size and form of a lentil, covered with normal epidermis, and slightly corrugated.

Its pedicle was short and thin.

On making an accurate examination, the following appeared to be its true structure. The matter scraped from the surface of the wart formed a white, dirty powder, which, under the microscope, was seen to consist of very thin, roundish, oval, or angular scales, devoid of nuclei (A a). They were in every respect identical with the flat cells forming the external layer of normal epidermis. The cells which formed the interior epidermic layers of the tumour were generally smaller and less flat, and exhibited decided nuclei (A. b). Hence the investment of the tumour consisted of normal epidermis. The interior of the wart was formed of a very dense fibrous tissue (B), and in some spots undulating bundles of caudate fibres might be seen, on many of which nuclei were perceptible (C). Throughout this structure, there were numerous caudate cells with nuclei (D), representing all the stages of the development of areolar tissue; which we have depicted in Plate IV. FIG. 1 and 2.

PLATE VIII.

CARCINOMA—SCIRRHUS—COLLOID.

Fig. 1—3. Scirrhus of the testicle. Magnified 220 diameters.

The extirpated testis was of the size of a goose-egg, and retained its perfectly oval form, without any inequalities or excrescences. The surface turned towards the *tunica vaginalis* was smooth, and only in parts united with that membrane. The epididymis was distinct, and did not appear to be enlarged. On cutting through the testis, its whole mass was seen to have been affected by an uniform change. It was very firm, cartilaginous, and of a white colour.

A microscopic examination exhibited the following results. Small masses that had been pared from a recent section of the tumour and moistened in water consisted entirely of an accumulation of cells. (Fig. 1.) These were very pale, varying in size and form, being sometimes roundish (*a*), sometimes oval (*b*), or caudate (*f*), or again of entirely irregular form. The greater number exhibited nuclei (*a, b,*), and in some a nucleolus was visible in the nucleus (*c, h*) ; few were devoid of nuclei. On some, fat-globules were observed (*g*). Between these cells there were perceived nuclei with or without nucleoli (*d*). In places there appeared between the cells smaller or larger portions of dark granules—fat granules (*e*) ; finally, at certain spots, isolated nodules were observed (Fig. 3. B.) consisting of indistinct fibrous capsules, containing the cells already described.

On cutting off small portions of the tumour with scissors, and placing them under the microscope, having moistened them with water, and drawn them into fibres by means of fine needles, the pale cells of varying size and shape, which we have already described, were observed. On treating them with acetic acid, they disappeared, leaving only the nuclei and nucleoli. On removing these cells as much as possible by constant washing, a tissue remained composed of broad transparent fibres (FIG. 2.). These fibres entirely resembled those of organic muscle. They mostly disappeared on being treated with acetic acid when oat-like masses—nuclei—appeared (FIG. 3. A.), entirely similar to those seen on treating the muscular fibres of the intestine or the uterus with acetic acid. These two elements—the cells and fibres—independently of the fat granules and crystals of cholesterin, which will presently be described, are the only ones which appear in this case.

Fine sections made, with the double knife, in the tumour, not only shewed the same constituents, but led to the assumption of a similar arrangement of these histological elements. The fibres did not follow a straight course, but formed curves—parabolas, ellipses, or circles—which were filled with cells. This arrangement was especially evident on the application of acetic acid, which caused the nuclei to come prominently forward, and the course of the fibres to be thus ascertained. (FIG 3. A,) shews a part treated in this way with acetic acid. One portion of the fibres runs in a nearly straight direction, while another forms a spherical capsule filled with cells. If we examine these portions with a lower power we clearly ascertain that the fibres not only form circular meshes, but actual spherical capsules; we here find fibrous nodules, without any trace of cells, which only appear when the spheres have been flattened by compression: or, when the fibres of the capsule have been made transparent by acetic acid, in which case the round nuclei of the inner cells distinctly appear, and are totally different from the elongated nuclei of the enclosing capsule.

On treating a thin section of the tumour with acetic acid, an amorphous viscid matter coagulated.

A small portion of the scirrhus was softened, and puriform. The semi-fluid, pulpy mass consisted of the remains of cells and fibres, neither of which were individually distinct; the whole being dissolved into a semi-fluid, indefinite mass, in which many dark brownish granules of fat were seen, partly isolated, and partly in large masses. Acetic acid rendered the whole mass paler, and gave it a conglobate appearance, without our being able to observe a distinct coagulation of any particular substance.

At one part of the scirrhus we perceived very large cells, mostly with nuclei, and interspersed with crystals of cholesterin (FIG. 3. C).

Certain parts of the *epididymis* and *tunica vaginalis* were scirrhous. These exhibited the same arrangement of histological elements.

FIG. 4 & 5. Scirrhus of the liver. Magnified 220 diameters.

A young man, a soldier, had suffered for a long time from a constantly increasing swelling of the abdomen. A firm tumour with several hard knotty parts occupied the whole of that region, and could be distinctly felt. *Febris hectica:* Death.

On making a post-mortem examination some purulent fluid was found in the abdominal cavity, while the intestines were mostly covered on their surface with coagulated fibrinous exudation. The liver was so greatly enlarged, that it extended into the pelvis, and occupied nearly the whole abdominal cavity. It weighed when removed upwards of fourteen and a half pounds. About half of this substance consisted of a large number (twenty or thirty) yellowish white nodules, of different sizes.

The parenchyma of the liver, which lay between these nodules, appeared perfectly normal. The enlargement extended tolerably regularly over all the lobes of the liver. The tumours on the liver were all roundish or oval, varying from the size of a walnut to that of a hen's egg. They were hard and firm to the touch—almost cartilaginous—and exhibited a pale yellowish colour on being cut. A whitish yellow fluid could be expressed from the greater number; in fact, in some the interior was entirely softened and converted into this fluid. Many of them craunched under the knife, and exhibited a shining fibrous structure, but no concentric layers could be distinguished. The scirrhous nodules had blood-vessels, which were visible even to the naked eye. They were intimately connected with the normal parenchyma, not being divided from it by any membrane, or peculiar histological stratum.

A microscopic examination of these scirrhous tumours gave the following results :

A. The pale yellowish fluid expressed from the cut surface of the tumor consisted of: 1. Evident fat-globules of different sizes, partly isolated (Fig. 4. A), and partly collected together in larger masses (B).

2. Larger, dark, granulated, roundish or oval corpuscles, similar to granular cells (Fig. 4. C). They appeared to be cells, containing or covered with small fat-globules.

3. Minute, pale, roundish corpuscles, varying from the 300th to the 400th of a line in diameter, (Fig. 4. D). The greater number had nucleoli, some a single, others a double nucleolus. These corpuscles (nuclei) appeared isolated at various spots, but the greater number were accumulated in masses. Most were pale, while a few

appeared darker and more compact, and had a sharply defined outline.

4. Some, although proportionately few, of these nuclei were surrounded by a pale cell-wall, (Fig. 4. D. *a*).

Different chemical agents had the following effects upon them.

Water did not change them in any way.

On the addition of ether the fat-globules (A. B.), together with the granulated corpuscles (C), disappeared. They flowed together and united into large fat-drops; while, by the coagulation of the albumen, the nucleoli and cells (D) were united in an irregular coagulated mass, rendering them indistinct.

Acetic acid produced a similar amorphous coagulation, resembling coagulated mucus. The nuclei shrivelled, became a little smaller, but were more distinctly marked. The fat-globules and fat-granules were not affected.

The cells and nuclei entirely disappeared in a solution of potash, (which had imbibed some carbonic acid from the atmosphere;) nothing remaining but the granulated corpuscles (C) and the globules of fat, which had not formed a soap with the potash, in consequence of there not being a sufficiently elevated temperature.

B. The fibrous stroma of the tumour, after the above-named parts had been removed as far as was possible by washing, consisted of distinct, broad, parallel fibres (Fig. 5. A), similar to those of organic muscle, as they appear in the uterus and the intestinal canal. They were firmly united together in membranous masses, in which it was difficult to distinguish the individual fibres (Fig. 5. B); indeed, at places, the substance appeared, although firm and compact, perfectly amorphous, without any trace of fibres; and the nuclei were so firmly deposited in it, as not to be removable by washing (Fig. 5. C.) Here, therefore, the nuclei appear to lie in an amorphous substance. In places, other fibres consisting of caudate cells with distinct nuclei, ranged one close to the other (Fig. 5. D), lay between the above-named band-like fibres (Fig. 5. A.) These caudate fibres formed separate groups, but were of comparatively rare occurrence. There was unfortunately no examination made of the relations of these different fibres to chemical reagents.

Thin sections of the unwashed tumour showed that the fat-globules (Fig. 4. A. B), the granulated bodies (Fig. 4. C), and the nuclei (Fig. 4. D), besides small crystals of ammoniaco-magnesian phosphate (probably originating subsequent to death) were all deposited in the interstices of the fibrous bundles. In some places the fibres preponderated; in others, as in the softer parts, the fat-globules were most frequent; and again the nuclei in others. The fibres did not exhibit any decided order of arrangement.

FIG. 6. and 7. Softer cancer (encephaloid) of the knee-joint. Magnified 220 diameters.

A young man suffered from considerable swelling of the left knee. The extremity, from the knee downwards, was much emaciated. There was also general emaciation of the whole body, and hectic fever. On the dorsum of the right foot there was a (scrofulous?) ulcer.

The diseased knee had increased to twice the normal size, and the tumour yielded on touch a deceptive sensation of fluctuation; the skin was somewhat tense, but not in any degree discoloured. The leg was amputated by Professor Stromeyer, at the lower third of the femur, and handed to me for examination immediately after the operation.

On laying open the knee-joint, it was evident that the disease was seated principally in the synovial membrane and in the adjacent adipose tissue. The synovia was not increased. There was no trace remaining of the actual synovial membrane; excepting where it covered the cartilage of the joint, it was changed into a grayish red mass, which was very soft, having the consistence and appearance of ordinary adipose tissue. It differed however from the latter in being of a reddish-gray colour. The surrounding adipose tissue was changed in the same manner, in some spots to the thickness of half an inch and more; while in other places, this difference did not extend beyond the depth of two or three lines. The altered synovial membrane and adipose tissue resembled each other so perfectly, that no limits could be discovered between them, as they merged directly into one another. In the degenerated mass there were many softened parts, about the size of a pea or bean, containing a dingy whitish-yellow, thickish, puriform fluid. They were scattered throughout the whole structure, without any definite arrangement, and it was only in a few places that the adipose tissue appeared to be normal in the immediate vicinity of the synovial membrane. It was evident that the quantity of adipose tissue was very great in the vicinity of the diseased joint, in proportion to the general emaciation of the rest of the body. The cartilage of the patella, as well as that of the articulation of the *os femoris* and *tibia* appeared perfectly normal. A section of cartilage from the outer surface of the patella was examined under the microscope; the cartilage-corpuscles, as well as the intervening intercellular substance, exhibited the usual characters, excepting that most of the cartilage-corpuscles contained many fat-globules. The free surfaces of the cartilage were almost everywhere covered with a thin membranous layer, which could easily be torn into shreds which appeared gelatinous, of a yellowish-gray dingy colour, and were about the thickness of letter-paper. The different parts of the tumour were then microscopically examined.

1. The thin layer on the outer surface of the cartilage appeared perfectly amorphous, similar to coagulated fibrin, without vessels or any trace of fibres, of areolar tissue, or of epithelium. Isolated cells were visible, most of which resembled those described in Fig. 6. A; others had a very thick cell-wall and granular contents, with a nucleus (Fig. 6. B); others, again, contained several nuclei, (Fig. 6. C). On the addition of acetic acid, the amorphous membranous mass became perfectly transparent, and many nuclei came prominently in view. It was, therefore, doubtlessly a blastema in the act of developing itself into a cancer.

2. The pale yellow puriform matter which appeared in the above-mentioned softened parts of the degenerated portion, contained numerous cells in a colourless fluid. These cells were roundish or oval; the smaller varied from the 200th to the 300th of a line in diameter (Fig. 6. A. *a*.); indeed some (*d*) were even smaller, (these were, however mere nuclei, measuring only about the 400th of a line;) the larger measured the 100th or even the 80th of a line in their longest diameter. Most of these cells were covered with granules (fat ?), and many exhibited a distinct nucleus and nucleoli; besides these cells there were isolated blood-corpuscles (Fig. 6. A. *c*.; the Plate shows them edgeways), and many fat-granules.

The fluid coagulated on the addition of acetic acid, the walls becoming very pale (Fig. 6. D. *a*), or entirely disappearing. The nuclei of the cells appeared more distinctly (Fig. 6. D), and were all single, and easily to be distinguished from the nuclei which appear on treating pus-corpuscles with acetic acid. The dark granules on the cells were not changed by the acid, (E.)

Caustic ammonia did not alter the fluid, but rendered the cell-walls, as well as the nuclei, pale, and finally caused them to disappear. The dark granules covering the cells were not affected by the ammonia, but came more distinctly in view (Fig. 6. E.)

With respect to the chemical character of the fluid in which the cancer-cells were suspended, microchemical experiments yielded the following results.

Nitric acid produced a very copious, almost amorphous, whitish coagulum, which enclosed the cells (albumen); the cells themselves were not changed.

On the addition of ether, a copious coagulation of an amorphous dark matter (albumen ?) appeared; the dark granules adhering to the cells were mostly dissolved, (fat).

Bichloride of mercury gave a very copious coagulum of an amorphous colourless mass, which enclosed the cells, (albumen).

Infus. Gallarum yielded also a very copious coagulum, partly amorpho-granular, of a brown colour (albumen), and partly altogether amorphous and colourless (extractive matter). The cells were enclosed in this coagulum.

Nitrate of silver gave a very copious coagulum; partly a black granular mass (chloride of silver), and partly dark-brown, perfectly amorphous masses, (albumen).

Acetic acid coagulated a moderate quantity of amorphous matter, (pyin ?).

Alumina yielded a moderate coagulum, about the same quantity as that given by acetic acid, and less than that by the agents which coagulate albumen. The mass was perfectly amorphous and colourless, and enclosed the unchanged cells.

The proper cancer-matter was of a grayish-red colour, and resembled adipose tissue; it contained evident blood-vessels, which running curvilinearly formed irregular meshes. The same cells appeared in this tissue which have been described as occurring in the softened parts. (Fig. 6, A). A portion of the fluid coagulated, on the addition of acetic acid, into an amorphous colourless mass. When the cells had been removed by pressure and washing, the stroma of the tissue remained, as an amorpho-fibrous substance disclosing on close investigation band-like fibres running in parallel directions, (Fig. 7, A) and perfectly resembling those of organic muscle They were especially evident on the free edges. On treating the tissue with acetic acid these fibres became very pale, and nuclei, either oval with nucleoli, or elongated, acuminated, and oat-shaped (Fig. 7, B *a*) appeared in them. The whole amorpho-fibrous mass became transparent in acetic acid, and showed (even in those places where the individual fibres could not be distinctly defined) many elongated nuclei ranged in parallel rows, (Fig. 7, B *b*). We hence see that even these apparently amorphous portions are formed from similar fibres. The fibres run in a parallel direction and tolerably straight for short distances, but no regular arrangement could be perceived on a large scale. The cells were interspersed, often in large groups, between the fibres; the fibres predominating in some parts, and the cells in others. Occasionally the cancer strikingly resembled in its external appearance normal adipose tissue, but microscopic investigation only exhibited the elements already described—fibres and cells—interspersed with many small globules of fat. The transition of the cancerous into the healthy tissue was very gradual. On examining a portion of the adipose tissue from the vicinity of the cancer, it appeared at first sight, even under the microscope, to be perfectly normal; nothing being discernible but the ordinary fat-cells reticulated with vessels; but when the fat was removed as much as possible from the cells by means of pressure and repeated washings in water, there remained a residuum, which consisted only in a very small degree of the normal constituents of adipose tissue, being principally composed of newly formed cancer-fibres, (Fig. 7). In this, which was certainly the earliest portion of the cancer-matter, it was evident that the fibres were formed from elongated fusiform cells, like the fibres of organic muscle.

Cells of this sort, whose nuclei and nucleoli were rendered very distinct by acetic acid, appeared in large quantities, sometimes isolated, sometimes united in groups, in the residuum of the adipose tissue, (Fig. 7, C). In other parts there were evident cancer-cells (Fig. 6, A) deposited between the normal fat-cells together with the cancer-fibres.

A portion of the degenerated mass from the vicinity of the synovial membrane was submitted to a chemical investigation, which, however, was unfortunately interrupted. The only results obtained were that 1000 parts of fresh cancer-matter yielded 171 parts of solid constituents, and 829 parts of water and other volatile constituents, at a temperature of 212°, and that the whole mass was rich in fat.

Fig. 8. Cancer-cells from a scirrhous breast. Magnified 220 diameters.

The cancer contained a few of the fibres delineated in Fig. 5, A and Fig. 7, A, between which were interspersed many nuclei (Fig. 8, A), and perfect cells, (Fig. 8, B). The club-like extremities of the milk-ducts appeared quite unchanged in the midst of the cancer-mass.

Fig. 9. Elucidates the origin of scirrhus. Magnified 220 diameters.

The man whose scirrhous testicle was described in the explanation of Fig. 1—3 died after the wound occasioned by the operation had nearly healed.

On dissection scirrhous deposits were found in both lungs, in the liver and in the spermatic cord of the right side where the testis had been extirpated. A deposition of scirrhous matter with a knotty surface was found upon the vertebral column, surrounding the aorta, about a hand in breadth, and from two to three inches in thickness, reaching from the promontory of the sacrum almost to the diaphragm.

An accurate examination of these scirrhous portions gave the following results.

The scirrhous masses in the lung were tolerably defined, roundish, varying from the size of a hazelnut to that of a chesnut, tolerably compact, and firmer than the surrounding tissue of this lung; a section presented a dark reddish brown colour with light and dark stripes, giving the cut surface a veined appearance. Under the microscope these parts appeared as an indistinct uniform mass, devoid of any trace of the true pulmonary tissue. When these portions were treated with ammonia the normal fibrous bundles of the pulmonary tissue distinctly appeared, and it was thus made evident that the scirrhous mass was deposited in the normal tissue of the lung, and filled up all its interstices. The scirrhous portions of the lungs contained no air. The mass appeared in most places perfectly amorphous and structureless (Fig. 9, B *a*), exhibiting, however, incipient cell-formation (Fig. 9, B): nuclei with and without nucleoli being distinctly visible. Around these were pale cell-walls, which were more or less clearly separate from the surrounding blastema and sometimes scarcely to be distinguished from it. In some places the cells appeared numerous, and collected in large groups (Fig. 9, A), while in others they were isolated, (Fig. 9, B). A thick cell-wall with a double outline was very distinctly visible in some of the larger cells (as in B). Elsewhere broad fibres appeared in the amorphous mass, which, on being treated with acetic acid, became paler and exhibited elongated nuclei (as in Fig. 7, B, but more faint and indistinct).

Some of the scirrhous nodules exhibited a more developed scirrhous structure: some caudate cells with nuclei in the act of transition into scirrhous fibres are exhibited in Fig. 9, C.

The scirrhus of the liver was situated immediately under the peritoneum on its upper convex side: it was round, of the size of a small apple, tolerably compact and yet fragile, exhibiting internally a reddish brown colour, interspersed with whitish and bluish portions.

It shewed under the microscope, besides normal hepatic cells, pale cancer cells, similar to those depicted in FIG. 4, D, and numerous caudate cells (FIG. 9, C—scirrhous fibres in the act of development.) When these elements were perfectly removed, a tolerably large and firm mass remained. This was whitish, compact, and not easily separable into fibres. It, in part, formed perfectly amorphous undefined spherical particles, varying in size from the 100th to the 20th of a line in diameter, and, at other places, fibrous masses in which the scirrhus fibres were more or less plainly to be seen. The mass became quite pale in acetic acid, disappearing almost entirely, and shewing only a few nuclei. Hence the blastema appeared to be still almost entirely unorganized.

The mass lying upon the aorta had the same appearance as the scirrhus of the liver. It was firm, and a section was reddish brown with white specks: the separate portions were roundish, nodular, and in some cases softened in the centre. A microscopic investigation shewed distinct blood-vessels, much fat, (partly in globules, partly in granules, and crystals of cholesterin,) isolated cells with nuclei, and, as a stroma, a firm compact mass, which, acting in part as a blastema, contained cells and nuclei, and in part was perfectly amorphous, or merely exhibited an imperfect formation of large cells with thick walls (FIG. 9, B). In some places the amorphous stroma of the tissue was composed of spherical masses from the 10th part of a line in diameter, or even less, exhibiting, in their interior, decided traces of incipient cell-formation (as in FIG. 9, B).

On treating them with acetic acid, they became perfectly transparent, and exhibited at spots elongated nuclei, similar to those occurring in the fibres of organic muscle—hence they were fibres in the process of development.

A softened portion in the interior of one of the scirrhous nodules, contained cancer-cells, some of which were partially disintegrated, many fat-globules, and some crystals of cholesterin; it was intersected by numerous fibrous arches and bands, which had withstood the influences producing the softening, and consisted of scirrhous fibres.

FIG. 10. Fibrous stroma of scirrhus; copied from Müller, Plate II. FIG. 1.

"Meshes formed by the bundles of fibres of *carcinoma reticulare* of the breast, as they appear after the globules are removed."

FIG. 11. Cells of *carcinoma alveolare* (colloid) of the stomach. Magnified 100 diameters. From Müller, Pl. II. FIG. 3, *a*.

PLATE IX.

ENCYSTED TUMOURS—MELANOSIS.

FIG. 1—3. Show the histological elements of an encysted tumour, about the size of a nut, which was situated beneath the skin, immediately in front of the left ear of a young man, and was extirpated by Breschet in the summer of 1839. Magnified 220 diameters.

The matter contained within the cyst of this tumour, was a thickish fluid substance, somewhat resembling boiled groats, of a yellowish white colour, and possessing a strong acid reaction. When examined beneath the microscope it was found to consist :—

1. Of pale very transparent cells, somewhat plicated, and from the 50th to the 100th of a line in diameter, (FIG. 1, A). The majority of them contained very pale nuclei. These cells underwent no change on the addition of acetic acid or ether, but by caustic potash they were gradually rendered more pale, and were eventually entirely dissolved. They formed the chief ingredient of the substance with which the cyst was filled, constituting about two-thirds of the entire mass.

2. Of tabular rhomboidal crystals of cholesterin, (FIG. 1, B) which were not affected by acetic acid or by caustic potash, but were soluble in ether ; these crystals constituted about a fourth part of the substance.

3. Of small round corpuscles, about the 250th of a line in diameter, (FIG. 1, C) resembling in form and general appearance pus-corpuscles and the cells of the undermost layers of the epidermis. On the addition of acetic acid the cell-walls of these corpuscles were rendered pale, and by degrees became completely dissolved ; upon which a single or double nucleus in each corpuscle was brought into view. In this respect also they resembled pus-corpuscles. There was a tolerably large number of these corpuscles interspersed between the large pale cells already described.

The membrane composing the cyst within which the soft mass of the tumour was enclosed, appeared at first sight to be about as thick as the back of an ordinary knife, and to consist of but one layer; but upon closer examination it was found to admit of separation into two distinct laminæ. The inner of these layers, which was the thicker of the two, was of a white pearly lustre, very pliable, and entirely composed of the large pale cells previously described, and of a few scattered crystals of cholesterin; consequently it was merely a condensed outer layer of the contents of the cyst, and did not form any part of the true cyst itself. The outer of the two layers, which was in reality the cyst, had a thickness not greater than that of letter-paper, and was soft and extensible. When examined microscopically it was observed to be composed of areolar tissue, the fibres of which were arranged in fasciculi crossing each other in every direction, and intimately woven together in the ordinary manner (FIG. 3),

The internal surface of this membrane or cyst, was lined by a distinct epithelium composed of flat cells arranged together in a tesselated manner; the nuclei of these cells were distinctly brought into view on the addition of acetic acid (FIG. 2).

FIG. 4. The contents of an encysted tumour about the size of a hen's egg, which was situated in front of the right ear of a female, and extirpated by Prof. Wilhelm. Magnified 220 diameters.

The cyst by which the substance of the tumour was surrounded consisted of a smooth membrane, the thickness of which was the same as that of letter-paper. When examined beneath the microscope, it was found to be made up of bundles of fibres of areolar tissue, (as in FIG. 3) densely woven together, so as to produce a compact membrane. Several blood-vessels were also distinctly observed traversing this membrane. On its internal surface it was lined by a layer of epithelium similar to that represented in FIG. 2.

This cyst contained in its interior a soft, grumous, very friable substance of a whitish colour. When examined beneath the microscope it was found to consist:—

1. Of a large quantity of colourless oval cells (FIG. 4, *a*) unprovided with nuclei; these cells formed the chief ingredient of the mass.

2. Of tabular crystals of cholesterin in tolerable quantity, (FIG. 4, *b*).

3. Of amorphous colourless granules of various sizes (FIG. 4, *c*).

A chemical analysis of the contents of this cyst gave the following results :

Water (with a trace of butyric acid) . .	751
Fat (cholesterin and butyrin in about equal proportions)	38
Alcohol-extract, with lactic acid. . .	92
Water-extract	27
Dry cellular substance (probably with a trace of albumen)	92
Fixed salts	a trace
	1,000

It would appear from the above analysis that the granules described in (3) consisted of butyrin.

FIG. 5—7. Illustrate the epigenesis of black pigment—melanosis. The figures are magnified 220 diameters.

FIG. 5 and 6. Newly formed black pigment from beneath the peritoneal coat of the intestines; from an aged woman who died from marasmus.

The intestinal canal was at various points covered with organized false membranes; it was externally of a greenish-black colour, and throughout its course presented several constrictions. On removing the serous coat it was found to be colourless; the pigment being deposited in the muscular coat. On placing a portion of this tissue under the microscope, roundish and intensely black granules varying from the 1200th to the 500th of a line in diameter (FIG. 5) were seen deposited in a colourless mass. These black granules were unaffected by acetic acid, which indeed by rendering the adjacent parts more transparent, brought them more prominently into view. A solution of potash did not alter them. On the addition of nitric acid, a large amount of albumen coagulated, and obscured the whole object; hence it could not be determined with certainty whether the granules were soluble in nitric acid.

The pigment-granules were collected in heaps and groups, the portions of parenchyma lying between them being more or less free from melanosis (FIG. 5 and 6). The pigment-granules were, in this case, not enclosed in cells.

At some parts there was a tolerably deep yellow-green coloration of the parenchyma (FIG. 6) between the black spots. This colour did not depend on the granules, but appeared to be dependant on a saturation of the tissue with a coloured fluid.

This case should probably be classed amongst those of false melanosis, where the formation of black pigment depends on a purely chemical process.

FIG. 6. Melanosis of the intestinal villi.

A powerful man—a trumpeter—who only two days before his death, was discharging the duties of his office, died suddenly from perforation of the intestines, in consequence of typhous ulcers.

The whole mucous membrane, both in and between the *valvulæ conniventes* was strewed with greenish black points, which could not be removed by washing. Beyond this, nothing abnormal was observed, the mucous membrane being rather pale than reddened.

On instituting a microscopic examination, it appeared that this black colour existed in the villi, which, in their interior, near the extremity, nearly all contained a black granular pigment. These granules were insoluble in acetic acid, and in caustic potash (FIG. 6). The mucous membrane and the villi were altogether destitute of epithelium.

This black spotted appearance extended throughout the whole course of the ileum, as far as the ileo-cæcal valve; beyond this point there were no more black spots, but the mucous membrane at places had blackish-green patches, which gradually lost themselves in the pale, almost white colour of the surrounding surface. The microscope shewed that the cause of this coloration was a deposition of irregular black granules under the mucous membrane. The epithelium was here perfect.

This, also, was probably a case of false melanosis.

FIG. 7. Development of black pigment in cells; from the lungs of a man who died from pleuritic empyema.

The right pleura was filled with a fluid exudation, consisting of serum with pus-corpuscles, and its walls were invested with thick fibrinous deposits. The right lung was much compressed, was drawn upwards and backwards, and externally presented a slate-coloured appearance. The inferior lobe was solid, tough, and fleshy; a section presented a grayish black colour, merging into a violet tint.

Under the microscope no air and very little blood were perceptible; on the removal of the latter, the pulmonary tissue appeared tolerably normal. Patches of black pigment, and fibrous bundles of pulmonary tissue were seen, the net-work at the borders being perfectly free. The only abnormal constituents were cells containing intensely black pigment (FIG. 7); they were strewed in considerable numbers through the pulmonary tissue, but never occurred in groups. These cells likewise occurred in the fluid expressed from a fresh section of the lung. On the addition of acetic acid, the walls of the cells became pale and gradually vanished; the pigment-granules were, however, unaffected.

This is a case of true melanosis, in which the pigment is developed in its proper cells.

Fig. 8 and 9. Walburga S. aged 27 years, a servant, entered the Munich Hospital on the 23rd of May, 1840. She had felt unwell for several days, and on admission had severe fever, diarrhœa, congestion of the head and chest, and difficult respiration. In a few days she presented a well-marked case of typhus; the lungs were considerably affected, there was tumefaction of the parotid glands, and on the 3rd of June she died. Shortly before death both arms became gangrenous, the right originating from a venesection-wound made at an early stage of the disease, and the left without any apparent cause.

An examination made twenty-four hours after death yielded the following results:—

The examination of the contents of the cranium presented nothing abnormal.

The left parotid was inflamed; its tissue appeared of a violet colour, with minute ecchymoses. From this inflamed tissue, minute masses could be expressed, (the size of a pin's head or less,) of a yellowish white colour, soft and semi-fluid. These appeared to be pus, but when examined under the microscope, exhibited no trace of pus-corpuscles, and appeared to be only the blastema for the formation of pus; they were amorphous, but contained fat-globules and minute granules (margarin) together with a few epithelial cells from the salivary ducts. On the addition of acetic acid the amorphous mass instantly disappeared; nothing remaining but the nuclei which resembled those of pus-corpuscles.

The lower lobes of the lungs were infiltrated with bloody serum; the bronchi were reddened and filled with a frothy fluid.

The mucous membrane of the stomach was soft and easily pulled off; at the lower part of the small intestines there were several *plaques* and small ulcers.

The mesenteric glands were slightly enlarged.

There was gangrene in both arms.

On the left side, from the back of the hand to four inches above the bend of the arm, the subcutaneous cellular tissue was reddened.

This redness penetrated to the bone and was associated with serous infiltration of the tissues. The muscles were also changed, being soft, viscid, and easily torn.

Muscular tissue from the middle of the forearm was examined under the microscope. It was of a grayish red colour, and very soft. The primitive fibres of the muscles retained their normal form, but they were very pale, transparent, gelatinous, and *without any trace of their normal transverse striæ* (Fig. 8). The cellular tissue, however, still retained its normal relations, showing the usual curved fibrous bundles. Between the muscles and the cellular tissue there were numerous fat-globules. There was no trace of blood corpuscles; they appeared to be wholly dissolved.

The same relation was exhibited by parts from other muscles of the fore-arm. The primitive fibres were pale, gelatinous, and without any trace of being striated, but the cellular tissue was normal. The blood-corpuscles had everywhere disappeared, while the fluid which saturated the whole of the tissue was of an uniform red colour.

On the right arm the subcutaneous tissue was also inflamed, especially in the vicinity of the wound previously mentioned; showing very considerable and numerous ecchymoses and incipient gangrene. The muscles were somewhat less soft, and less easily torn than in the left arm.

In the adipose cellular tissue, infiltrated with blood, blood-corpuscles were seen under the microscope partly dissolved, and partly still present, but all changed (spherical, dentated, and indistinct). The greater number of the fat-cells contained groups of crystals of margarin. The primitive muscular fibres appeared pale, and in parts striated, while in other portions this appearance was wanting. (Fig. 9).

Fig. 8. Exhibits primitive fibres of muscle, softened by gangrene, whose striated appearance was quite lost. They are covered with numerous fat-globules (on the left arm).

Fig. 9. Shows primitive fibres of muscle softened by gangrene, taken from the right arm. They are pale, the striated character still discernible in some parts, but wanting in others; their destruction is therefore not so far advanced as those delineated in Fig. 8.

Both figures are magnified 220 diameters.

Fig. 10. Exhibits gangrene with extravasated and decomposed blood. Magnified 220 diameters.

In t his figure a mass of decomposed blood from a partially gangrenous spleen, with black granules, (pseudo-melanosis,) is represented.

A man died from tubercles in the lungs, with perforation of the pleura and effusion of the softened tubercular mass into the pleural cavity.

He had exhibited no symptoms of derangement of the spleen; it was, however, larger than common, of a slate colour on the outer surface, and partially covered with old false membranes. In some places irregularly oval, yellowish white specks about the size of a bean were visible, presenting the appearance of tubercles shining through the fibrous membrane.

On cutting the spleen through the centre, it appeared normal, but rather soft. The external edge was of a dark bluish black colour; the coloration penetrating at some points only one or two lines in depth, and at others seven or eight lines; in those places which appeared externally as yellowish white specks, the dark tint extended to the greatest depth.

The spleen emitted a fetid gangrenous odour.

The red portion of the spleen, with the exception of being rather soft, was quite normal. It was very full of blood, and when this was removed by washing, normal spleen-corpuscles appeared (caudate cells, filaments with nuclei lying on them), which formed the parenchyma of the spleen without there being any intervening substance. When they were dissolved in ammonia, nothing remained but the vessels, and the fibrous bundles in the stroma of the spleen.

The black substance on the edge of the spleen was very soft, and admitted of being easily reduced to a pulp. Where it occurred in thin layers, it consisted of an accumulation of intensely black granules, which were irregularly round, and varied from the 400th to the 800th, or even 1000th of a line in diameter; and were neither dissolved or in any way altered by acetic acid, water, ammonia, or nitric acid. In some parts the black matter was so thickly crowded together that no individual granules could be discerned.

Where the black coloration penetrated deeply into the interior, larger or smaller portions of decomposed blood were found in the tissue of the spleen, forming coagulated masses of a yellowish, or blackish brown colour, such as are commonly met with in gangrene. Between them there were black (melanotic) granules in large quantities (Fig. 10).

a a are portions of decomposed blood— *b b* are the melanotic granules interspersed between them.

FIG. 11. The histological constituents of enchondroma. This figure represents a portion of enchondroma of the hand, with partial ossification. Magnified 220 diameters.

This preparation is in the Pathological Museum of Clinical Surgery at Erlangen, where I examined it in the summer of 1841. I am indebted to the kindness of Dr. Herz for the following notice of the patient, the operation he underwent, and the tumour on its first examination.

George Spoerl, a peasant from Schleifhausen near Erlangen, aged thirty-four years, of a healthy family, and having himself enjoyed excellent health, came to the School of Clinical Surgery, at Erlangen, in the autumn of 1839, with a tumour on the last joint of the right thumb. Two years previously, several small pisiform excrescences had appeared upon it, which were not at first stationary, but became gradually larger, until they covered the whole volar surface of the phalanx.

The skin covering them was at first normal, but it subsequently became red and discharged slightly; after which the patient suffered violent pain. He had used the thumb constantly when at work, and ascribed the aggravation of the disease to this circumstance. On examination, it was found that the volar surface of the last phalanx of the thumb was covered with a tumour, of the size of a walnut, consisting of uneven separate tuberous divisions, varying from the size of a pin's-head that of a pea or a hazel-nut, rounded off and well defined. The tumour covered by the reddened and distended skin had a smooth porcelain-like appearance. It was immovable, and firmly seated upon the bone, while the upper nodules were cartilaginous to the touch, their base being firmer and more osseous. While the joint was still free, the upper phalanx was removed. The wound healed without any difficulty. An examination after its extirpation shewed that the tumour consisted of separate divisions, which were cartilaginous above and on the sides; there being only isolated bony particles to be felt in the interstices. The base was osseous; it was not, however, immediately attached to the phalanx, but separated from it by the periosteum. The tumour had penetrated in two places into the phalanx, which was consequently excavated at those parts. Firm membranous bands passed from the tumour to the phalanx, and their insertion could only be recognized after a careful preparation of the parts. The remaining parts were normal, but the whole phalanx thinner, excepting at the places of insertion. The patient has had no relapse up the present time (July, 1842).

This tumour exhibited several deviations from ordinary enchondroma. It did not originate in the phalanx itself, but was divided from it by the periosteum. It consisted, further, only in part of cartilaginous matter, analogous to that of ordinary cartilage; *a. a.* being cartilaginous cells in an amorphous intercellular substance (A. A.); of which a portion (B. B.) was ossified and converted into true bony substance. It was of the hardness of bone, effervesced freely when immersed in hydrochloric acid (from the decomposition of carbonate of lime), and exhibited perfectly developed bone-corpuscles and osseous canals, surrounded by cylindrical, concentric laminæ.

PLATE X.

CONCREMENTA—EPIPHYTA—EPIZOA.

Fig. 1. Shows the crystalline deposition of cholesterin in atheroma of the aorta. Magnified 220 diameters.

An old man, aged eighty-four years, who had died from a perforating ulcer in the stomach, exhibited a deposition of calcareous salts (false ossification) in the arch of the aorta, between its inner and middle coats, besides a deposition of a yellowish-white greasy mass, (atheroma). This soft mass was found to consist of the following elements, when examined under the microscope :—

(1). Of many tabular colourless crystals of cholesterin, of the ordinary characteristic form, (rhomboidal tablets with angles measuring 103° and 77°).

(2). Of many irregular amorpho-granular masses, which did not dissolve in water, but were soluble in alcohol; after the evaporation of which, they again thickened into amorphous brownish clots—probably fat.

Besides these elements and some few fat-globules (3), nothing was present.

Fig. 2. Crystalline deposition of calcareous salts in the cuticle of the scrotum. Magnified 220 diameters.

A healthy man, aged thirty-three years, a baker by trade, had suffered from pruritus of the scrotum, from about his eighteenth year. There had gradually appeared upon the scrotum small wart-like excrescences, which after they had attained the size of a pea, dried up and disappeared; after which, new formations appeared in other parts, which again underwent the same change. This process has continued to the present time, (March, 1841), without much inconvenience to the patient, or the slightest influence upon his general health.

A minute examination showed a number of roundish tumours on the scrotum, varying from the size of a pea to that of a hazel-nut. There were upwards of a hundred and fifty of these protuberances scattered over its whole surface. They were situated immediately under the skin, which nevertheless appeared perfectly normal, and not in the slightest degree discoloured. They could be moved in any direction with the skin.

When these tumours were opened with a lancet, they discharged a pulpy, perfectly white mass, which when moistened with water, exhibited an alkaline reaction, and, on exposure to the air, became as hard as stone. This pulpy mass was found to consist, when microscopically examined (FIG. 2), of an indefinite finely granular mass, which appeared of a brownish colour by transmitted light, with colourless fragments of crystals, which were mostly rounded, but of an indistinct form, and never exhibiting any perfect shape.

This mass was not affected by water, alcohol, ether, or alkalies; but dissolved in acids with effervescence.

An accurate chemical investigation gave, as the chief constituents, carbonate and phosphate of lime, with a trace of chloride of sodium, and a slight admixture of organic matter, (fat and extractive matters).

One of the tumours, together with the enclosing cyst, was removed, and carefully examined, in order to discover the relation of the deposited calcareous salts to the surrounding tissue. The whole cyst was so impregnated with cutaneous crystals, that nothing definite could be ascertained concerning its structure. The external layer of the cyst, which was free from calcareous particles, consisted of undoubted bundles of fibres of areolar tissue, and contained much blood. A portion of the cyst was treated with dilute nitric acid, in order to remove the salts of lime, but nothing could be then seen under the microscope except fibrous bundles of areolar tissue and blood-vessels.

It therefore remained uncertain whether the salts were deposited in the tissue of the skin, or in the cutaneous glands; the latter is, however, most probably the case, since the calcareous fragments abraded from the inner surface of the cyst gave evidence of non-nucleated epithelial cells.

FIG. 3. Crystalline depositions of margarin. Magnified 220 diameters.

These depositions are frequently observed in the adipose tissue of the dead body, and probably owe their origin to purely chemical relations, as for instance, to a preponderance of margarin over olein in the human body, in consequence of which the former separates and crystallizes on the cooling of the body. These crystalline depositions are most frequently met with in fatty gangrenous parts, where indeed they are seldom absent.

The most frequent form of this structure is that in which the points of the crystals radiate round a central point in a star-like figure (Fig. 3. *a.*); seen sideways, this star appears like a sheaf (Fig. 3 *); sometimes two such sheaves appear united together (*b*); large needles occur but rarely, either isolated or decussating.

These crystalline groups are formed within the fatty cells (Fig. 3. *b. b*), and are only liberated when the latter are destroyed.

Fig. 4. Crystals of ammoniaco-magnesian phosphate. Magnified 90 diameters.

They are formed in all parts of the human body in which free ammonia occurs. The crystals form several modifications of one type, but all are hemiedric. The type (Fig. 4. *a.*) is a three-sided prism, with the corresponding angles of one of the sides truncated.

a * shows an ideal section of this form seen sideways. This type changes only on the further truncation of two, polarly opposite, corresponding angles (4. *b.*), and then by further truncating one of the two remaining angles, (Fig. 4. *c.*)

Fig. 5. Is a piece of soft gallstone from the human subject, given in order to illustrate its mechanical composition. Magnified 220 diameters.

The colourless portions are crystals of cholesterin; the coloured part consisting also of indistinct crystallized cholesterin, coloured by gall-pigment.

Fig. 6—8. Epiphyta—parasitic plants occurring in the human body.

Fig. 6. and 7. are fungi which compose the crusts of the scrofulous scald-head, (*Favus et Alphus*, Fuchs).

They consist partly of roundish granules (cells) ranged one upon the other, and partly of elongated, single, or ramifying threads; they are generally colourless, but sometimes faintly tinged with green. Fig. 6. is magnified 180 diameters, and Fig. 7. 400.

Fig. 8 Exhibits the yeast-plant, (*Torula Cerevisiæ*, Turpin), taken from a fluid ejected in large quantities by a man suffering from stricture of the pylorus, (hypertrophy of the muscular coat of the stomach). Magnified 220 diameters.

It forms round colourless granules, or cells, which increase by gemmation, and then form single or branching rows. Some have young cells within them (*), others increase by simultaneous gemmation and epigenesis of cells (* *) in their interior.

These fungi are found in the urine in Diabetes mellitus.

Fig. 9. and 10. Epizoa—parasitic animals occurring in the fluids of the diseased (?) human body.

Fig. 9. The *Trichomonos vaginalis*; an infusorium discovered by Donné, in the vaginal mucus of a woman. Magnified 300 diameters. (Copied from Donné, Recherches microscopiques sur la nature des Mucus, &c. Paris, 1837. Fig. 3).

Fig. 10. *Vibriones*, which develop themselves in large quantities in all putrid animal fluids, as putrid blood, albumen, &c., and are scarcely ever absent from foul ulcers, (*Vibrio prolifer.?* Ehrenberg). Magnified 410 diameters.

Fig. 11. The *Sarcina ventriculi*. *a*. In a perfect state. *b*. One of the four-celled frustules.

Fig. 12. The upper portion represents Fungi in Tinea favosa.

The lower portion, tubes observed in the sputa and in tubercular matter. (Bennett.)

END.

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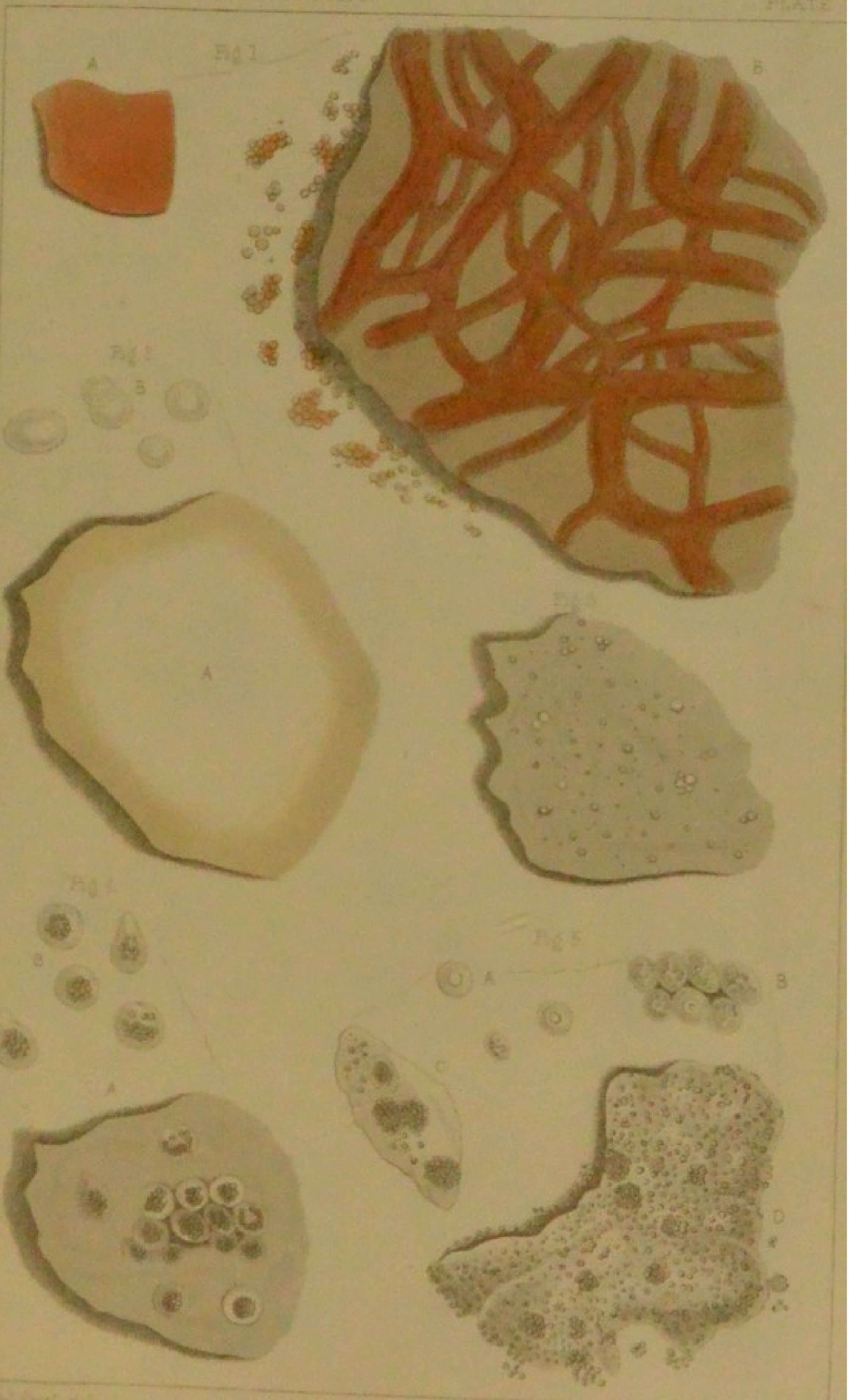

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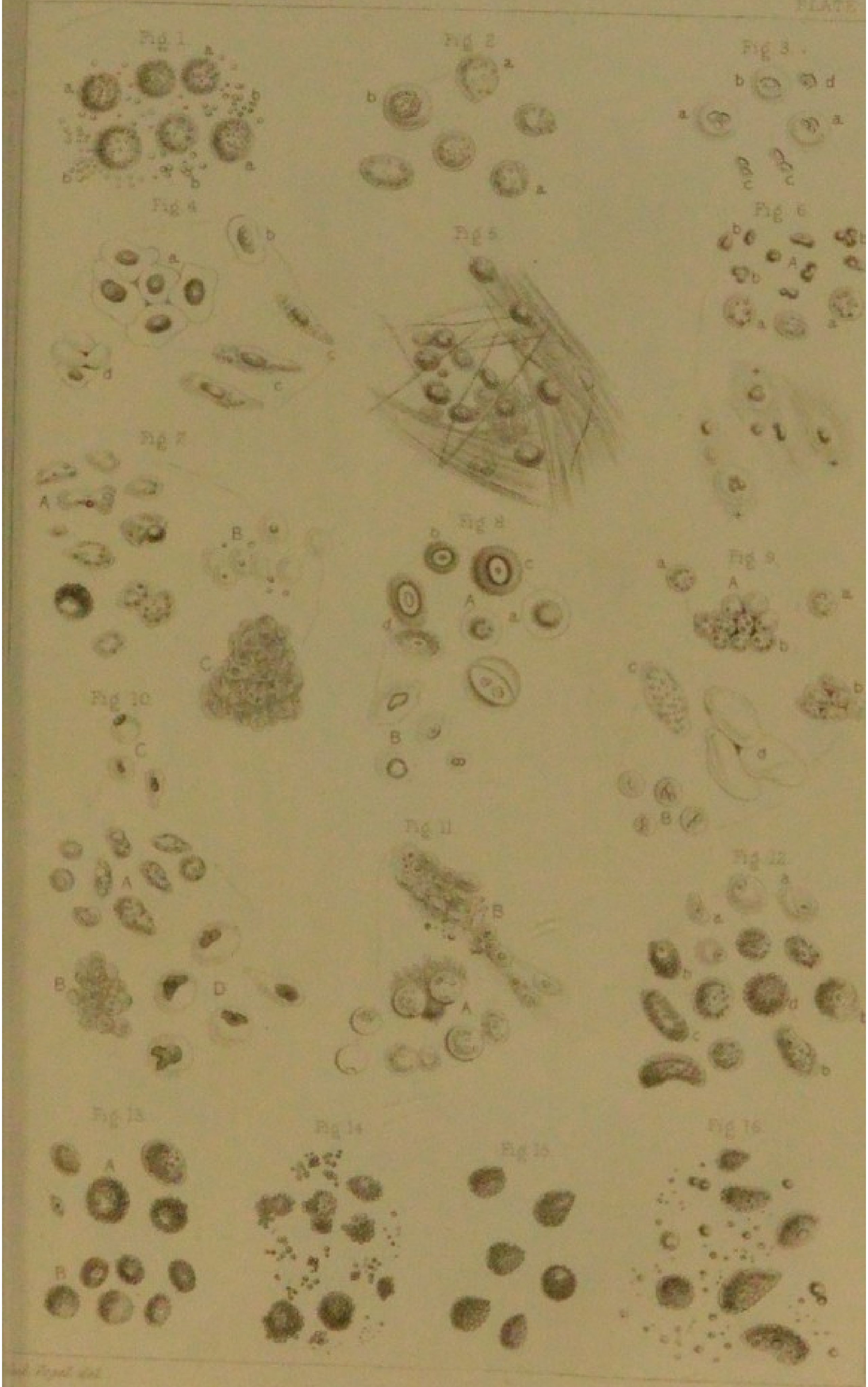

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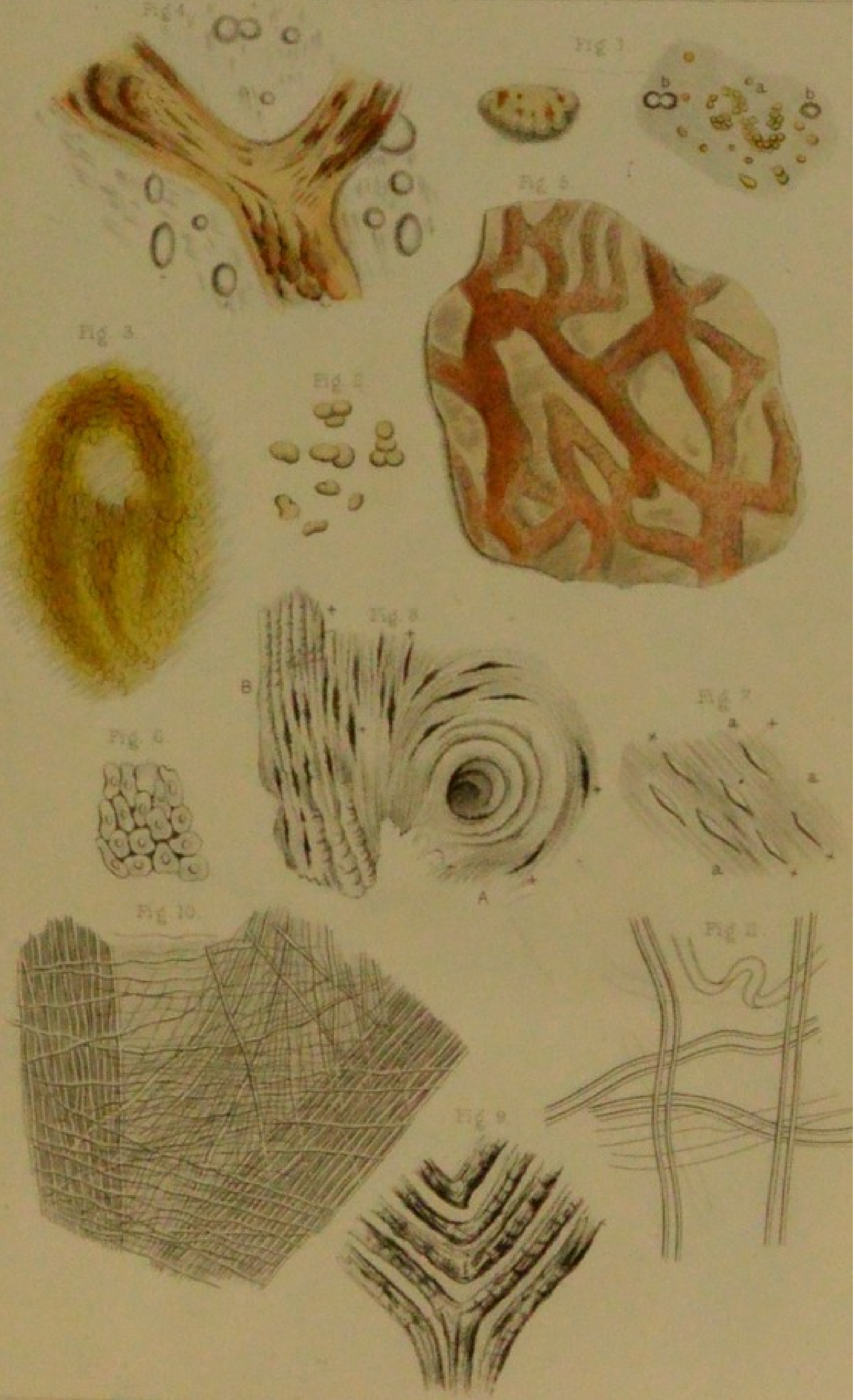

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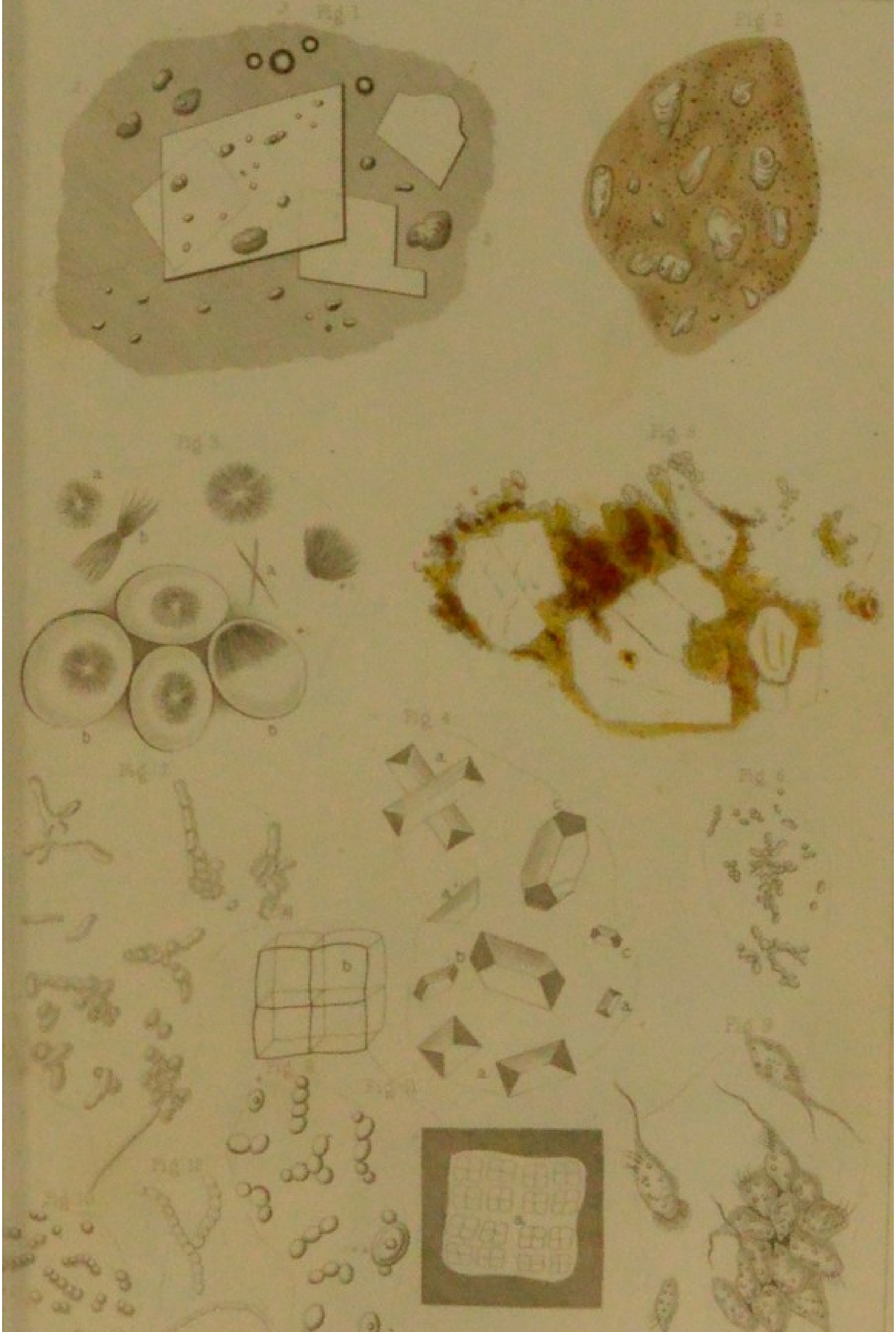
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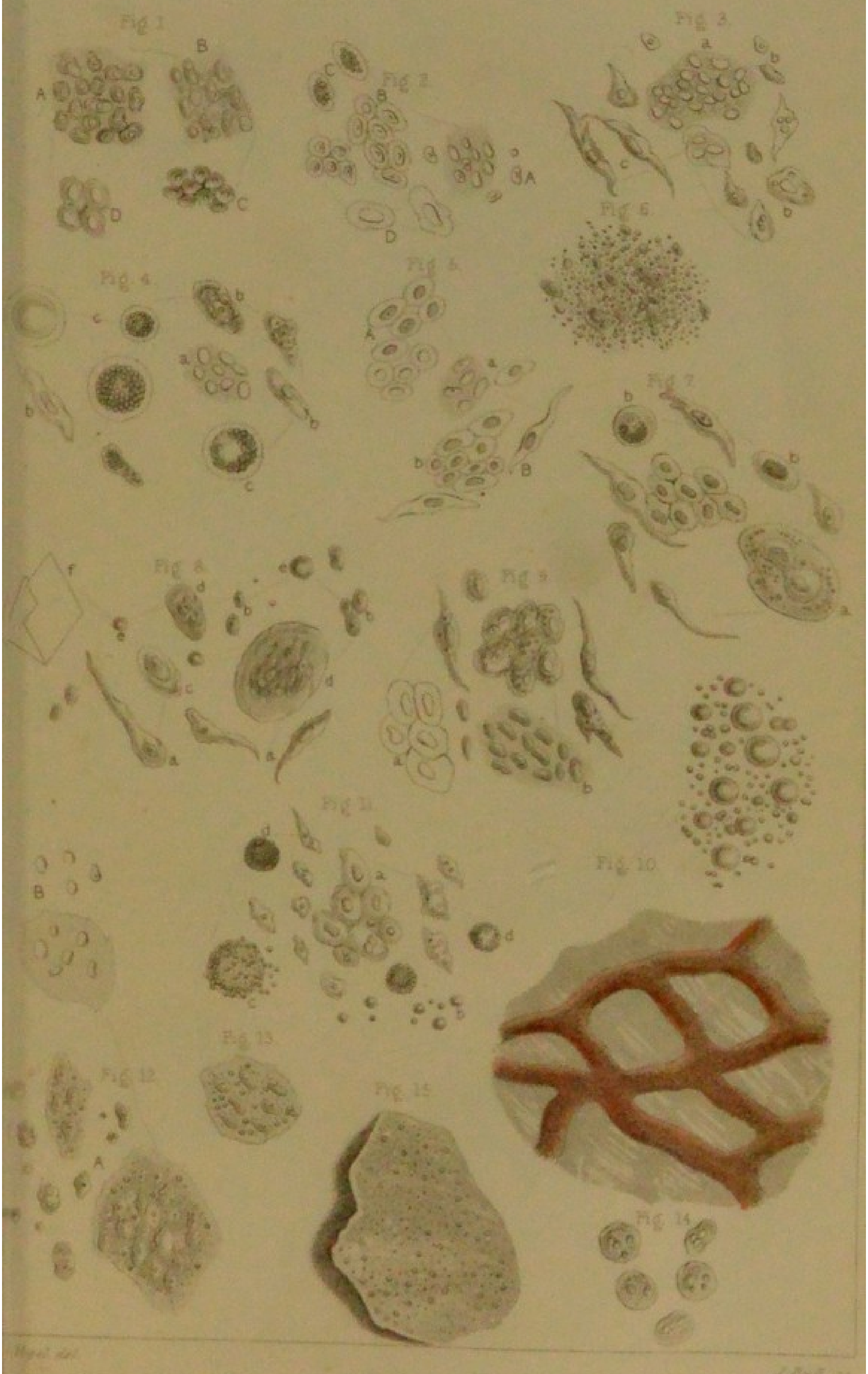
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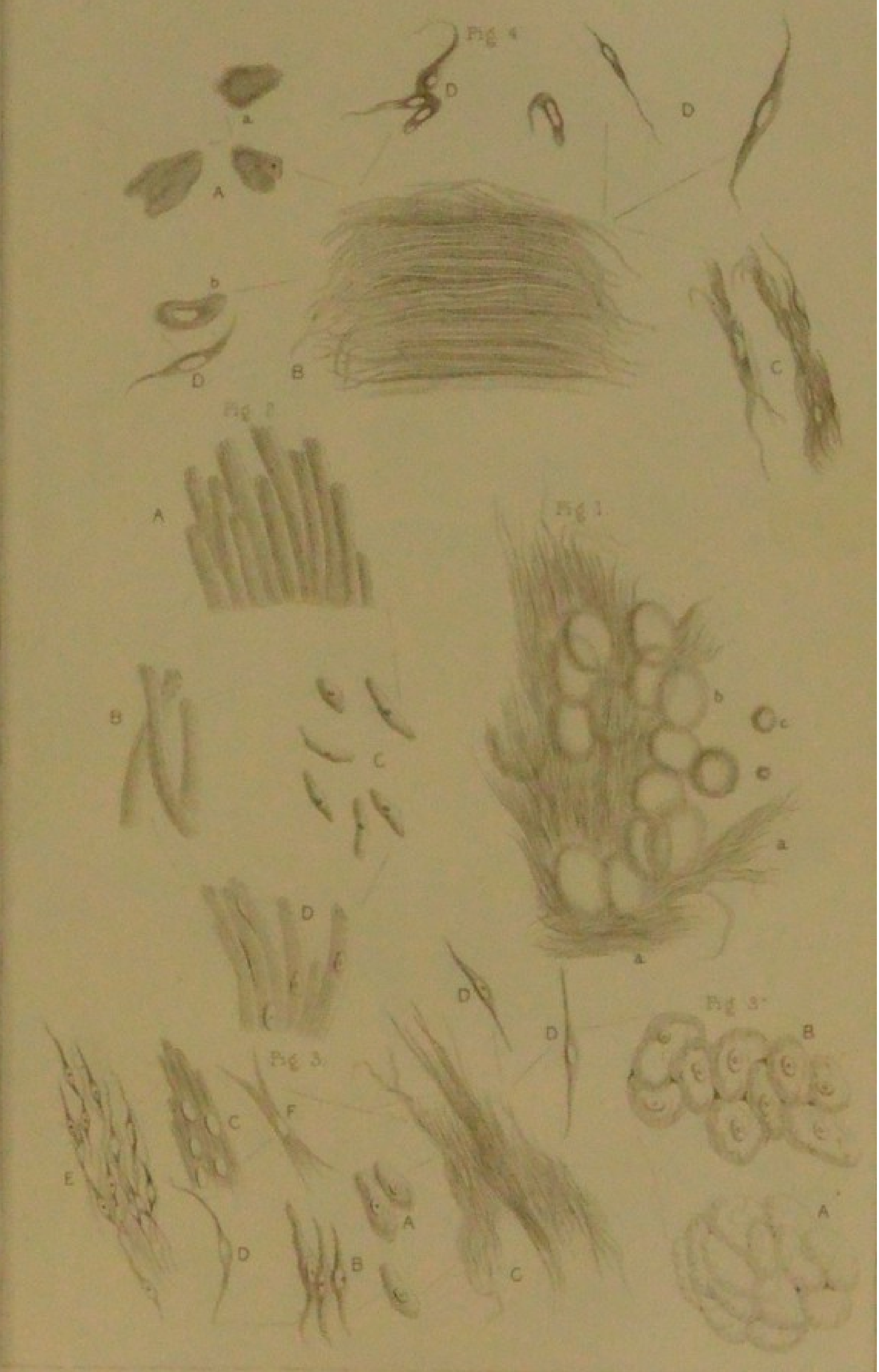

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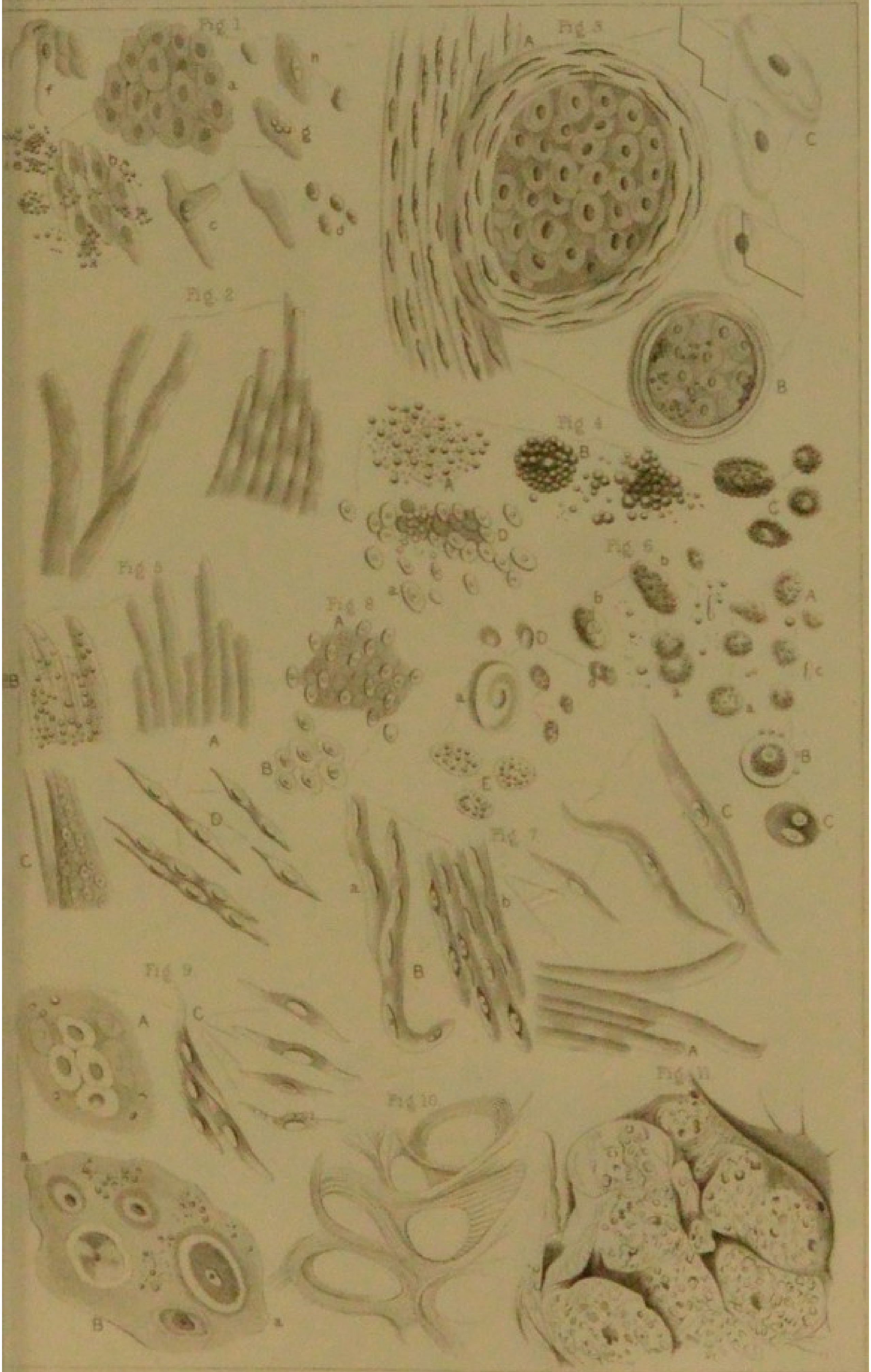
LIPOMA. FIBROUS TUMOUR.



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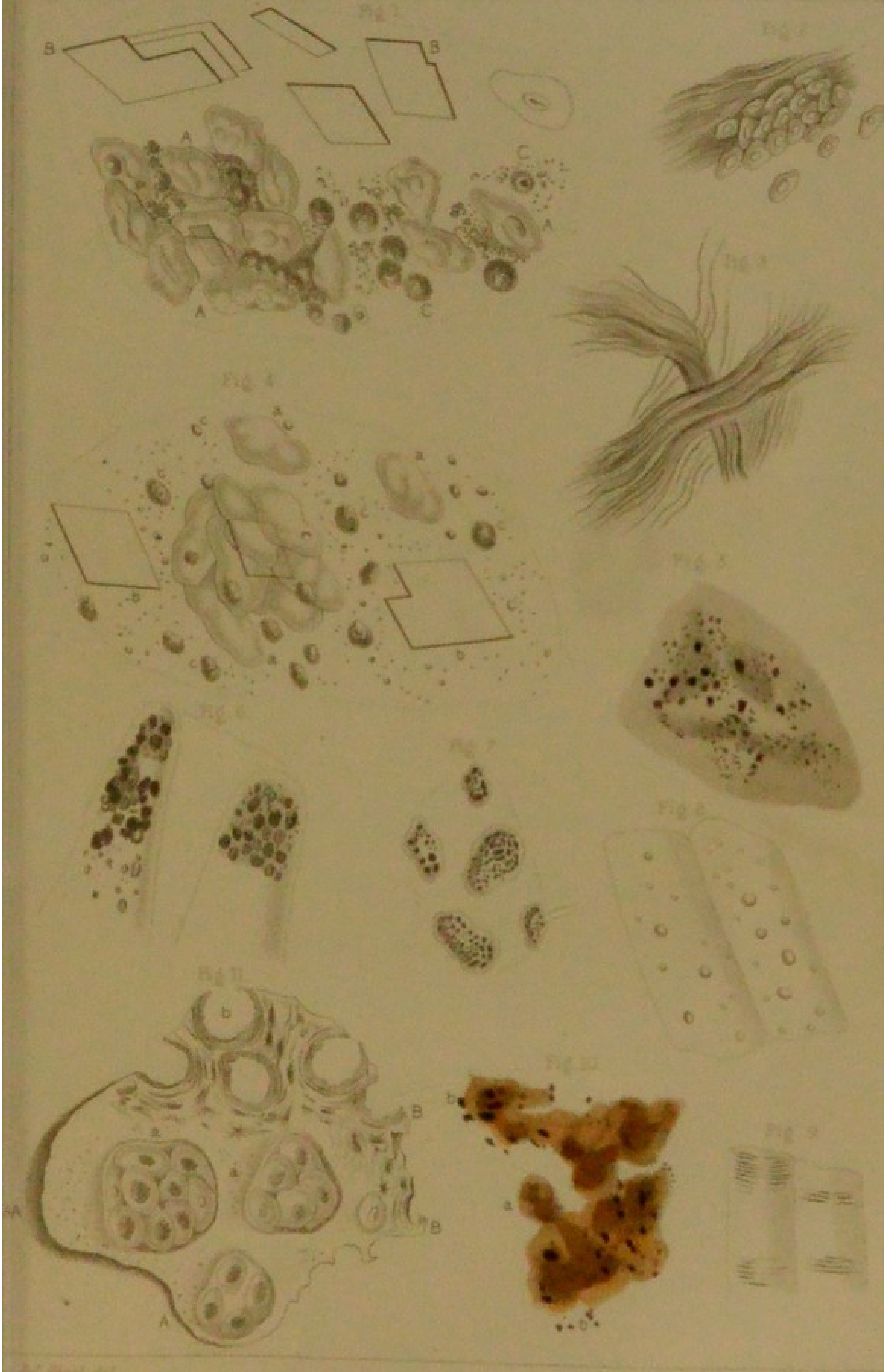

CYSTIC TUMOURS, MELANOSIS, GANGRENE, ENCHONDROMA

10.2.1978