LECTURES

ON

NUTRITION, HYPERTROPHY,

AND

ATROPHY,

Delivered in the Theatre of the Royal College of Surgeons, May 1847,

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NUTRITION, HYPERTROPHY, AND ATROPHY,

&c. &c.

LECTURE I.

Hypertrophy and atrophy the subject chosen for illustration—Prefatory remarks on the process of nutritive assimilation—the process considered in its several modes of development, growth, and assimilation — difference between these three forms of the formative process —Source of the waste undergone by all parts of the body—mode in which the repair of this waste is effected—proofs that each integral part of the body possesses a definite period of existence—Principal conditions necessary to healthy nutrition—Exact adaptation between the blood and the tissues—power of assimilation in the blood by which this adaptation is maintained—evidence of this adaptation afforded by symmetrical diseases—and by those blood-diseases possessing "seats of election"—other points proved by this class of diseases—Share taken by the several organs in preserving a right condition of the blood for healthy nutrition.

Mr. President and Gentlemen,—In the anxiety which I feel while undertaking the responsibility of the duties of Professor of Anatomy and Surgery to this College,—a responsibility commensurate with the dignity which the office has hitherto enjoyed,—it is satisfactory to feel no doubt respecting the subject to be chosen for the lectures. I believe that I owe the honour of being elected this year to the professorship, in great measure, to the circumstance of my having been long engaged in the study of the pathological department of the College-Museum, while arranging and describing it, under the superintendence of Mr. Stanley, for the new catalogue. And I may fairly suppose it to be the wish of the council, that, as the Museum is open to the examination of the members and pupils of the College, and of men of scientific pursuit, so should be the knowledge and the opinions which it has supplied or suggested to those who have had occasion to study it most deeply. For, indeed, to what thus grows out of the study of the Museum, the College has, in some measure, the right which the proprietor has to the produce of the cultivated soil. And, now that for a long time past, the most learned Hunterian Professor has every year brought in, from every source, so large a store of deep and wide-extending knowledge, of sagacious interpretation, and acute suggestion of the ways of nature, I hardly wonder that some return should be looked for from an inferior labourer in the field.

But, although it was plain that I should make the chief purpose of my lectures the illustration of some portion of the pathological collection, I was embarrassed what best to choose in the multitude of rare and instructive things which it contains,—till I resolved to make no choice at all, and take what first presents itself to the student of the Museum. The subjects, therefore, on which, Mr. President and Gentlemen, I beg your favourable hearing, are those, to the general illustration of which, the first two series of preparations in the Museum are devoted — hypertrophy and atrophy — the simple excess, and the simple deficiency, of nutrition in parts. Let me, however, as preparatory to the consideration of these, first engage your attention on the healthy formative process, or process of nutritive assimilation.

The formative process manifests itself in three modes, which, though they bear different names, and are sometimes described as if they were wholly different things, yet probably are only three expressions of one law operating in different conditions. The three, enumerating them in the order of their time, are development, growth, and assimilation.

By development, we mean the process by which a tissue or organ is first formed; or by which one, being already imperfectly formed, is so changed in shape or composition as to be fitted for a higher function; or, finally, is advanced to the state in which it exists in the most perfect condition of the species.

We must carefully distinguish development from mere increase: it is the acquiring, not of greater bulk, but of new forms and structures, which, by greater powers, are adapted to higher conditions of existence. For example, when, in the child, cartilage is changed to bone, there is not, necessarily, an increase of size; or, if there be, there is something more; there is that change of texture by which it is *developed* into bone. So, when, from the simple cavity of the embryonic digestive system, the stomach, intestines, liver, pancreas, and other organs are produced, these are developed; there is increase, but, at the same time, something more than mere increase of quantity.

And the distinction between development and increase, or growth, is shewn in this,—that, sometimes, even in instances in which they usually concur, the one proceeds without the other. I might quote many instances of this. I will choose two or three which illustrate some other striking facts. These brains of two adult idiots [exhibiting specimens] are equally diminutive, and of nearly equal size; but in one, so far as we can see, there is a due proportion of the several parts;—it is only too small. In the other, the parts are not well-proportioned; the posterior parts of the cerebrum do not half cover the cerebellum; indeed, no posterior cerebral lobes appear to be formed. Herein we recognize something more than a checked growth; for this truncation of the cerebrum is due to an arrest of its development, at the time when its hind-lobes—the parts last produced, and peculiarly characteristic of the human brain—were only just beginning to be formed. Our explanation of this most interesting specimen must be, that, when the brain had attained that degree of development which, according to Professor Retzius,* is proper to the human fœtus, about the beginning of the fifth month, and corresponds with the completed development of the brain of lower mammalia,—then its developement ceased. But though in form it is like the fœtal brain in the fifth month, yet, in all its dimensions, it is larger; so that when its development had ceased, its growth must have continued; and this was not checked till the brain had attained the size of the mature fœtus. In this brain, therefore, we find at once defective development and defective growth; but in that [pointing to the example first described] the development proceeded, and the growth alone was checked.†

Again, for an example in which development was checked and growth proceeded even beyond its normal limits—this heart, [exhibiting the specimen] from a child of three years old, presents only a single cavity; no partition has been developed between its auricles or its ventricles; it is, in respect of its development, like the heart of a fœtus in the second month; but though its development was checked thus early, its growth continued, and it has more than the average bulk of the heart at three years old.‡ So has this heart,§ in which development was arrested at a later period, when the septum of the ventricles was incompletely formed: in the eleven years the patient lived after birth, the development made no further progress, but the growth passed its ordinary bounds.

I will not multiply examples more than by referring to those two striking specimens in the physiological Museum—the skeletons of O'Byrne the giant, and of Madlle. Cracami the dwarf: compare these with the model-skeletons which stand beside them, and, allowing for the age of the dwarf, you will not find in it a defect, nor in the giant's skeleton an excess, of development; the one has not less than all the characteristic human forms, the other has no more; but the one is defective, the other is excessive, in

* Arch. d'Anat. et de Physiol., Janv. 1846.

† The two brains, together with casts of them, which were exhibited, are contained in the Museum of St. Bartholomew's Hospital, and are described in the Physiological Catalogue, Series 23, No. 40 and No. 70. The one in which the posterior cerebral lobes are deficient, weighed in its recent state 13 oz. 2 drachms avoirdupois; the individual from whom it was taken was 22 years of age, and had been an idiot from birth. The other brain (No. 70) was from a female, aged 21, who also was idiotic from birth.

‡ The above specimen is contained in the Museum of St. Bartholomew's Hospital, Physiological Division, Series 23, No. 33. The pulmonary artery is contracted and has no valves; the mitral velves are also absent; the ductus arteriosus is open.

§ Exhibited from the Museum of the College of Surgeons; Malformations, No. 127.

its bulk ; the growth has been erroneous in both.

It is, then, by the change to a higher state of form or composition, that development differs from growth,—the second mode of the formative process. For in mere growth no change of form or composition occurs; parts only increase in weight, and, usually, in size. In growth there is an addition of quantity, but no improvement in the quality of a part; the power of the growing part increases with the growth, but is, after all, only more of the same power; so, in the attainment of manhood, the heart of the boy, having all its necessary parts, and all well formed, acquires perfection by acquiring greater bulk, and, therewith, greater power.

Lastly, in the formative process, as it is normally manifested in the adult,—*i. e.*, in ordinary assimilation, parts only maintain their *status*. No perceptible change of size or weight ensues; no change of form or composition; there is exact stability. But this stability is maintained through continual changing of the particles; the change consisting in the regular formation of new parts in the place of those which are impaired, or die, in the ordinary course of life. Now for the elucidation of this mutation of parts—in the perfecting of which the formative process is continually occupied in the healthy adult body,—let me speak

1st. Of the sources of that impairment, or, if I may so say, that wear and tear, to which every part of the body appears to be subject.

2dly, Of the conditions necessary for the healthy state of the formative process by which the wear and tear is repaired.

3dly, Of the formative process itself.

First, then, the deterioration of the body may be traced to two principal sources, namely, the wearing out of parts by exercise; and the natural deterioration or death of every part or organ, independent of the decay or death of the whole body, after a certain period of existence.*

The first of these, the wearing out of parts by exercise, is admitted as a fact beyond question: and probably no tissue or part can be supposed to enjoy an immunity from this source of waste. For, although in all the passive apparatus of the body—the joints, bones, ligaments, elastic vessels, and the like—much of the beauty of their construction consists in the means applied to diminish the effects of the friction, and the various pressures and stretchings to which they are subject, yet, in enduring these at all, they must be impaired, and, in the course of years, must need removal. Doubtless, however, their waste by exercise is much less than that of the more active organs—the muscles, and perhaps the nervous system.

For, with regard to the muscles, it is growing more and more probable that the origin of their contractile force is in some decomposition of their substance, and it is certain that such decomposition attends their continued action; for their action is always followed by the increased discharge of urea, carbonic acid, and water; and, as the late researches of Helmholtz* show, they themselves, after long-repeated contractions, are found changed in chemical composition.

We have nearly similar evidence of the impairment of the nervous system by prolonged exertion of its power. We have, indeed, no proof that the simple conduction of an impression through a nervous cord can affect in any way its composition or its structure; but the abundance of alkaline phosphates discharged with the urine after great mental exertion, show that the various acts of the mind impair the brain through which they are manifested. And to this point tend, also, the researches of Dr. Bence Jones†, who has shown that the excretion by the kidneys of a large quantity of phosphates is a frequent result of inflammatory action in the brain. To this conclusion also, that mental exercise, whether perceptive or active, impairs the structure of the brain, we are led by our knowledge of the nature of the Mind; for to the principle, the immaterial thing, we cannot ascribe a weariness; it cannot be obnoxious to waste or to decay: mental fatigue, as we vaguely call it, is only what the Mind feels of an impaired state of the brain, and the recovery from what we call a weary mind is the restoration, not of the Mind itself, but of the organs which connect it with the external world, and in which, during tranquil sleep, the reparative nutrition goes on undisturbed.

But, whether active or passive, it is probable that no part of the body is exempt from the second source of impairment—that, namely, which consists in the natural death or deterioration of the parts (independent of the death or decay of the whole body) after a certain period of their life. It may be proved, partly by demonstration, and partly by analogy, that every integral part of the body is formed for a certain natural period of existence in the ordinary conditions of active life, at the end of which period, if not previously destroyed by outward force or exercise, it degenerates and is absorbed, or

* The merit of having first maintained in terms nearly similar to the above, and as more than an hypothesis, that "each part of the organism has an individual life of its own," and "a limited period of existence," belongs to Dr. Carpenter. (See his Principles of Human Physiology, 3d edit. page 623.)

* Müller's Archiv, 1845, Hefte 1, 2.

† Report of paper read before the Med. Chir. Soc. 27 Jan. 1847; Med. Gaz. vol. xxxix. p. 252.

dies and is cast out; needing, in either case, to be replaced for the maintenance of health.

The simplest examples that I can adduce of this are in the hair and teeth; and I beg you to observe that in the process which I shall describe we seem to have an image in which are plainly marked—though, as it were, in rough outline—all the great features of the process of nutrition.

An eyelash which naturally falls, or which can be drawn out without pain, is one that has lived its natural time, and has died, and been separated from the living parts. In its bulb such an one will be found very different from those that are still living in any period of their age. In the early period of the growth of a dark eyelash, we find its outer end almost uniformly dark, marked only with darker short linear streaks, and exhibiting no distinction of cortical and medullary substance. Not far from its end, however, this distinction is plainly marked; dark as the cortical part may be, the medullary appears like an interior cylinder of much darker granular substance: and in a young hair this condition is continued down to its deepest part, where it enlarges to form the bulb. Now this enlargement, which is of nearly cup-like form, appears to depend on the accumulation of nucleated cells, whose nuclei, according to their position, either by narrowing and elongation, are to form the fibrous substance of the outer part of the growing and further protruding shaft, or are to be transformed into the granular matter of the medullary portion. At this time of most active growth, all the cells and nuclei contain abundant pigment-matter, and the whole bulb looks nearly black. The sources of the material out of which the cells form themselves are, at least, two; the inner surface of the sheath, or capsule, which dips into the skin, enveloping the hair, and the surface of a vascular pulp, which fits in a conical cavity in the bottom of the hair-bulb.

Such is the state of parts so long as the growing hair is all dark. But as it approaches the end of its existence, it seems to give token of advancing age, by becoming grey. Instead of the almost sudden enlargement at its bulb, the hair only swells a little, and then tapers nearly to a point; the conical cavity in its base is contracted, and hardly demonstrable, and the cells produced on the inner surface of the capsule contain no particle of pigment. Still, for some time it continues thus to live and grow, and we find that the vigour of the pulp lasts rather longer than that of the sheath or capsule, for it continues to produce pigment-matter for the medullary substance of the hair for some time after the cortical substance has been entirely white. Thus, we can trace the column of dark medullary substance growing paler and more slender, and perhaps interrupted, down to the point of the conical pulp, which, though smaller, is still distinct, because of the pigment-cells covering its surface.

At length the pulp can be no longer discerned, and uncoloured cells alone are produced, and maintain the latest growth of the hair. With these it appears to grow yet some further distance, for we see traces of the elongation of their nuclei into fibres in lines running from the inner surface of the capsule inwards, and along the surface of the hair; and we can always observe that the column of dark medullary substance ceases at some distance above the lower end of the contracted hair-bulb.

The end of all is the complete closure of the conical cavity in which the hair-pulp was lodged, the cessation of the production of new cells from the inner surface of the capsule, and the consequent detachment of the hair as a dead part, which now falls by the first accident—falls, sometimes, quite bare and smooth on the whole surface of its white bulb, but sometimes brings with it a layer of cells detached from the inner surface of the capsule.

Such is the life of a hair, and such its death; which death, you see, is natural, spontaneous, independent of exercise, or of any mechanical external force—the natural termination of a certain period of life. Yet, before it dies, it makes provision for its successor, for when its growth is failing you often find, just below the base of the old hair, a dark spot, the germ or young pulp of the new one covered with cells containing pigment, and often connected by a series of pigment-cells with the old pulp or capsule. And this appears to be the product, as it were an offshoot, from some portion of the capsule of the old hair; for though it may sometimes appear only in the form of a conical pulp, yet more often, I think, it shows signs of connection with the capsule, and the cone is only more evident than the rest because of its covering of dark cells.

I believe that we may assume an intimate analogy between the process of successive life and death, and life communicated to a successor, which is here shewn, and that which is believed to constitute the ordinary nutrition of a part. It may be objected, indeed, that the death and casting out of the hair cannot be imitated in internal parts; but, we are not without an example in which the assumed absorption of the worn-out internal particle is also exactly imitated in larger organs at the end of their appointed period of life. I adduce the instance of the deciduous or milk-teeth.

We trace each of these developed from its germ, and, in the course of its own development, separating a portion of itself to be the germ of its successor: then, each, having attained its due perfection, retains for a time its perfect state, and still lives, though it does not grow. But at length, coincidently, not consequently, as the new tooth comes, the deciduous tooth dies; or rather, its crown dies, and is cast out like the dead hair, while its fang, with the bony sheathing, and the vascular and nervous pulp, degenerates, and is absorbed. It is here especially to be observed, that the degeneration is accompanied by some spontaneous decomposition of the fang, for it could not be absorbed unless it was first so changed as to be soluble. And it is degeneration, not death, which precedes its removal; for when a tooth-fang really dies, as that of the second tooth does in old age, then it is not absorbed, but is cast out entire, as a dead part.

Such, or nearly such, it seems almost certain, is the process of assimilation everywhere: these may be taken as types of what occurs in other parts, for these are parts of complex organic structure and composition, and the teeth-pulps, which are absorbed as well as the fangs, are very vascular and sensitive; and, therefore, we may be nearly sure, are subject to only the same laws as prevail in all equally organized parts.

Nor are these the only instances that might be adduced. We see the like development, persistence for a time in the perfect state, death, and discharge, in all the varieties of cuticles, with which, also, we may connect the example of the gland-cells; and in the epidermis we have, as in the teeth, an evidence of decomposition of the old cells, in the fact of the very different influence which acetic acid and potash exercise on them and on the younger cells, making these transparent, but leaving the old ones scarcely changed.

These things, then, seem to shew that the ordinary course of each complete elementary organ in the body, after the attainment of its perfect state by development and growth, is, to remain in that state for a time; then, independently of the death or decay of the whole body, and, at least in a great measure, independently of its own exercise, or exposure to external violence, to die or to degenerate; and then, being cast out or absorbed, to make way for its successor.

It appears, moreover, that the length of life which each part is to enjoy is fixed and determinate, though of course, in some degree, subject to accidents which may shorten its existence, as sickness may prevent death through mere old age; and subject to the expenditure of life in the exercise of parts. I do not mean that we can assign, as it is popularly supposed we can, the time that all our parts will last; nor is it at all likely that all parts are made to last a certain and equal time, and then all need to be changed. The bones, for instance, when once completely formed, must last longer than the muscles and other softer tissues. But, when we see that the life of certain parts is of determined length, whether they be used or not, we may assume, from analogy, the same of nearly all.

Now, the deciduous human teeth have an appointed duration of life: not, indeed, exactly the same in all persons, yet, on the whole, fixed and determinate. So have the deciduous teeth of all other animals, even, we may be sure, to those which, row after row, follow each other in regular succession, in the sharks.

So, again, in all those numerous instances of moulting, of shedding of the antlers, of the entire desquamation of the serpents, and of the change of plumage in birds, and of the hair in mammalia,—what means all this, but that these organs have their severally appointed times, degenerate, die, are cast away, and in due time are replaced by others, which, in their turn, are to be developed to perfection, to live their life in the mature state, and, in their turn, to be cast off.

The force of the evidence I have adduced is increased by the consideration of the exact analogy—almost the identity—of the processes of secretion and nutrition; for in no instance is the fact of this determinate life of the individual parts more clearly shewn than in the gland-cells, by which periodical secretions are elaborated; and, for the connecting link between their office and the nutrition of the most highly organised parts, as well as a manifest instance of determinate length of life and natural death, I may adduce the ova. These attain their maturity in fixed successive periods of days: they are separated (as some of the materials of several other secretions are) while yet living, and with a marvellous capacity of development, if only they be impregnated during the few days of life that remain to them after separation; but, if these days pass, and impregnation is not effected, they die, and are cast out, as impotent as the merest epithelium cell.

Now from these cases it is not by a far-fetched analogy that we assume the like mortality in all other tissues; and that these are the principal sources of impairment and of change for the worse, which every part of the body has within itself, even in the most perfect state, and in the conditions most favourable to life. And I may anticipate a future subject of consideration, by saying that the application of these truths is of some importance in practical pathology, inasmuch as the results of this degeneration of parts at the close of their natural term of life may be mingled with the effects of all the morbid processes by which the natural assimilation of a part is hindered or perverted: hence the long-continuing or permanent loss of power in a part—say a muscle—which has been disused, or, better, which has been the seat of inflammation. This loss is not due to a primary change in the fibre; for, as Mr. Hunter has explained in one of his far-sighted sentences quoted in the Catalogue, when a muscle or a nerve is inflamed, the inflammatory deposit is not in the fibres, but in the cellular tissue between and among them.* The loss of power, which abides after the inflammation, is mainly because the inflammatory process and the organisation of the newly effused morbid material exclude the ordinary process of nutrition, and the muscular fibres, which in the ordinary course of life degenerate, are not replaced, or are imperfectly repaired. To this same degeneration, too, we may perhaps ascribe the quantity of fat which is found in nearly all inflamed parts.

But of the results of these natural and unrepaired degenerations of tissues I shall speak hereafter. Now permit me to consider the conditions under which the repair of parts thus deteriorated is effected; for it is against the effects of these natural deteriorations that the process of nutrition in the adult is chiefly directed; and it appears to be by the disturbance or removal of certain necessary conditions, more often than by any suspension or perversion of itself, that error is engendered in the process of nutrition, and so disease is produced. And, in speaking of these conditions of healthy nutrition, I shall take leave occasionally to diverge, even very far, into the consideration of certain points of interest in the general physiology of the process.

Doubtless the conditions necessary to healthy nutrition are very many: but the chief of them are these four:—

1. A right state and composition of the blood or other nutritive material.

2. A regular and not far distant supply of such blood.

3. (At least in most cases) a certain influence of the nervous system.

4. A natural state of the part to be nourished.

And, first, of the right state of the blood, I may observe that I use the expression "right state" rather than "purity," because, if the latter be used, it seems to imply that there is some standard of composition to which all blood might be referred, and the attainment of which is essential to health; whereas the truth rather seems to be, that from birth onwards the blood and tissues of each creature are adapted to one another, and to the necessary external circumstances of life, and that the maintenance of health depends on the maintenance and continual readjustment of the peculiarities on which this exact adaptation depends.

The necessity for this right or appropriate state of the blood as a condition of healthy nutrition, involves of course the necessity for the due performance of the blood-making and blood-purifying functions—healthy digestion, healthy respiration, healthy excretion. Any one of these being disturbed, the formative process in a part or in the whole body may be faulty, for want of the appropriate material. But, important as these are, we must not let the consideration of them lead us to forget that there is something in the blood itself which is at least as essential to the maintenance of its healthy state as these are, and which is, indeed, often occupied in correcting the errors to which these more than itself are subject—I mean the power of assimilation, which the blood possesses in and for itself, as perfectly and at least as independently as any of the tissues. By this it is, that notwithstanding the diversity of materials put into the blood, and the diversity of conditions in which the functions ministering to its formation are discharged, yet the blood throughout life retains in each person certain characters as peculiar as those outer features of the man, for the continual renewal of which it provides appropriate materials. And by this assimilative power of the blood it is that the tissues are continually guarded; for by it many noxious substances introduced into the blood are changed and made harmless before they come to the tissues; nor can any substance introduced from without produce disease in an organ, unless it be such an one as can escape the assimilative and excretory power of the blood itself.

However, notwithstanding its possession of this power, the blood is subject to most various diseases, in consequence of which the nutrition of one or more tissues is disordered. The researches of modern chemistry have detected some of these changes—finding excesses or deficiencies of some of the chief constituents of the blood, and detecting in it some of the materials introduced from without. But a far greater number of the morbid conditions of the blood consist in changes from the discovery of which the acutest chemistry seems yet far distant, and for the illustration and discussion of which we cannot adopt the facts, though we may adopt the language and the analogies, of chemistry. For, as I shall now chiefly endeavour to illustrate, the healthy process of nutri-

* The quotation referred to above is taken from the Hunterian MS., and is inserted in the 1st vol. of the Pathological Catalogue of the College Museum, p. 44. The morbid specimens which this quotation illustrates will be found described at page 43.

tion depends on so nice a refinement of affinities—such an exact and constant adjustment of the adaptation between the blood and tissues—as we can only discern when we see the consequences of its loss.

I know no instances so well adapted to prove this as the examples of symmetrical diseases. I have here numerous specimens, and here, through the kindness of my friend Dr. William Budd, many sketches of other specimens. The uniform character of them all is, that a certain morbid change of structure on one side of the body is repeated in the exactly corresponding part on the other side. In this lion's pelvis, for example, multiform as the pattern is in which the new bone, the product of some disease comparable with a human rheumatism, is deposited—a pattern more complex and irregular than the spots upon a map—there is not one spot or line on one side which is not represented, as exactly as it would be in a mirror, on the other. The imitation is accomplished with daguerréotype exactness. And so with all the rest.

[Other specimens were shown, which displayed symmetrical syphilitic ulceration of the skull,—symmetrical necrosis of the jaw, — symmetrical ulceration of articular cartilage and fibrous tissue, — and many other affections. The diagrams displayed examples of equal symmetry in psoriasis, ichthyosis, eczema, lepra, paralysis from ead, &c.]

But I need not detain you with examples; they are so common that every day's practice will supply one or more in which this symmetry of disease is displayed with more or less exactness.

Now, to apply these facts as evidences of the refinement of the affinities which operate in the formative process. Excluding, perhaps, the cases of congenital symmetrical defects, and a few which seem to depend on morbid influence of the nervous system, it may be stated generally that all symmetrical diseases depend on some morbid material in the blood. You may find the proofs of this position in papers written simultaneously by Dr. William Budd and myself in the 25th volume of the Medico-Chirurgical Transactions; and in Dr. Budd's essay you may find it nearly demonstrated, by a masterly discussion of the subject, that in most of these cases the morbid material enters into combination with the tissue which is diseased, or with the organised product of the morbid process. Now the evident truth in all these cases is, that the morbid substance in the blood, whether the mercurial compound, or the organic compound peculiar to rheumatism, or the poison of syphilis, or, be it what it may, this substance acts upon and changes only certain portions of what we might otherwise suppose to be all the very same tissue. Such a substance fastens on certain islands on the surface of a bone, or of the skin, and leaves the rest unscathed: and these portions are the exactly corresponding pieces upon opposite sides of the body. The conclusion is unavoidable, that these are the only two pieces that are exactly alike; there was less affinity between the morbid material and the osseous tissue, or the skin, or the cartilage, close by, else it would also have been similarly diseased. But, manifestly, when two substances display different degrees of affinity for a third, their composition cannot be identical; so that though we may speak of all bone and all skin as if it were all alike, yet there are differences; and in all the body the only parts which are exactly like each other are those which are symmetrically placed upon the opposite sides.

No power of artificial chemistry can, indeed, tell the difference; but a morbid material can: it tests out the parts to which it has the greatest affinity, unites with these, and passes by the rest. I say no power of artificial chemistry can detect the difference; perhaps I should have said no power of imagination can conceive either the nature of the difference or the perfection of that adjustment with which, amid all the varieties of healthy life, the blood is maintained in perfect adaptation to these differences, and supplies to every part its appropriate material*.

I might magnify the wonder of this truth by showing how exceedingly small must be the quantity of the morbid material existing in the blood in some of these cases. But I prefer to illustrate a fact which singularly corroborates the evidence, afforded by symmetrical diseases, of the refinement of the operations of organic affinities. The fact is that of certain diseases,—and I think these are nearly all blood-diseases, — having "seats of election." For example, in these

* The following was added in a recapitulation of this portion of the lecture. "In what these differences consist I do not pretend to explain. Some of them may not even be permanent, but may depend on the several parts of a bone, or of the skin, of a limb (for example), being in different stages of development or degeneration. The symmetrical parts of the tissue being, in this respect, exactly alike, may be simultaneously and equally affected by the disease, while other parts of the same remain unaffected till, in the course of time, they attain by development or degeneration, the very same condition as the parts first affected. Then, if the morbid material still exist in the blood, these parts also become diseased: and so in succession may nearly the whole of a tissue. This view agrees very well with the fact that these symmetrical diseases spread, and so give evidence that a part which in one week or month is not susceptible of the influence of the morbid material may, in the next, become as susceptible as that which was first affected."

two lions' pelves [exhibiting the specimens] not only is the morbid product on each exactly symmetrical, but its arrangement is almost exactly alike in both: hardly a spot appears on one which is not imitated on the other. So in these rheumatic tibiæ and these syphilitic skulls. These, however, are only examples of a large class of cases commonly observed, of which the general character is that the disease is much more likely to affect one certain portion of a bone, or of the skin, or of some other tissue, than to attack any other portion: we are all in the habit of using the fact as an aid in diagnosis. But we may have overlooked the bearing of such a fact on the physiology of nutrition. It proves, on the one hand, as the cases of symmetrical diseases do, that the composition of the several portions of what we call the same tissue is not absolutely identical: if it were so, these diseases would as often affect one part of a bone or other tissue as another part, or would affect all parts alike. And it proves, on the other hand, a constant similarity, even an identity, of the morbid material on which each of these diseases depends, though it be produced in different individuals; so that we may venture to predict, that whenever chemistry shall discover the composition of these substances, it will be found as constant and as definite as the composition of those inorganic substances which the science has most successfully scrutinised.

In short, these symmetrical diseases with seats of election, prove,—

1st. That in the same person the only parts of any tissue which are identical in composition are, or may be, those which occupy symmetrical positions on the opposite sides of the body.

2dly. That in different individuals, the portions of the body which are identical, or most nearly so, in composition, are those in exactly corresponding positions.

3dly. That even in different individuals the specific morbid materials on which most of the diseases of the blood depend, are generally of identical composition.

But I must not forget to add (what Dr. William Budd has proved, and illustrated by some of his diagrams) that these diseases often show that, next to the parts which are symmetrically placed, none are so nearly identical in composition as those which are analogous; as, for examples, the backs of the hands and of the feet, which are here shown, not only symmetrically, but exactly similarly affected with psoriasis: and the corresponding parts of the thighs and arms, in this case of ichthyosis*. The same is shown in this specimen of fatty and earthy deposits in the arteries, from Mr. Liston's museum, in which exact similarity is shown in the plan, though not in the degree, with which the disease affects severally the humeral and femoral, the radial and peroneal, the ulnar and posterior tibial, arteries.

It would be foreign to my purpose to enter now upon all the subjects of interest which are illustrated by these causes. I may refer you again to the papers already mentioned, especially to Dr. Budd's. For the present it will be sufficient if I have proved (without pretending to explain or describe) the perfect and most minute exactness of the adaptation which, in health, exists between the blood and all the tissues; and that certain inconceivably slight disturbances of this adaptation may be sources of disease. If this be proved, I shall not fear to be met with an objection against too great refinement in what I shall next say concerning some of the means by which that right state of the blood, which is appropriate to the healthy nutrition of all the parts, is attained and preserved.

Before such an audience as this it would be useless and unbecoming to repeat the current truths of the physiology of the blood, or of the processes which serve in subordination to its development and renewal. These I may assume to be well known by nearly all who hear me; and I must endeavour to elucidate such points as appear wholly, or too nearly, neglected.

In this view I beg your attention to a source of change (it may be in one case for the better, in another for the worse) in the constitution of the blood, which is of much interest, and may be hereafter made of much importance in both physiology and pathology.

The germ of what I shall endeavour to develop is in the writings of Treviranus. His sentence is, that "each single part of the body, in respect of its nutrition, stands to the whole body in the relation of an excreted substance*." In other words, every part of the body, by taking from the blood the peculiar substances which it needs for its own nutrition, does thereby act as an excretory organ, inasmuch as it removes from the blood that which, if retained in it, would be injurious to the nutrition of the rest of the body. Thus, he says, the polypiferous zoophytes all excrete large quantities of calcareous and siliceous earths. In those which have no stony skeleton these earths are absolutely and utterly excreted; but in those in which they form the skeleton, they are, though retained within the body, yet as truly excreted from the blood and all the other parts, as if they had been

* Diagrams illustrating the above were exhibited.

* Die Erschein. und Gesetze des organischen Lebens, 1st Band, p. 401.

thrown out and washed away. So the phosphates which are deposited in our bones are as effectually excreted from the blood and the other tissues, as those which are discharged with the urine.

But Treviranus seems not to have apprehended the full importance of the principle which he thus clearly, though so briefly, stated; for it admits, I think, of far extension and very interesting application.

The influence of the principle may be considered in a large class of outward-growing tissues. The hair, in its constant growth, serves, over and above its local purposes, for the advantage of the whole body, in that, as it grows, it removes from the blood the bisulphide of protein and other constituents of its substance, which are thus excreted from the body. Now this excretion-office appears, in some instances, to be the only one by which the hair serves the purpose of the individual; as, for example, in the fœtus. Thus, in the fœtus of the seal, and, I believe, of most other mammals, removed as they are from all those conditions against which hair protects, a perfect coat of hair is formed within the uterus, and very shortly after birth is shed, and replaced by another coat of wholly different colour, the growth of which had begun within the uterus. Surely, in these cases, it is only as an excretion, or chiefly as such, that this first growth of hair serves to the advantage of the individual. The *lanugo* of the human fœtus is an homologous production, and must, I think, similarly serve in its economy by removing from the blood, as so much excreted matter, the materials of which it is composed.

Now, if this be reasonable, we may carry this principle to the apprehension of the true import of the hair which exists in a kind of rudimental state on the general surface of our bodies, and to that of many other permanently rudimental organs, such as the mammary glands of the male, and others. For these rudimental organs certainly do not serve, in a lower degree, the same purposes as are served by the homologous parts which are completely developed in other species, or in the other sex. To say they are useless, is contrary to all we know of the absolute perfection and all-pervading purpose of Creation; to say they exist merely for the sake of conformity with a general type of structure, is surely unphilosophical, for the law of the unity of organic types is, in larger instances, not observed, except when its observance contributes to the advantage of the individual. No; all these rudimental organs must, as they grow, be as excretions, serving a definite purpose in the economy by removing their appropriate materials from the blood, and leaving it fitter for the nutrition of other parts, or adjusting the balance which might else be disturbed by the formation of some other part. Thus they minister to the self-interest of the individual, while, as if for the sake of wonder, beauty, and perfect order, they are conformed with the great law of the unity of organic types, and concur with the universal plan observed in the construction of organic beings.

LECTURE II.

Importance of the excretory office of each organ in the process of development—circumstances favouring the supposition that the existence of certain materials in the blood leads to the formation of corresponding tissues — conclusions which may be drawn from these two principles in relation to the successive development of parts.—Complemental relation in which certain organs stand, in their nutrition, to each other—evidence of such relation afforded by the changes in nutrition undergone simultaneously by two or more parts, and by the commensurate development of certain organs.

Second condition essential to healthy nutrition, namely, a due supply of appropriate blood—proofs of the necessity of this condition afforded by mortification when the supply is diminished or cut off—cases and preparations illustrating this.—Nutritive materials derived from the blood-vessels by imbibition—the vessels themselves take no active share in nutrition — the whole process extra-vascular.

Third condition esssential to healthy nutrition, namely, the influence of the nervous system—arguments against, and those in favour of, the existence of such influence — evidence furnished by the effects of mental conditions on the formative process, and by the defective nutrition resulting from interruption of nervous supply to a part—class of nerves through which the formative process is influenced.

The principle illustrated in the last lecture—that each organ, while it nourishes itself, serves the purpose of an excretion, in that it removes from the blood certain constituents, which leave that fluid in a state more fit for the nutrition of the other parts—this principle has an application of peculiar interest in the history of development. For if it be influential when all the organs are already formed, and are only growing or maintaining themselves, much more will it be so when the several organs are successively forming. At this time, as each nascent organ takes from the nutritive material its appropriate constituents, so it will co-operate with the gradual self-development of the blood, to induce in it that condition which is essential, or most favourable, to the formation of the organs next in order to be developed.

The importance of this will the more appear, if we consider the probability that the consequence of the existence of certain materials in the blood is the formation of an organ, or structure, into the composition of which those materials may enter.

This is made certain, as a rule in pathology, by the cases in which diseased structures are formed, embodying materials which had their origin or previous existence in the blood; as in most of those inoculable and other blood-diseases in which morbid organisms are produced. It may be made very probable as a rule in physiology also. For example, when one kidney is destroyed, the other often becomes much larger—does double work, as it is said—and the patient does not suffer from the retention of urine in the blood: the full meaning of which (a well-known fact, and not without parallel) seems to be this:—The principal constituents of the urine are, we know, ready formed in the blood, and are separated through the kidneys by the agency—that is, by the development, growth, and discharge—of the renal cells; now, when one kidney is destroyed, there must for a time be an excess of the constituents of urine in the blood; for since the separation of urine is not mere filtration, the other kidney cannot at once, and without change of size, discharge a double quantity. What, then, happens? The kidney grows; more renal cells develope, and discharge, and renew themselves; in short, the existence of the constituents of the urine in the blood induces the formation of renal substance.

An analogous fact is furnished by the increased formation of adipose tissue in consequence of the existence of abundant hydro-carbon principles in the blood: a fact of daily observation, and not inapplicable, because fat is really a tissue, especially in its early development. And another, bearing on the same point, though not admitting of definite description, is the influence supposed, or perhaps proved, to be exercised by various diets in producing the especial growth of certain tissues—as the muscles, the bones, the hair, or the wool.

I add again, on this point, as on a former one, that the case as concerning nutrition is remarkably corroborated by the observation of similar facts in instances of secretions.

These facts seem enough to make highly probable the principle I mentioned—namely, that the consequence of the existence of certain materials in the blood is the formation of an organ, or structure, into the composition of which those materials may enter. At any rate, they make it nearly certain for the more lowly organised tissues, and for the products of disease; and hence, by analogy, we may assume it for the other tissues. Even for the very highest, we may safely hold that a necessary condition, if not a part of the cause, of their formation, is this previous existence of the appropriate materials in the blood.

Now, if we combine these two principles —firstly, that the blood is definitely altered by the abstraction of every material necessary for the nutrition of a part, and secondly, that the existence of certain materials in the blood induces, or, at the least, favours, the formation of corresponding tissues—it will follow, at any rate as a reasonable hypothesis, that the order in which the several organs of the body appear in the course of development, while it is conformable with the law of imitation of the parent, and with the law of progressive ascent towards the higher grade of being, is yet (at least in part, and in this part more directly,) the result of necessary and successive consequences: the formation of one organ, or series of organs, inducing, or supplying a necessary condition for, the formation of others, by the changes successively produced in the composition of the nutritive material from which they all take their nutriment. In other words, the development of each organ or system, co-operating with the self-development of the blood, prepares it for the formation of some other organ or system, till, by the successive changes thus produced, and by its own development and increase, the blood is fitted for the maintenance and nutrition of the completed organism.

Perhaps I may seem to have carried theory too far: I would apologise for doing so, and would carry it no further, if I did not feel that to such an audience as this, instructed in all the current facts of physiology, and, for the most part, engaged in acquiring knowledge by their own observation, rather than by the teaching of others, it becomes me to endeavour, not so much to instruct, as to suggest things which they may examine by their own knowledge.

I will, therefore, be bold to go on, and propose that this principle—that each organ, in its acts of self-nutrition, is as an excretory organ to all the rest—may be applied to individual instances; on the assumption that certain organs stand, in their nutrition, in a complemental relation to each other; so that neither of them can be duly formed, or maintained in healthy structure, unless the right condition of the blood be induced and preserved by the formation of the other.

It is, of course, very difficult, or even impossible, to find instances by which this theory of complemental nutrition can be proved; while, really, we neither know exactly what materials are necessary for the formation of any organ, nor have the means of detecting the presence of more than a very few of them in the blood. For it is all very well for the discussion of certain parts of physiology to say, for instance, that a muscle mainly consists of fibrine; but when we are considering the physiology of the formation of organs, we must remember that in every muscular fibre there are at least three different compounds—those of the sarcolemma, of the nucleus, and of the fibril; that these are all equally essential to the formation of the fibre; and that we know not the composition of any one of them, nor could detect the absence of any one of them from the blood, though the result of that absence might be to render the formation of a muscular fibre impossible.

But, though it may lack direct evidence, the theory seems, in itself, probable; and there are many facts which we can explain by it so well, that they become evidence for it:—which facts, moreover, are very fair subjects for theoretical explanation, since, I believe, they are admitted to be as yet wholly unexplained.

Among these is the general fact that a great change in nutrition rarely takes place in one organ at a time, but usually affects simultaneously two or more parts, between whose nutrition there is a manifest and constant connection, although there is little or no relation between their external functions. Such, to take an instance from a large class, is the connection between the growth of various appendages of the integuments and the development or maintenance of the genital organs. This appears to be a general rule. The growth of the beard at the period of puberty in man, with which we are so familiar, is more instructively represented in many animals: especially in birds. In these, as you know, at the approach of every breeding time, the genital organs begin to develope themselves for the season, as in man they do for the whole time of vigorous life. And, commensurately with this development, the plumage (especially in the male bird), becomes brighter and more deeply coloured, both by the growth of new feathers, and by the addition of colour to the old ones. The height and perfection of the plumage are coincident with the full development and activity of the reproductive organs; but, as in man, when the development of the genital organs is prevented, the development of the beard, and all the other external sexual characters is, as a consequence, hindered: so, in the birds, when the breeding season ends, and the sexual organs pass gradually into their periodic atrophy, at once the plumage begins to assume the paler and more sober colours which characterise the barrenness of winter.

So is it, also, at least in certain instances, in the mammalia, of which we have interesting evidence in the history of specimens presented to the museum by Sir Philip Egerton. These show that if a buck be castrated while his antlers are growing and still covered with the velt, their growth is checked, they remain as if truncated, and irregular nodules of bone project from their surfaces. Or, if the castration be performed when the antlers are full grown, these, contrary to what Redi said, are shed, nearly as usual, at the end of the season; but in the next season, only a kind of low conical stumps are formed in the place of antlers*.

It appears, then, as a general fact, that the development and activity of the reproductive organs have as a consequence, or as a necessary coincidence, a peculiar development and active growth or nutrition of certain other structures which, therefore, form the external sexual characters; but whose external functions stand in no apparent, often in no conceivable, connection with the generation of the species. The fact,—of the certainty and extent of which there can be no doubt,—is not hitherto explained; it is explicable on the theory of complemental nutrition,—by believing that the materials which in the formation of these organs of external sexual character are removed from the blood, leave and maintain the blood in the state necessary for the further development, growth, and active function of the proper sexual or reproductive organs. In other words, I would say, that where two or more organs are thus manifestly connected in nutrition, and not connected in the exercise of any external office, their connection is because one is partly formed of materials left in the blood by the formation of the other; so that each, at the same time that it discharges its own proper and external office, maintains the blood in the condition most favourable to the formation of the other.

Now, if the theory be admissible, we may find through it the meaning of the commensurate development and nutrition of many other organs, which in their external functions appear unconnected. Such are the concurrent development and activity of the thymus gland and the air-breathing organs, during the body's growth,—of the thyroid gland and the brain, (instances of commensurate development cited by Mr. Simon)*,—of the spleen and pancreas, (as pointed out by Professor Owen),—and, I would add, of the embryo and the mammary gland; for the same theory may hold true concerning the formation of certain organs which are, finally, connected in their external functions.

In all these cases, I think it will be hereafter proved (what I can now only suggest as being probable), that these several organs are, in their nutrition, complemental; that the formation of the one is essential to the production of some material necessary for the construction of the other: and that, as we may be sure of Treviranus' law, in general,—that each organ of the body, while it nourishes itself, is in the character of an excretion towards all the rest,—so, we may believe, more particularly, that certain organs are, mutually, as excretions from each other.

Such, gentlemen, is the theory I venture to propose to you. But now, let me return, and remind you that this grew out of the consideration of the first condition necessary for healthy nutrition,—namely, the right state of the blood; a state not to be described merely as purity, but as one of exact adaptation to the temperament, or peculiar structure and composition, of the individual: —an adaptation so exact that it may be disturbed by the imperfect nutrition of a single organ, and for the maintenance of which against all the disturbing forces of the outer life of the body, nothing can suffice except continual readjustment by the assimilative power of the blood itself.

The second condition of which I spoke as essential to the healthy process of nutrition, is,—

A regular supply of appropriate blood, in or near the part to be nourished.

The proofs of the necessity of this condition must be familiar to all. Instances will at once occur to your minds, in which too little blood being sent to a part, it has suffered atrophy: others, in which the supply being wholly cut off, mortification has ensued: others, in which the blood being stagnant in a part, has not efficiently contributed to its nutrition.

If I can give interest to this part of the subject at all, it is only by adducing interesting examples of the fact. Reserving examples of merely diminished nutrition to a future lecture, I will mention now only some of those which the museum displays,

* That these should be produced may depend on the accessory organs of reproduction being developed; for these would not necessarily at once fail to be produced because the testicles were extirpated.

* A Physiological Essay on the Thymus Gland, 4to. London, 1845; and, The Comparative Anatomy of the Thyroid Gland, in the Philosophical Transactions, 1844, Part 2.

of Nutrition wholly stopped by the absence or deficiency of fresh blood.

This is a specimen from Mr. Swan's donations :—the larynx of a man who, while in low health, cut his throat, and suffered so great a loss of blood that the nutrition of one of those parts to which blood is most difficultly sent, became impossible, and before he died, his nose sloughed.*

The case is analogous to one which you may remember is recorded by Sir Benjamin Brodie.† A medical man wished to be bled, in a fit of exceeding drunkenness; and some one bled him,—bled him to three pints. He became very ill, and next day both his feet were mortified, from the extremities of the toes to the instep.

This specimen, presented by Mr. Guthrie, exhibits a mortified, *i. e.* a completely unnourished, leg, from a case in which the femoral artery was obliterated near the groin through disease of its coats. The leg was amputated by Mr. Guthrie with justifying success; for the stump, though cut at some distance below the obliteration of the artery, did not slough, and the patient, an elderly lady, died only of exhaustion.‡

As a similar, and very rare, example of sloughing after the obliteration of a main artery, I may refer to this drawing of a large slough in the very substance of one of the hemispheres of the cerebrum, in consequence of a wound of the supplying common carotid,—a wound made by a tobacco-pipe thrust into the bifurcation of the carotid, and nearly closing its channel. The case is described by Mr. Vincent in the last volume of the Medico-Chirurgical Transactions.§

Here, also, is a specimen in which dry gangrene ensued in very unusual circumstances. While I was a pupil at St. Bartholomew's Hospital, a woman 48 years old, died, under the care of Mr. Earle, who had received some injury of the femur eighteen months before death. Whether it were a fracture, or indeed what it was, cannot now be said; but the injury was followed by enlargement of that portion of the wall of the femur with which the artery and vein are nearly in contact as they pass in the sheath of the triceps adductor muscle. At this part, then, the vein is compressed, and the artery, though not distinctly compressed, appears to have been hindered from enlarging. The consequence was dry gangrene of the leg, which slowly destroyed life, and which had no other apparent cause than this.*

Here are specimens, more interesting, perhaps, for the history of surgery, than for pathology. One is a tibia and fibula, the lower ends of which, together with the whole foot, perished in consequence of the obstruction of the circulation by an aneurism in the ham. It is an Hunterian specimen†; and surely we may imagine that sometimes Mr. Hunter would contemplate it with pride, to think how rare such things would be in after times; for here is a strong contrast: the limb of a man who once had an aneurism like the one which in the former case was so destructive, yet on whom Hunter was permitted to confer fifty years of healthy life by his operation of tying the artery at a distance from the diseased part. The museum of St. Bartholomew's owes this rare specimen and most interesting relic to the zeal of my colleague, Mr. Wormald. The patient was the fourth on whom Mr. Hunter performed his operation. He was 36 years old at the time; and though the tumor was not large, yet the whole leg was swollen, the veins were turgid, and he was exhausted, and in such bad health that the case seemed desperate; but he recovered, and lived, as I have said, fifty years. The artery was tied in the sheath of the triceps muscle; and in this operation, for the first time, Mr. Hunter did not include the vein. The preparation shews the whole length of the artery obliterated from the origin of the profunda, to that of the anterior tibial, and the aneurismal sac, even after fifty years, not yet removed, but remaining as a hard mass like an olive.‡

Now, the supply of appropriate blood, of which these specimens prove the necessity, must be in or near the part to be nourished. We cannot say exactly how near it must be, but, probably, all that is necessary is, that the nutritive material should admit of being inbibed in sufficient quantity into the substance of the part to be nourished. For imbibition must be regarded as the means by which all parts supply themselves with nutritive matter: thus deriving it from the nearest blood-vessels, the blood-vessels

* The specimen was exhibited from the Pathological Museum of the College of Surgeons, No. 1821.

† Lectures illustrative of various subjects in Pathology and Surgery, London, 1846, p. 350.

‡ The specimen is contained in the Pathological Museum of the Royal College of Surgeons (No. 141); and is described in the Pathological Catalogue, vol. i. p. 59.

§ Vol. xxix. p. 38.

* For a further description of this preparation, see the published Catalogue of the Anatomical Museum of St. Bartholomew's Hospital, First Series, No. 134.

† No. 710 in the Pathological Museum. A description of it will be found in one of the forthcoming volumes of the Pathological Catalogue.

‡ A description of the above preparation may be found in the Catalogue of the Museum of St. Bartholomew's Hospital, vol. i. Series 13, Sub-Series F. No. 4. The case is recorded in the "Transactions of a Society for the Improvement of Medical and Surgical Knowledge," vol. i. p. 138; and in Mr. Palmer's edition of Hunter's Works, vol. iii. p. 604.

themselves being only the channels by which the materials are brought near. The blood-vessels thus serve alike for the nutrition of the vascular, and, as we call them, the non-vascular parts, the difference between which, in this regard, is really very little. For the vascular, the nutritive fluid is carried in streams into the interior: for the other, it flows on one surface: but for both alike, the parts have to imbibe the fluid; and though the passage through the walls of the blood-vessels may possibly effect some change in the materials, yet all the business of formation is, in both alike, outside the vessels. Thus, in muscular tissue, the fibrils in the very centre of the fibre nourish themselves; yet these are distant from all blood-vessels, and can only by imbibition receive their nutriment. So, in bones, the spaces between the blood-vessels are wider than in muscle. yet the parts in the meshes nourish themselves, imbibing materials from the nearest source. And in the non-vascular epidermis, though no vessels pass into its substance, yet it imbibes nutritive matter from those of the immediately subjacent cutis: and maintains itself, and grows. The instances of the cornea and vitreous humour are stronger, yet similar.

There is, therefore, no real difference as to the mode in which these tissues obtain their nutriment; and, sometimes, even the same tissue is in one case vascular, in the other not,—as the osseous tissue, which, when it is in masses or thick layers, has blood-vessels running into it; but when it is in thin layers, as in the lachrymal and turbinated bones, has not. These subsist on the blood flowing in the minute vessels of the mucous membrane, from which, on the same plan, the epithelium derives nutriment on one side, the bone on the other, and the tissue of the membrane itself on every side.

It is worth while to remember this, else we could not understand how the non-vascular tissues—such as the cornea, the hair, and the articular cartilages, and, as I suspect, the various cuticles,—should be liable to diseases proper to themselves, primarily and independently.

Neither, except by thus considering the subject, shall we be clear of the error and confusion which result from speaking of the "action of vessels:" as we say, the healthy or disordered action, the increased action. of vessels, as if the vessels really made and unmade the parts. We have no knowledge of the vessels as anything but carriers of the materials of nutrition to and fro. These materials may, indeed, undergo some change as they pass through the vessels' walls: but that change is not an assuming of definite shape—the vessels only convey and emit the "raw material," and the parts make it up, each after its own fashion. The real process of formation of tissues is altogether extra-vascular, even, sometimes, very far extra-vascular, and its issue depends on the affinities (if we may so call them) between the part to be nourished and the blood.

The third condition stated to be essential to the healthy nutrition, is a certain influence of the nervous system.

Of late years, the current of opinion has run against the belief of this; and, of those who admit some influence of the nervous system upon the formative process, many do it, as it were, grudgingly and doubtfully. They hold that at most the influence is exercised only indirectly, through the power which the nervous system has of altering the size of the blood-vessels; or that the nervous system influences only the degree, without affecting at all the mode, of nutrition in a part.

The chief argument against the belief that the nervous system is always exercising influence on nutrition, and therefore always essential to its healthy course, is, that in plants and the early embryo, and in the lowest animals, in which no nervous system is developed, nutrition goes on well without it. But this is no proof that in animals which have a nervous system nutrition may be independent of it: rather, even if we had no positive evidence, we might assume that in ascending development, as one system after another is added or increased, so the highest, and highest of all the nervous system, would always be inserted and blended in a more and more intimate relation with all the rest. This would, indeed, be only according to the general law, that the inter-dependence of parts augments with their development. And, in fact, we find this is so; for not only will various conditions of the Mind, acting through the nervous system, variously affect the formative processes in the whole body, but there is scarcely an organ the nutrition of which may not be affected by the Mind. It is scarcely necessary to adduce examples of a fact so often illustrated; yet I may mention this one:—Mr. Lawrence removed several years ago a fatty tumor from a woman's shoulder; and, when all was healed, she took it into her head that it was a cancer, and would return. Accordingly, when by accident I saw her some months afterwards, she was in a work-house, and had a large and firm painful tumor in her breast, which, I believe, would have been removed, but that its nature was obscure, and her general health was not good. Again, some months afterwards, she became my patient at the Finsbury Dispensary: her health was much improved, but the hard lump in the breast existed still, as large as an egg, and just like a portion of indurated mammary gland. Having heard all her account of it, and how her mind constantly dwelt in fear of cancer, I made bold to assure her, by all that was certain, that the cancer, as she supposed it, would go away; and it did become very much smaller, without any help from medicine. As it had come under the influence of fear, so it very nearly went under that of confidence. But I lost sight of her before the removal of the tumor was complete.

Cases of this kind are hardly rare; and there are other cases in which the influence of the nervous system alone, quite independent of the Mind, is as clearly shown. Of course, such cases can only be drawn from those of abstraction of the nervous influenced; the effects of which are most plainly expressed in the nutrition of parts exposed to external agencies, as the integuments generally, the extremities, and other external parts.

Here is an example of central penetrating ulceration of the cornea, in consequence of destruction of the trunk of the trigeminal nerve, by the pressure of a tumor near the pons. The case is related by Mr. Stanley, in the first volume of the MEDICAL GAZETTE.* The whole nutrition of the corresponding side of the face was impaired; the patient had repeated attacks of erysipelatous inflammation, bleeding from the nose, and, at length, destructive inflammation of the tunics of the eye, and this ulceration of the cornea.†

This is the hand of a man, whose case is related by Mr. Swan, (the donor of the preparation) in his Treatise on the Diseases and Injuries of the Nerves‡. The median nerve, where it passes under the annular ligament, is enlarged, with adhesion to all the adjacent tissues, and induration of both it and them. A cord had been drawn very tight round this man's wrist seven years before the amputation of the arm. At this time, it is probable, the median and other nerves suffered injury, for he had constant pain in the hand after the accident, impairment of the touch, contraction of the fingers, and (which bears most on the present question) constantly repeated ulcerations at the back of the hand.§

Mr. Hilton has told me this case:—A man was at Guy's Hospital, several years ago, who, in consequence of a fracture at the lower end of the radius repaired by an excessive quantity of new bone, suffered compression of the median nerve. He had ulceration of the thumb, and fore and middle fingers, which had resisted various treatment, and was cured only by so binding the wrist that, the parts on the palmar aspect being relaxed, the pressure on the nerve was removed. So long as this was done, the ulcers became and remained well; but as soon as the man was allowed to use his hand, the pressure on the nerves was renewed, and the ulceration of the parts supplied by it returned.

Mr. Travers, in his Further Inquiry concerning Constitutional Irritation,* mentions a case in which a man was paralysed by fracture of the lumbar vertebræ. He fractured at the same time his humerus and his tibia. The former, in due time, united: the latter did not.

Sir B. C. Brodie mentions the having seen mortification of the ankle begin within twenty-four hours after an injury of the spine.†

It would be easy to multiply facts of this kind—and that without adducing instances of experiments on lower animals, which, though they be corroborative, cannot be fairly applied with much weight here, since the probability is that the influence of the nervous system in nutrition increases uniformly and commensurately with its development. I will only refer, in general, to the numerous examples of the little power which paralysed parts have of resisting the influence of heat—the sloughing after injury of the spinal chord—the slower repair and reproduction of parts whose nerves are paralysed or divided—all alike contributing to prove that the integrity of the nervous centres and trunks which are in anatomical relation with a part, is essential to its due nutrition, or, at the least, is essential to its capacity of maintaining itself against the influence of external force—which capacity is, indeed, itself an expression of the formative power.

And all this is strengthened by the consideration of the influence of the nervous system on secretion, which is so nearly identical with nutrition: and, I may add, by the connection which manifestly exists between the development of the brain and the power of maintaining a steadfast temperature by the development of animal heat, as illustrated this year by Professor Owen.

Probably no tissue is wholly exempt from this influence of the nerves. In the cuticle it is manifest; and, for its influence in acting even through a considerable distance, I mention this case, as one in near relation to those in which the hair grows quickly grey in mental anguish. A lady, who is subject to

* Page 531.

† The specimen is preserved in the Museum of St. Bartholomew's Hospital; and a further description of it may be found in the published catalogue of that museum, Vol 1. Ninth Series. No. 9.

‡ Page 60.

§ This preparation is preserved in the Pathological Museum of the College of Surgeons, No. 2177.

* Page 436.

† Lectures on Pathology and Surgery, 1846, page 309.

attacks of what are called nervous headaches, always finds next morning that some patches of her hair are white, as if powdered with starch. The change is effected in a night, and in a few days after, the hairs gradually regain their dark brownish colour.

If, now, we may take this influence of the nervous system to be proved, we may consider the question—by or through what class of nerves is the formative process influenced?

Indirectly, it is certain that the motor or centrifugal nerves may influence it; for, when these are paralysed, the muscles they supply will be inactive, and atrophy will ensue, first, in these muscles: then, in the bones of the limb, (if a limb be the seat of the paralysis,) for the bones, in their nutrition, always observe the example of their muscles: and, finally, the want of energy in the circulation, which is, in some measure, dependent on muscular action, will bring about the atrophy of the other tissues of the part. Hence, after a time, the evidences of paralysis of the facial nerve may be observed in nearly all the tissues of the face.

But the effects of destruction of the trigeminal nerve, while the motor nerves of the parts which it supplies are unimpaired, proved that a more direct influence is exercised through sensitive or sympathetic nerves. The olfactory, optic, third, fourth, sixth, and facial nerves, may be one and all destroyed, yet no disturbance of the nutrition of the nose or eye may ensue. After destruction of the facial, indeed, there may be inflammation of the eye from irritants, which the paralysed orbicularis palpebrarum cannot shut out or help to remove; but neither this nor any other injury of these nerves is comparable with the consequences of the destruction of the trigeminal;—consequences which in the rabbit are manifest, and may be very grave, within a day of the destruction of the nerve, and may be completely destructive of the eye within three days.

The direct influence of the trigeminal nerve, with its mingled sensitive and sympathetic fibres, is confirmed by some cases which are said to have shown that after injuries or diseases of the spine, sloughing of the bladder and other parts has occurred earlier and more extensively when sensation than when motion alone was lost.

Mr. Curling, also, has recorded a case* which somewhat strengthens the view. Two men were, at nearly the same time, taken to the London Hospital with injury of the spine; one had lost only the power of motion in the lower extremities; the other had lost both motion and sensation; and at the end of four months the atrophy of the lower extremities in this last was far more advanced than in the other.

None of these cases, however, enables us to say whether the influence on nutrition is xercised through sensitive fibres of the cranio-spinal system, or through sympathetic fibres; nor do I think this question can be yet determined.

On the one side we have the fact (according to Magendie and Longet) that the destructive inflammation of the eye ensues more quickly after division of the trigeminal nerve, in front of the Casserian ganglion, than when the division is made between the ganglion and the brain. From this we might assume, that filaments derived from the ganglion, or passing through it from the sympathetic nerve, are those through which the influence on nutrition is exercised. And this would be supported by the fact that increased secretion of tears and mucus from the eye, and increased redness of the conjunctiva, are ordinary consequences of the extirpation of the superior cervical ganglion of the sympathetic in dogs.

But, on the other side, we have the facts of defective nutrition in consequence of injuries of the spinal chord, when the sympathetic centres are uninjured; as in the cases already mentioned from the works of Sir B. C. Brodie and Mr Travers. For this view, also, is the occurrence of general atrophy in consequence of diseases of the brain.

The case really seems to be, that the influence may be exercised through either kind of nerves;—but perhaps it may be well to defer judgment till fresh evidence is obtained.

* In the Medico-Chirurg. Trans., vol. xx. page 342.

LECTURE III.

Fourth condition essential to healthy nutrition, namely, a healthy state of the part to be nourished—this implied in the very idea of assimilation.—Precision of the assimilative process in diseased as well as in healthy parts—shewn in the persistence of cicatrices, thickenings, and indurations—and illustrated in the case of infectious and inoculable diseases—evidence furnished by frequently recurring diseases not contradictory of this—both prove that an alteration once produced in a part is likely to be perpetuated.—Tendency of altered blood and tissues to revert to the perfect state.—Exactness of assimilation applied in explanation of the connection between the immaterial Mind and the brain.

Nature of the process of assimilation—its object the replacement of lost particles—mode in which the old particles are disposed of—distinction between parts which die and those which simply degenerate—the former cast out entire, the latter absorbed.—Formative portion of the assimilative process probably always one of development—evidences of this—difference between nutritive reproduction and nutritive repetition.

Second variety of the formative process, namely, Growth—this consists in the addition of fresh quantities of the same material—amount of this addition proportioned to the requirements of the part—"reserve power" in tissues by which this is effected—excess of such addition constitutes hypertrophy—deficiency of it, atrophy.—Besides growing in hypertrophy, parts may, on an emergency, be developed into higher forms of tissue.—The conditons essential to healthy nutrition equally or more necessary in hypertrophy.

The last condition which I mentioned as essential to healthy nutrition, is a healthy state of the part to be nourished.

This is, indeed, involved in the very idea of assimilation; wherein the materials are supposed to be made like to the structures in which they are deposited: for unless the type be good, the anti-type cannot be.

With the consideration of this part of the subject, let me connect some illustration of the exactness of assimilation in diseased as well as in healthy parts,—that is, of the precision with which the new-formed blood and tissues take the likeness of the old ones in all their peculiarities, whether structural, chemical, or vital; whether normal, or anormal.

The exactness of this assimilation in the healthy parts has been already, in some measure, illustrated, as preserving through life certain characteristic differences, even in the several parts of one organ,—preserving, also, all those peculiarities of structure and of action, which form the proper features, and indicate the temperament, of the individual. In these, and in a thousand similar instances, the precision of the assimilative process is perfect and absolute, except in so far as it admits of a very gradual alteration of the parts, in conformity with the law of change in advancing years.

Nor is there less of exactness in the assimilation of which a part that has been diseased is the seat. For, after any injury or disease, by which the structure of a part is impaired, we find the altered structure,—whether an induration, a cicatrix, or any other,—perpetuated, as it were, by assimilation. It is not that an unhealthy process continues: the fact is the result of the process of exact assimilation operating in a part of which the structure has been changed: the same process which once preserved the healthy state, maintains now the diseased one. Thus, a scar or a diseased spot may grow and assimilate exactly as its healthy neighbours do. The scar of the child, when once completely formed, commonly grows as the body does, at the same rate, and according to the same general rule; so that a scar which the child might have said was as long as his own fore-finger, will still be as long as his fore-finger when he grows to be a man.

Yet, though this increase and persistence of the morbid structure be the general and larger rule, another within it is to be remembered, namely, that in these structures there is usually (especially in youth) a tendency to revert to the original state: a looking back, as if with longing, after the old perfection. Hence, cicatrices, after long endurance, and even much increase, may, as it is said, wear out; and thickenings and indurations of parts may give way, and all become again pliant and elastic.

The maintenance of morbid structures is so familiar a fact, that not only its wonder, but its significance, seems to be too much overlooked. What we see in scars and thickenings of parts appears to be only an example of a very large class of cases: for this exactness by which the process of assimilation in a part maintains the change once produced by disease, offers a reasonable explanation of the fact that certain diseases usually occur only once in the same body. The poison of small-pox, or of scarlet fever, being, for example, once inserted, soon, by multiplication or otherwise, affects the whole of the blood: alters its whole composition: then, the disease, in a definite form and order, pursues its course; and, finally, the blood recovers, to all appearance, its former state. Yet it is not as it was: for now the same material, the same variolous poison, will not produce the same effect upon it; and the alteration thus made in the blood or the tissues, is made once for all: for, commonly, through all after-life, assimilation never deviates from the altered type, but reproduces particles exactly like those altered by the disease; the new ones, therefore, like the old, are incapable of alteration by the same poison, and the individual is safe from the danger of infection.

So it must be, I think, with all diseases which, as a general rule, attack the body only once. The most remarkable instance, perhaps, is that of the vaccine virus. Inserted once in almost infinitely small quantity: yet, by multiplying itself, or otherwise, affecting all the blood: it may alter it once for all. For, unsearchable as the changes it effects may be; inconceivably minute as the difference must be between the blood before, and the blood after vaccination, yet, in many instances, that difference is perpetuated; in nearly all it is long retained; for by assimilation, the altered model is precisely imitated, and all the blood thereafter formed is insusceptible of the action of the vaccine matter.

In another set of diseases we see an opposite, yet not a contradictory, result. In these, a part once diseased is, more than it was before, liable to be affected by the same disease; and the liability to recurrence of the disease becomes greater every time, although in the intervals between the successive attacks the part may have appeared quite healthy. Such is the case with gout, with common inflammation of a part, as the eye, and many others, in which people become, as they say, every year more and more subject to the disease.

I do not pretend to determine the essential difference between the two classes of disease in these respects, in which they are antipodal; but in reference to the physiology of the formative process, they both prove the same thing, viz. that an alteration once produced in a tissue, whether by external influence, or by morbid material in the blood, is likely to be perpetuated by the exactness of assimilation, *i. e.* by the constant reproduction of parts in every respect precisely like their immediate predecessors.

But it will be said, the rule fails in every case (and they are not rare) in which a disease that usually occurs but once in the same body, occurs twice or more; and in every case of the second class in which liability to disease is overcome. Nay, but these are examples of the operation of that other, not less certain, though, as it seems, less powerful and more slowly acting, law,—that after a part has been changed by disease, it tends, naturally, to revert towards the perfect state. Most often the complete return is not effected; but sometimes it is,—and the part, at length, becomes as if disease had never changed it.

I will here refer again to what was said in the first lecture concerning the blood's own assimilative power. After the vaccine and other infectious or inoculable diseases, it is, most probably, not the tissues alone, but the blood as much or much more than they, in which the altered state is maintained; and in many cases it would seem that, whatever materials are added to the blood, the stamp once impressed by one of these specific diseases is retained; the blood exactly assimilating to itself—its altered self—the materials derived from the food.

And this, surely, must be the explanation of many of the most inveterate diseases,—that they persist because of the assimilative power of the blood. Syphilis, chronic lepra, eczema, gout, and many more, seem thus to be perpetuated: in some form or other, and in ever varying quantity, whether it manifests itself externally or not, the material they depend on is still in the blood; because by assimilation the blood constantly makes it afresh out of the materials that are added to it, let those materials be almost what they may. The tissues once affected may (and often do) in these cases recover; they may seem even to have regained their right or perfect composition; but the blood, by assimilation, still retains its taint, though it may have in it not one of the particles on which the taint first passed: and, hence, after many years of seeming health, the disease may break out again from the blood, and affect a part which was never before diseased. And this appears to be the natural course of these diseases, unless the morbid material be (as we may suppose) decomposed by some specific; or be excreted in the gradual tendency of the blood (like the tissues) to return to its former state; or, finally, be, if I may so speak, starved by the abstraction from the food of all such things as it can possibly be made from.

In all these things,—as in the phenomena of symmetrical disease,—we have proofs of the surpassing precision of the nutritive process,—a precision so exact that, as we may say, a mark once made upon a particle of blood, or tissue, is not for years effaced from its successors. And this seems to be a truth of widest application, so that I cannot doubt that herein is the solution of what has been made a hindrance to the reception of the whole truth concerning the connection of an immaterial Mind with the brain. When the brain is said to be essential, as the organ or instrument of the Mind in its relations with the external world, not only to the perception of sensations, but to the subsequent intellectual acts, and, especially, to the memory of things which have been the objects of sense,—it is asked, how can the brain be the organ of memory when you suppose its substance to be ever changing? or, how is it that your assumed nutritive change of all the particles of the brain is not as destructive of all memory and knowledge of sensuous things as the sudden destruction by some great injury is? The answer is, because of the exactness of assimilation: the impression once made upon the brain, whether in perception or in intellectual act, is fixed and there retained; because the part, be it what it may, which has been thereby changed, is exactly represented in the part which, in the course of nutrition, succeeds to it. Thus, in the recollection of sensuous things, the Mind refers to a brain, in which are retained the effects, or, rather, the likenesses, of changes that past impressions and intellectual acts had made. As, in some way passing far our knowledge, the Mind perceived, and took cognizance of, the change made by the first impression of an object acting through the senses on the brain; so afterwards, it perceives and recognizes the likeness of that change in the parts inserted in the process of nutrition.

Yet here also the law of tendency to revert to the former condition, or else the law of change with advancing years, may interfere; —the impress may be gradually lost or superseded, and the Mind—itself, in its own immortal nature, unchanged, and immutable by anything of earth,—no longer finds in the brain the traces of the past.

Such appear to be the principal conditions essential to the nutrition of a part;—failure in any of them has for its necessary consequence disease,—and disease seems due to failure in the conditions, much more often than to any imperfection in the very power, of nutrition.

But what this power is, and what is the exact process of assimilation, are subjects of most difficult inquiry. I will endeavour, as I proposed, to state what is most probable concerning the process.

You may remember that I spoke of the waste, or wear and tear, of the body, as that against the effects of which the formative process is directed; and referred it to two principal sources, namely, the deterioration which every part suffers in the exercise of its function; and, the natural degeneration or death to which every part is subject after a certain period of existence, independent of the death or degeneration of the whole body, and, in some measure, independent of the discharge of function.

The first question, therefore, in the consideration of the nutritive process, may be, —what becomes of the old particle; the one for the replacement of which the process of formation is required. In answer,—we must, probably, draw a distinction between the parts which die, and those which only degenerate, when they have finished their course. Those which die are cast out entire: those which degenerate are disintegrated or dissolved, and absorbed. We seem to have a good example of this difference in the fangs of the two sets of teeth; those of the deciduous ones degenerate, are decomposed so as to become soluble, and are absorbed; those of what are called permanent,—more properly, those of teeth which are not to be succeeded by others deriving germs from themselves—die, and are cast out entire. And we may probably hold it as very widely true, that, as Mr. Hunter was aware, living parts alone are absorbed in the tissues: dead parts, it is most probable, however small, must be separated and cast out; and, as the phenomena of necrosis shew, this must be accomplished, not by the absorption of the dead parts themselves, or their borders, but by the absorption or retirement of the adjacent borders or surfaces of the living parts. Now, all external, all integumental, parts appear thus to die, and to be cast out entire from the body; but we have no certain knowledge of the changes they may undergo before they die.

In regard to the changes which take place in the degeneration that precedes absorption of the old particles, we have again no certain—nay, scarce any probable—knowledge. Chemistry has, indeed, revealed much concerning the final disposal of the old materials,—finding their elements in the excretions; and proving that, invariably, the process is one of descent towards simplicity of organic chemical composition,—one of approximation towards inorganic character,—and, perhaps always, one accomplished by the agency of oxygen. But we have no ground for assuming that the whole process by which, for example, urea is formed from worn-out muscle, is accomplished at the muscle itself; or that in any case, the deterioration by oxygen is effected at the deteriorated tissue: it is more likely that the principal part of this process of change is accomplished, after absorption, in the blood itself.

What the change in the part itself is, we do not know; I can only suggest two things: first, that in parts of active function, as the muscles, the products of deterioration by exercise are probably different from those which are formed in the spontaneous degeneration in the inactive state. For, the repair of the deterioration in the former case is much more complete than in the latter: parts that thus spontaneously degenerate in an inactive state, degenerate constantly more and more; so that for the tissues, as for most things, it is better to wear out than to rust out. And, secondly, I would suggest that the frequency with which fatty matter is found in parts that have simply degenerated, may indicate that it is one of the products of this degenerative transformation in most of the tissues. But of this I shall have to speak hereafter.

With regard to the formative portion of the process,—that by which the old particle, however disposed of, is to be replaced,—it is probably always a process of development,—a renewal, for each particle, of the process which was in simultaneous operation for the whole mass in the original development of the tissue:—*i. e.* the fibre (for example) which is to be formed anew in a muscle, passes through the same stages of development as those did which were first formed in the embryo. We are led to this conclusion, not only by the evident probability of the case, but, first, by the analogy of the hair, the teeth, the epidermis, and all the tissues we can watch. In all, the process of repair or replacement is effected through development of the new parts. And, secondly, by the existence of nuclei or cytoblasts in, I think, all parts which are the seats of active nutrition. For these nuclei, such as are seen so abundant in strong, active muscles, are not the loitering, impotent remnants of the embryonic tissue, but germs or organs of power for new formation. Their abundance is, I think, directly proportionate to the activity of growth. Thus, they are always abundant in the fœtal tissues, and those of the young animal; and they are more plentiful in the muscles and the brain than, so far as I know, any other tissue of the adult. It is interesting, too, and significant in this regard, to notice their absence or infrequency in the nerve-fibres of the adult, which in so many points are comparable with the muscular fibres. And to these evidences of their power I may add, that their disappearance from a part in which they usually exist is a sure accompaniment and sign of degeneration.

As arising from this consideration, I would suggest, for a subject of very interesting inquiry, the difference which we may perceive between what may be called nutritive reproduction and nutritive repetition. I may illustrate my meaning by reference again to the teeth. In our own case, as the deciduous tooth is being developed, a part of its productive capsule is detached, and serves as a germ for the formation of the second tooth; in which second tooth, therefore, the first may be said to be reproduced, in the same sense as that in which we speak of the organs by which new individuals are formed, as the reproductive organs. But in the shark's jaws, in which we see row after row of teeth succeeding each other, the row behind is not formed of germs derived from the row before: the front row is simply repeated in the second one, the second in the third, and so on.

So, in cuticle, the deepest layer of epidermis-cells derives no germs from the layer above them: their development is not like a reproduction of the cells that have gone on towards the surface before them: it is only a repetition.

Probably we shall find hereafter an analogy in this respect between tissues and whole animals; and that, as in the latter, the capacity of regeneration of lost parts is in direct proportion to the degree in which the members of the body are only repetitions one of another, so in the tissues, much of the difference in the degree of repair they severally undergo after injuries or diseases, is connected with the ordinary mode of nutrition by repetition or by reproduction. When the whole cuticle of a part is removed, it may be again formed by repetition; but when a portion of muscle is removed, its germs are taken with it, and it is not reproduced.

In the development of each new particle, it is worth remembering that it is made, in successive stages, like what the old particle *was*, not like what it is: as we see in the young hair following the course of the old one—just as the child is made like, not what his father is now, but what he was at his age. The new particle is, therefore, not made after a present model—a fact very characteristic of the difference between assimilation and the ordinary process of the growth of crystals.

I propose now to consider, though as yet only generally, the second variety of the formative process—Growth—in health and in disease.

This consists in the increase of a part or of the whole body by addition of new material like that already existing. The essential characters of the organ or tissue are maintained, but its quantity is increased, and thus it is enabled to discharge more of its usual function.

For a general expression of the course of events, we may say that the development and the growth of the body go on together till all the natural structures are attained;

and that then, development ceases, and growth goes on alone till the full stature, and the full proportion of each part to the rest, are gained. But this is only generally true; for we cannot say that all development ceases at a determinate period, since some organs may go on to be developed when many others are complete. Neither can we assign the period of terminated growth; since, not only is the period, even stated generally, very various in different persons, but, some parts, unless placed in unfavourable conditions of disease, continue growing to the latest period of life. M. Bizot and Dr. Clendinning have proved, of the heart and arteries, that their average size regularly increases, though with a decreasing ratio of increase, from childhood to old age, provided only the old age be a lusty one.* And this is a real growth; for the heart not only enlarges with advancing years, but its weight augments, and the thickness of its walls increases; so that we may believe it acquires power in the same proportion as it acquires bulk—the more readily, since the increased power is necessary for the increasing difficulties put in the way of the circulation by the increasing rigidity of the parts.

It may be that the same is true of some other parts. This certainly is true—that any part, after it has attained its ordinary dimensions, according to the time of life, may grow larger if it be more exercised: in other words, every part has, throughout life, the power of growing, according to its particular needs, in correspondence with the degree in which its function is discharged.

Now, when such growth as this is the result of the natural, though almost excessive, exercise of a part—as of the limbs, for example, during hard work—we regard it only as an indication of health, and its result is admitted to be a desirable accession of strength. But, when such growth in one part is the consequence of disease in another, it is commonly described as a disease,—it bears the alarming name of Hypertrophy,—and it comes to be a subject of consideration in Morbid Anatomy.

But in both these cases the process of growth is the same, and is according to the same rules; and the tendency of the process of genuine hypertrophy in disease, like that of healthy growth in active exercise, is always conservative. I say "genuine hypertrophy," meaning, under that term, to include only the cases in which the enlargement of a part is effected with development, or with increase of its natural tissue. To include nearly all enlargements, as some do, under the name of hypertrophy, leads only to confusion.

* See the Croonian Lectures delivered by Dr. Clendinning in 1838; reported in the LONDON MEDICAL GAZETTE for 1837-8, vol. xxii. p. 450.

The rule, then, concerning hypertrophy is, that so long as all conditions remain the same, after the attainment of the average size, each part of the body merely assimilates, retaining its state, or, at most, growing at a certain determinate slow rate; but when the conditions alter, so that a part is, or needs to be, more than usually exerted, then it manifests a power of renewing or accelerating its growth. As we may say, each healthy part has a reserve-power of growth and development, which is put forth in the time of emergency.

The converse is equally true: that, when a part is less than usually exercised, it suffers atrophy; so that the whole rule may be that each part nourishes itself according to the amount of function which it has to discharge. We may constantly see this in many more examples than I need refer to. The simplest case that can be cited is that of the epidermis. In its original formation, even before it has come into relation with the external world, it is formed on the several parts of the body—take, for example, the back and the palm of the hand—in different quantity and kind adapted to the several degrees in which the cutis it has to protect will be exposed to pressure, friction, and the influence of other external forces. Not only is its original quantity and construction on these parts different, but its rate of growth is so; for, though the back of the hand loses comparatively little by friction or otherwise, yet its epidermis does not grow thick; and though the palm loses more, yet its epidermis does not grow thin. So, then, both in original construction, and in rate of nutrition, the epidermis is thus adapted to the amount of function it has to discharge—that is, to the amount of protection it has to afford. But suppose now, that, by some new handicraft, the amount of exercise of the epidermis is increased; its rate of waste is increased in the same proportion, yet it does not grow thin—nay, it grows thicker, till it is completely adapted to protect the cutis from the greater sources of injury to which it is now exposed: it puts forth its reserve-power, which is enough not only to repair all amount of waste within certain limits, but, further than this, to increase the quantity of the tissue to the amount required for the discharge of its increased functions.

What we can see in this case of the cuticle, we may be sure of for other tissues. For example, in a muscle: or in this heart, by disease of the valves, an obstacle is put in the way of the circulating blood: it is held back at the heart: and the heart, or one of its cavities, acts with additional force to drive it on. But, as we know, the more of action in a muscle, the more consumption of the tissue; so that we might now expect a diminution of the heart. On the contrary, it enlarges,—it becomes hypertrophied,—its reserve-power of nutrition not only meets the immediate exigencies of the increased consumption of its tissue, but produces tissue enough to act with the additional power required by the increased difficulty of the circulation.

Such are the effects of growth in examples of hypertrophy. Let me add, that, to meet the increasing difficulties of these and the like cases, a part may do more than grow—it may develope itself,—it may acquire new structures fitted for higher functions and the exercise of greater power. For example, in the most ordinary hypertrophy of the heart, the muscular tissue is developed to more robustness. In the pregnant uterus, such fibres are developed as are not seen in the unimpregnated state; and the change by development, which in pregnancy is natural, is often imitated by disease, when, by the growth of fibrous tumors in it, the uterus is developed, and grows till it attains the size, the structure, and even the full capacity of action, of the pregnant organ. In several of such cases (as in this) the uterus has at length imitated the course of labour, and delivered itself of the tumor by its contractile power.

A similar change, by development and growth of muscular fibres, may occur in the gall-bladder, as this specimen shews, in which slender bundles of fibres appear decussating each other, and prominent, like the fasciculi of a columnar urinary bladder, on the inner surface of the organ.* A similar example of the development of organic muscular fibres in an obstructed ureter has also been accurately recorded by Tourtual.†

We have an example of development of a secreting structure in the bursa, which, as Hunter has displayed it, is produced under a corn. The corn itself is a kind of hypertrophy, tending to shield the cutis from unnatural pressure; but, itself becoming a source of greater trouble than that against which it was directed, it gives rise to the development of a bursa beneath it, which may, for a time, more effectually protect the joint beneath, by diffusing the pressure over a wider extent of its surface.

Let me repeat, then, that this hypertrophy, as we call it, though it happens in circumstances of disease, is yet in general, so far as itself is concerned, a process of full and vigorous health, serving to remedy or keep back the ill effects that would ensue from disease in some other part. It is, in a less degree than the repair of a fracture or other mechanical injury, an instance of the truth that we are provided for accidents and emergencies; framed not merely to live in peace and sameness, but to bear disturbances; to meet, and balance, and resist them, and, sometimes at least, to counteract them.

As we might suppose, all the conditions necessary for ordinary nutrition are equally or more necessary for this extraordinary purpose. Thus, for the condition of appropriate blood, one of the most interesting studies is to watch the effects of coincident disease on the occurrence and progress of hypertrophy, especially that of the heart; and in some of these cases death appears to be the consequence of impairment of the blood, which can no longer maintain the heart in the excited nutrition required for its increased functions.

We find, moreover, very constantly, that, to insure sufficient blood to the grown or growing part, the main arteries and veins belonging to it are enlarged. This is usually well shewn in the enlarged coronary arteries of the hypertrophied heart,—an instance analogous to the enlargement of the arteries of the pregnant uterus, and the growing antlers of the deer, and many others. According to all analogy, we must consider this increase of the blood-vessels to be secondary. As in the embryo, parts form without vessels, till, for their further nutrition as their structure becomes more complex, the passage of blood into their interior becomes necessary,—so we may be sure it is here. It is, indeed, strange that a part should have the power, as it seems, of determining in some measure the rate at which blood shall flow into it and through it; but so it is, and nearly all examples of hypertrophy are examples of the fact; though, as I shall hereafter shew, there are instances in which hypertrophy is the consequence, not the cause or precedent, of increased supply of blood.

With the increased supply of blood proportioned to the increased nutrition of the growing part, the nerves may also increase; as in the pregnant uterus and the hypertrophied heart. So, at least, I believe; but probably I need not apologise for evading the discussion of this matter.

* The specimen was exhibited from the Pathological Museum of the College of Surgeons (No. 5). A further description of it may be found at page 5 of the Pathological Catalogue, vol. i.

† Müller's Archiv, 1842.

LECTURE IV.

Hypertrophy—its two kinds—the three principal conditions which give rise to it—cases and preparations illustrating the influence of these conditions—especially that of the increased flow of blood through a part—as shewn in John Hunter's experiment of transplanting the spurs of cocks—and in the case of hypertrophied fingers.—Specimens exhibiting hypertrophy in the different tissues—hypertrophy of the bladder in consequence of obstructed flow of urine—Hunter's remarks—enlargement of intestinal canal above seat of obstruction.—Hypertrophy in consequence of the too irritable action of a muscle—as in the case of the bladders of some children—hypertrophy of muscle probably accomplished by enlargement of existing fibres, not by the addition of new ones.

Hypertrophy of Bone—usually the result of change in the parts in intimate relation with the bone.—Eccentric and concentric hypertrophy of the skull—the former frequently the result of hydrocephalus—the latter an accompaniment of atrophy of the brain—the excessive growth most manifest about the centres of ossification. Hypertrophy of other bones, as a morbid process, rare—instances of its occurrence in consequence of increased flow of blood through a bone, resulting from neighbouring disease—distinctions between the effects of such hypertrophy and the distortion of rickets—complications which may ensue from such forms of hypertrophy.

Specimens illustrating the effects of pressure according as it is from without or from within—or constant or occasional—constant pressure produces atrophy and absorption—occasional pressure, hypertrophy and thickening.—Presence of cutaneous structures in the contents of ovarian cysts—probable mode of origin of such cysts.

I PROPOSE to devote the present lecture to the more detailed consideration of Hypertrophy.

We have seen that there are two kinds of hypertrophy—that with increase or mere growth, and that with development. The distinction is, indeed, only for utility's sake, since generally, when a part grows, it becomes more robust or stronger, and, so far, may be said to be developed; and, on the other hand, a part is rarely, if ever, developed in circumstances of disease, without at the same time acquiring bulk. Still, we shall find the distinction as convenient in pathology as in physiology, in which it is certain that some obscurity has arisen through the neglect of the true distinction between the development and the growth of a part.

The conditions which give rise to hypertrophy are chiefly or only three, namely—

1. The increased exercise of a part in its healthy functions.
2. An increased afflux of healthy blood.
3. An increased accumulation in the blood of the particular materials which any part appropriates in its nutrition or in secretion.

Of hypertrophy as the consequence of the increased exercise of a part, I have already spoken generally, and we need no better examples of it than the muscles of a strong man's arm fitted for the very exercise in which they acquired bulk and power, or the great and robust heart of a man who has suffered some disease producing obstacle to the movement of the blood. Both alike are the results of vigorous healthy growth, brought about by exercise of the part in its proper function.

In a former lecture* I spoke of the increased growth of the kidney, and of the adipose tissue, when the constituents of urine or of fat exist in excess in the blood. To these I may refer again as examples of the third kind of hypertrophy; and I may illustrate one of them by this preparation of the urinary organs of an Argus Pheasant,† in which one kidney is very small, granular, and shrivelled, the other very large, and large, not by dilatation, but by growth of its natural texture,—growth accompanied with a more active discharge of its office, as elucidated by the proportionally great size of the renal artery.

In the last lecture,‡ also, I alluded to the increased flow of blood through a growing part as the consequence of the augmented nutritive process carried on in it; and I just mentioned, that although in most cases this increased circulation is the consequence of hypertrophy, yet there are cases in which the course of events is inverted. The increased flow of healthy blood through a part,

* Lecture II. MEDICAL GAZETTE, vol. xxxix. p. 1018.

† Prepar. 3, Pathological Museum of the College of Surgeons.

‡ MEDICAL GAZETTE, vol. xl. p. 57.

if it be not interfered with by local disease, will give rise to hypertrophy of the part, or, at least, of some of its tissues.

This specimen* shews the fact. Mr. Hunter described it as "a sore which had continued inflamed a long time, where the increased action had made the hair grow." The integuments, you see, for about an inch round the ulcer, where probably there was simply increased supply of blood, are covered with thick-set, long, and rather coarse, dark hairs: while on the more distant parts of the integuments, the hair is paler, more slender, and more widely scattered.

Similar examples of overgrowth of the hair through increased supply of blood, are not unfrequently seen near the ends of stumps which have remained long inflamed, and about old diseased joints,—not, indeed, at the very seat of inflammation, for there the process of organising, or otherwise changing, the morbid product, may interfere with or exclude all healthy growth,—but at some little distance from it, where the parts share the increased supply of blood, but not the disease of inflammation. I lately saw a very striking case of such growth of hair in the thigh of a child about five years old. The femur had been fractured near the middle: the case did not proceed favourably; and union was not accomplished without much distortion. When I saw the child, I was at once struck with a dark appearance on the thigh: it was all covered with dark hair, like that of a strong coarse-skinned man, and it had been darker, the mother said; yet, on the rest of the body, the hair had all the fineness and softness which are proper to it in early life.

Facts illustrative of these are presented by some cases of transplantation. When the spur of a cock, for example, is transplanted from the leg to the comb, which abounds in quickly moving blood, its growth is marvellously augmented, and it increases to such a long, strange-looking mass of horny matter as you see in these two preparations.† In one (No. 54) the spur has grown in a spiral fashion, till it is six inches long; in the other (No. 52) it is like a horn curved forwards and downwards, and its end needed to be often cut, to enable the bird to bring his beak to the ground in feeding, and to prevent injurious pressure on the side of the neck.‡

It is worth observing, that these excessive growths have taken place on the combs without any corresponding diminution in the growth of the spurs in their proper places. The legs of these cocks are amply spurred, though the spur reproduced is not so long as that which had not been interfered with. In one instance, moreover,* there is an excessive production of the horny scales upon the legs, while the horny spur was also excessively growing on the comb.

I shall have occasion presently to mention cases which make it very probable that the more complex and vascular tissues, such as the muscles, integuments, and bones of a limb, can be thus hypertrophied by excess of blood. I will now only suggest the probability that the cases of congenital or spontaneous hypertrophy of a hand or a foot, or of one or more fingers, have their origin in some excessive formation of the vessels, permitting the blood to flow more abundantly through the part. Here are casts of such cases†; and, for the description of these, and of other similar examples, I refer you to a paper by Mr. Curling, in the 28th volume of the Medico-Chirurgical Transactions. An enlargement of the radial artery has been observed by Dr. John Reid in a case of such hypertrophy of the thumb and fore-finger referred to by Mr. Curling‡; but there is no evidence to determine whether in this case the enlargement of the artery was previous or subsequent to the excessive growth of the part.

But whatever be the case in these instances of enlargement, the fact—which the others shew—that well-organized tissue, like hair and horn, is produced in consequence of simply increased supply of blood, stands in interesting contrast with the phenomena of inflammation, where no tissue, or only the most lowly organized, is ever formed. No fact can better shew how far the mere enlargement of the blood-vessels is from constituting the essential part of inflammation.

Let me now further illustrate the general physiology of Hypertrophy, by adducing some of the specimens in the Museum which exhibit it in the principal tissues.

The first specimen in the Pathological division of the Museum is an urinary bladder hypertrophied in consequence of stricture of the urethra. It affords an admirable instance of genuine unmixed hypertrophy; for every part of the bladder is grown large; it is not contracted as if it had been morbidly irritable; and its mucous membrane, without induration or any similar morbid change, is increased, apparently by simple growth, to

* No. 6 in the Pathological Museum of the College of Surgeons; described at page 5 of the Pathological Catalogue, vol. i.

† Nos. 52 and 54 in the Pathological Museum of the College of Surgeons.

‡ A further account of these preparations is given in vol. i. p. 25, of the Pathological Catalogue of the College Museum.

* No. 53 in the same collection.

† From the Museum of the College of Surgeons; others from the Museum of St. Bartholomew's Hospital, Casts, No. 142.

‡ L. c. page 343. Dr. J. Reid's account of this case may be found in the Lond. and Edin. Monthly Jour. of Med. Sci. 1843, p. 198.

a thickness proportionate to that of the muscular coat.

I adduce this especially as an example of hypertrophy of muscular tissue, concerning which, instead of adding to what was said in the last lecture, I will quote Mr. Hunter's account. Referring, perhaps, to this very specimen, he says, in a passage which I have inserted in the Catalogue :* "The bladder, in such cases [of obstruction to the passage of urine] having more to do than common, is almost in a constant state of irritation and action; by which, according to a property in all muscles, it becomes stronger and stronger in its muscular coats; and I suspect that this disposition to become stronger from repeated action is greater in the involuntary muscles than the voluntary; and the reason why it should be so is, I think, very evident: for in the involuntary muscles the power should be in all cases capable of overcoming the resistance, as the power is always performing some natural and necessary action; for whenever a disease produces an uncommon resistance in the involuntary parts, if the power is not proportionally increased, the disease becomes very formidable; whereas in the voluntary muscles there is not that necessity, because the will can stop whenever the muscles cannot follow; and if the will is so diseased as not to stop, the power in voluntary muscles should not increase in proportion."†

Nothing, surely, could more appositely, or more exactly, express the truth concerning hypertrophy of muscle; and it may be observed, from what he says in a note, that Mr. Hunter appears to have been the first who rightly apprehended the nature of this growth of the bladder. He says, "This appearance was long supposed to have arisen from a disease of this viscus; but, upon examination, I found that the muscular parts were sound and distinct, that they were only increased in bulk in proportion to the power they had to exert, and that it was not a consequence of inflammation, for in that case parts are blended into one indistinct mass‡."

What this specimen shows in the urinary bladder is an example of the change which ensues in all involuntary muscles under the same circumstances. They all grow and acquire strength for the new and extraordinary emergencies of their case. Thus, the œsophagus, the stomach, the intestinal canal, as often as any portion is the seat of stricture, display hypertrophy of the muscular coat above the stricture. The enormous enlargements of the intestinal canal which gradually ensue above nearly impassable strictures of the rectum are not mere dilatations, but growths of the intestinal walls, the muscular coat augmenting in power to overcome, if it may, the increased hindrance to the propulsion of the contents, and even the glands and other textures of the mucous membrane simultaneously increasing. It was so in this large intestine of a child only five years old, in which contraction of the rectum occurred in consequence of the healing of a wound made by an enema-pipe, and for ten months fluid fæcal matter gradually collected till it amounted to a pailful*.

In a great majority of cases the hypertrophy of muscles, whether voluntary or involuntary, is the consequence of an increased obstacle to their ordinary action. It may be a question whether it is ever engendered by an unhealthy action—as by spasm or convulsion—of a muscle; for, as a general rule, no morbid action in a part leads to any healthy process in it. Yet there are cases in which the too irritable action of a muscle appears to engender an hypertrophy of it. This is the case with the bladders of some children whom you may find suffering with frequent and very painful micturition, and nearly all the signs of calculus; but in whom no stone exists. The bladder in such children is found, after death, exceedingly hypertrophied, and there may appear no other disease whatever of the urinary organs. Dr. Golding Bird† has shewn that phymosis, by obstructing the free exit of urine, may give rise to these signs and to extreme hypertrophy of the bladder; but in some cases it appears certain that hypertrophy may occur without either phymosis, calculus, stricture, or any similar obstruction. It was so in this case from the Museum of St. Bartholomew's Hospital:‡ the bladder of a child four years old, who had suffered intensely with signs of stone in the bladder, but in whom no stone existed, nor any disease of the urinary organs except this hypertrophy of the muscular coat of the bladder. An exactly similar case has been recently under Mr. Stanley's care, in which, after exceeding irritability of the bladder, the enlargement of its muscular coat appeared the only change.

In such cases it is possible that the too frequent action of the bladder, though irritable and unhealthy, may have given rise to hypertrophy of the fibres; but it is also

* Vol. i. p. 3.

† Vide Mr. Palmer's edition of Hunter's Works, Vol. ii. p. 299.

‡ Loc. cit. p. 299: quoted in the Pathological Catalogue, Vol. i. p. 3.

* For a further description of this preparation, and of another containing the rectum, uterus, and vagina of the same child, see the 1st vol. of the Catalogue of the Anatomical Museum of St. Bartholomew's Hospital, 16th Series, Nos. 93 and 94, p. 319. The canal of the rectum is reduced to an eighth of an inch in diameter.

† London Medical Gazette, vol.

‡ Series xxvii. No. 14: vide p. 383 of the Anatomical Catalogue.

not unlikely that the change may be due to narrowing of the urethra by muscular action. If, for example, the compressors of the urethra, instead of relaxing when the muscular coat of the bladder and the abdominal muscles are contracting, were to contract with them, the obstacle they would produce in the urethra would soon engender hypertrophy of the bladder.

Hunter, whose ingenuity was ever tempting on his intellect and industry, asked himself whether the hypertrophy of the heart were accomplished by the addition of new fibres, or by the enlargement of those that already exist. This question could hardly be determined without more microscopic aid than Hunter had at his command. But if we may believe (and there can be little doubt we may) that hypertrophy is, in this respect also, exactly similar to common growth, the question set by Hunter has been answered by Professor Harting, of Utrecht*. He has shown that in the growth of muscles there is no multiplication, no numerical increase, of the fibres, but an enlargement of them with addition to the number of the fibrils. I certainly do not see so great an enlargement of the fibres of the hypertrophied heart as there should be according to this account; yet the Professor has taken much pains to ascertain the fact, and is an accurate observer. So that I am disposed to rely on his description, and believe that the enlargement of a muscle (at least of one with transverse striæ) is due to the enlargement, without increased number, of the fibres; and that as each fibre enlarges, the number of its contained fibrils is augmented.

Hypertrophy of Bone presents itself in many interesting cases. It is usually a secondary process, one ensuing in consequence of change in some other part with which the bones are intimately connected. For, just as in their natural development and growth, the bones of the skull are formed in adaptation to the brain, and those of the limbs are framed to fitness for the action of the muscles; so in disease they submit in their nutrition to adapt themselves to the more active parts. Thus, the skull enlarges when its contents do; and the bones of the limbs strengthen themselves as the muscles implanted on them become stronger and more active; and they do this in adaptation to the force of the muscles, and not merely because of the movements they are subject to: for no extent or force of passive movement would prevent the bone of a limb whose muscles are paralysed from suffering atrophy.

* Recherches Micrométriques, 4to. 1845. See Report on Anatomy and Physiology for 1844-5, in No. xliii. of the British and Foreign Medical Review.

In the skull, if in any organ, we might speak of two forms of hypertrophy: eccentric and concentric. When the cranial contents are enlarged, the skull enlarges with corresponding augmentation of its area; and when the cranial contents are diminished, the skull (at least in many cases) is hypertrophied with concentric growth and diminution of its capacity.

The first, or eccentric form, is usually the consequence of hydrocephalus; wherein, as the fluid collects and distends the dura mater, so the skull grows; still, as it were, striving to attain its purpose, and form a complete envelope for the expanding brain.

The process of enlargement in these cases is often one of simple growth, and that, indeed, to a less extent than it may seem at first sight: for it is very rarely that the due thickness of the skull is attained while its bones are engaged in the extension of their superficial area. Hence, the weight of an hydrocephalic skull is not much, if at all, greater than that of a healthy one; large, as is this parietal bone,* measuring nine inches diagonally, it weighs only four ounces, while the weight of an ordinary parietal bone is about three ounces.

It is interesting to observe in some of these cases, how the formative process, though thus thrown into straits and difficulties, yet obeys, both in growth and in development, the law of symmetry, as shown in the symmetrical placing of the Wormian bones, by which the extent of the skull is in some measure made up.

It would be yet more interesting if we could certainly trace here something of obedience to the law of unity of organic type, in the fact or the mode of insertion of these intercalary bones, as Müller has shown them to be, when compared with those of the cranial vertebræ of other animals, of which Professor Owen has been lately so ingeniously and instructively discoursing. It cannot be certainly done; and yet, in some of these specimens, there appears (as if in accordance with that law,) a tendency to the formation of the Wormian bones at the posterior part of the sagittal suture more than in any other part, as if in imitation of the interparietal bones of Rodents. And in this specimen,† in the midst of great confusion of the other bones, we have a remarkable bony arch, extending from between the two frontals to the occipital bone,—occupying, therefore, the place of a larger interparietal bone, and reminding us of the interparietal bones of some of the monkeys, *e. g.* Cebus and Jacchus. We have a somewhat corroborative specimen in

* Prepar. 2, in the Pathological Museum of the College of Surgeons.

† From the Pathological Museum of the College of Surgeons.

the hydrocephalic skull of the skeleton from Mr. Liston's Museum, in which the inter-parietal Wormian bones are larger than any others.

The hypertrophy of the skull, which may be called concentric, is that which attends atrophy with shrinking of the brain, or, perhaps, any disease of the brain which is attended with diminution of its bulk. In such a case it usually happens, as was first shown by Dr. Sims, in a paper in the 19th Volume of the "Medico-Churvrgical Transactions,"* that the skull becomes very thick.

All the specimens which I have examined show, however, that in these cases the thickening of the skull is not, in itself, a morbid process; it manifests definite purpose; is usually effected by healthy growth; and observes the rules followed in the natural formation of the skull.

Thus, as in first formation, it exactly adapts itself to the form and size of the brain, or, rather, of its membranes; only now it does so without representing on its exterior the change which has taken place within. The thickening of the skull is effected by the gradual remodelling of the inner table and diploe of the bones of the vault; so that, although the exterior of the skull may retain its natural form and size, the inner table grows more and more inwards, as if sinking towards the retiring and shrinking brain; not thickening, but simply removing from the outer table, and leaving a wider space filled with healthy diploe.

Again, it is a fact of singular interest that this thickening, this hypertrophy of the skull, most commonly, if not always, takes place especially, and to a greater extent than elsewhere, in the parts of the bones at and about which ossification commenced in the fœtal state: as if some of the potency that of old brought the fœtal membrane of these parts first into the development of bone, were always afterwards concentrated in them; as if the reserve-power of growth had its seat in the same centres where was formerly the originative power of development. The fact is shown in many of these specimens;†—and we may find some further, though less sure evidence of the indwelling formative energy of these old centres, in the fact that those diseases of bone which are accompanied with excessive formation, such as morbid thickenings of the skull, and tumors, are, in a large majority of cases, seated in or near the centres of ossification, —you rarely find them except at the articular ends, or round the middle of the shaft. The same does not hold of necrosis, rickets, ulceration, or other diseases indicative of depression of the formative power of the bone. Here are specimens of ricketty disease of the skull, and the femora,* which shew the centres of ossification remarkably exempt from the change of structure which has extensively affected the later-formed parts.

This abiding power of the centres of ossification is the more remarkable when we remember that, in many cases, the thickening of the skull takes place in persons far past the middle period of life; it may happen even in very old age, and may give one more evidence of that precision of assimilation which maintains, throughout life, characteristic distinctions among portions of what we call the same tissue.

Let me, however, remark, that it is not peculiar to old persons; I believe that at whatever age, after the complete closure of the cranial sutures, shrinking of the brain may happen, this hypertrophy of the skull may be its consequence. This (No. 379) is part of the skull of a suicide, only 30 years old: this also, (No. 380) from an idiotic woman, has not the characters of an old skull.†

I lately examined a remarkable case, showing the same conditions, in a person less than 30 years old, in whom the thickening of the skull must have begun in early life.

The case was that of a lady, of remarkable personal attractions, but of slenderly developed intellect, whose head did not, externally, appear below the average female size. Yet her cranial cavity was singularly contracted; the skull had adapted itself to an imperfectly-grown brain, by the hypertrophy of its diploe, which was nearly half an inch thick at and near the centres of ossification of the frontal and parietal bones.

I must present this specimen, however,‡ as evidence that this hypertrophy is not always the mode by which the skull is adapted to the diminished size of the brain. In congenital and very early atrophy of the brain, the skull is proportionally small, and may exactly represent the size and shape of the cerebrum. It does so in the cases of the idiots, which I exhibited in the first lecture;§ and it does so in this instance. The man from whom this skull was taken received a compound fracture of the left frontal bone when he was only 14 years old.

* "On Hypertrophy and Atrophy of the Brain," page 315.

† Exhibited from the Pathological Museum of the College of Surgeons, and from the Museum of St. Bartholomew's Hospital: of these preparations, Nos. 3234 and 3235, in the College Museum, are the most striking.

* Nos. 390, 391, and 392, in the Pathological Museum of the College of Surgeons.

† Both the above specimens were from the College Museum.

‡ From the Museum of St. Bartholomew's Hospital.

§ Vide Medical Gazette, vol. xxxix, page 931.

Portions of bone were removed, hernia cerebri ensued, and several pieces of brain were sliced off. But he recovered and lived 33 years; and Mr. Grayling, lately a very zealous student of St. Bartholomew's Hospital, procured his head. The left hemisphere of the cerebrum was altogether small. Where the brain had been sliced off, its surface had sunk in very deep, and had left a cavity filled with a vascular spongy substance containing ill-formed nerve-fibres. You will observe here, that in the modelling of the skull, the left side has become in every part less capacious than the right, adapting itself to the diminished brain without any hypertrophy of the bones.

The cases are very rare in which hypertrophy of any other bones than those of the skull occurs in connection with what is recognised as disease. For, as I have said, the bulk of most of the other bones is principally determined by the activity of the muscles fixed on them; and a morbidly excessive action of muscles, sufficiently continued to produce hypertrophy of bones, is seldom, if ever, met with.

But there is a condition of bones so similar to hypertrophy in many respects, and so little different from it in any, that I may well speak of it here; yet not without acknowledging that nearly all I know about it is derived from Mr. Stanley.

When any of the long bones of a person who has not yet attained full stature is the seat of disease attended with unnatural flow of blood in or near it, it may become longer than the other or more healthy bone. For example, a lad has necrosis of the femur, it may be of a small portion of it, and he may recover completely from this disease; but for all his life afterwards (as I had constant opportunity, once, of observing in a near relative), he may be lame, and the character of his lameness will show very plainly that the limb which was diseased is now too long; so that he is obliged, in walking, to lift the lame leg, almost like a hemiplegic man, lest his toe should trip upon the ground.

Such cases are not uncommon: I once saw, with Mr. Stanley, a member of our profession, in whom this elongation of one femur had taken place to such an extent that he was obliged to wear a very high shoe on the other, that is, the healthy, limb. And this, which he had adapted for himself, affords the only remedy for the inequality of limbs. Nor is the remedy unimportant: for, to say nothing of the unsightly lameness which it produces, the morbid elongation of the limb is apt to be soon complicated by one of two serious consequences. Either the patient, in his endeavours to support himself steadily and upright, will acquire first the habit, and then the malformation, of talipes of the healthy limb: or else, through the habit of always resting on the short, healthy, and stronger limb, he will have lateral curvature of the spine. Cases of both these kinds have occurred in Mr. Stanley's practice; being brought to him for the remedy, not of the elongated femur, for that had been unnoticed, but of the consequent deformity of the foot or the spine.

A considerable elongation of the lower extremity almost always depends on the femur being thus affected: another, and very characteristic result, ensues from the same kind of hypertrophy when it occurs in the tibia. The femur can grow longer without materially altering its shape or direction, but the tibia is tied by ligaments at its two ends to the fibula; so that when it lengthens, unless the fibula should lengthen to the same extent, it, the tibia, must curve; in no other way, except by the lengthening of the ligaments, which, I believe, never happens to any considerable extent, is elongation of the tibia possible.

Tibiæ thus curved are far from rare; specimens are to be found in nearly every museum: yet I know of none in which the pathology of the disease is clearly shown, except this from the museum of Saint Bartholomew's Hospital:* for here, alone, the fibula, and the healthy tibia of the opposite, limb are preserved with the diseased and elongated tibia. The anterior wall of this diseased tibia, measuring it over its curve, is more than two inches longer than that of the healthy one: the posterior wall is not quite so long.

Here are other specimens, in all of which you observe the characteristic form of the curve, and its distinction from the curvature of rickets. The distinction is established by these particulars: the ricketty tibia is always short: the other is never short, and may be longer than is natural. In the ricketty one the articular ends always enlarge very suddenly, for the shortening is due to the imperfect formation of the ends of the shaft: in the elongated tibia, there is usually even less contrast of size between the shaft and epiphyses than is natural, because the elongation of the shaft is commonly attended with some increase of its circumference. But, especially, the ricketty tibia is compressed, usually curved inwards, its shaft is flattened laterally, and its margins are narrow and spinous; while in the elongated tibia the curve is usually directed forwards, the margins are broad and round, its surfaces are convex, and the compression or flattening, if there be any, is from before backwards.

* Series 1. Subseries A. No. 46.

The elongation of the bones in these cases may occur, in different instances, in two ways. In some cases it seems due to that change in bone which is analogous to chronic inflammation of soft parts; and which consists in the deposit of the products of inflammation in the interspaces of the osseous tissue, their accumulation therein, and the remodelling of the bone around them as they accumulate. Such a change appears to have occurred in this specimen from St. Bartholomew's [the tibia previously described]; and would, necessarily, in a growing bone, give rise, as it does in soft parts, to enlargement in every direction, to elongation as well as increase of circumference.

But in other cases the elongation is probably due to the more genuine hypertrophy which follows the increased flow of blood. When, for example, a small portion of bone, as in circumscribed necrosis, is actively diseased, all the adjacent part is more vascular; hence may arise a genuine hypertrophy, such as I have shown in hair under similar circumstances. Or, when an ulcer of the integuments has long existed in a young person, the subjacent bone may share in the increased afflux of blood, and may enlarge and elongate. Even, it appears, when one bone is diseased, another in the same limb may thus be increased in length. A remarkable instance of this kind has lately been observed by Mr. Holden, in a young man, who, in childhood, had necrosis of the left tibia, one of the consequences of which was defective growth of the left leg, with shortening to the extent of more than an inch. Yet the whole limb is not shorter than the other; for, without any apparent morbid change of texture, the femur of the same side has grown so as to compensate for the shortening of the tibia.

I must not forget to say, that the interest of these cases of inequality of the limbs by lengthening of one of the bones, is increased by comparison with another class of cases, in which as great or greater inequality of length depends on one limb being anormally short. In these, the short limb has been the seat of atrophy, through paralysis of the muscles dependent on some of the very numerous conditions in which they may be rendered inactive. The complication of the cases, the talipes, and the curvatures of the spine, depending, as they do, on the inequality of the length of the limbs, from whatever cause arising, will be alike in both; and much care may be needed in diagnosis, to tell which of the limbs, the long one or the short one, is in error. The best characters probably are, that when a limb is, through disease or atrophy, too short, it will be found, in comparison with the other, defective in circumference as well as in length; its muscles, partaking of the atrophy, will be weak and flabby, and all its tissues will bear signs of imperfect nutrition. If none of these characters be found in the short limb the long one may be suspected, and this suspicion will be confirmed, if there be found in it the signs of increased nutrition—enlargement, growth of hair, and the rest; or if, in the history of the case, there be evidence of a disease attended with an excess in the supply of blood.

Continuing to select from the Museum only such examples of hypertrophy as may illustrate its general pathology, I pass over many, and take next, those which display the formation of corns—a subject which, while Hunter deemed it worth consideration, we shall not be degraded by discussing. He made many preparations of corns, to show not only the thickening of the cuticle, but the formation of the little sac of fluid, or bursa, between the thickened cuticle and the subjacent articulation. His design appears to have been, mainly, to illustrate the different results of pressure—to show how that which is from without, produces thickening: that from within, thinning and absorption of parts. He says, having regard to these specimens, "The cuticle admits of being thickened from pressure in all parts of the body: hence we find that on the soles of the feet of those who walk much the cuticle becomes very thick; also on the hands of labouring men. We find this wherever there is pressure, as on the elbow, upper part of the little toe, ball of the great toe, &c. The immediate and first cause of this thickening would appear to be the stimulus of necessity given to the cutis by this pressure, the effect of which is an increase of the cuticle to defend the cutis underneath. Not only the cuticle thickens, but the parts underneath, and a sacculus is often formed at the root of the great toe, between the cutis and ligaments of the joint, arising from the same cause to guard the ligaments below."*

In another place, he says, "When, from without, pressure rather stimulates than irritates, it shall give signs of strength, and produce an increase of thickening: but, when from within, the same quantity of pressure will produce waste [see, for illustrations of this, preparations No. 120 and 121 in the Pathological Museum]; for the first effect of the pressure from without is the disposition to thicken, which is rather an operation of strength; but if it exceeds the stimulus of thickening, then the pressure becomes an irritator, and the power appears to give way to it, and absorption of the parts pressed takes place, so that nature very readily takes on those steps which are

* Mr. Palmer's edition of Hunter's Works, vol. i. page 560; quoted in the Pathological Catalogue of the College Museum, vol. i. p. 4—5.

to get rid of an extraneous body, but appears not only not ready to let extraneous bodies enter the body, but endeavours to exclude them by increasing the thickness of the parts."*

It is evident from these passages that Mr. Hunter was aware that pressure from without might produce atrophy; though he may appear to favour the belief, which, I think, is commonly adopted as on his authority, that the direction of the pressure is that which determines its result. Really, the result seems to depend more on whether the pressure be occasional or constant. Constant extra-pressure on a part always appears to produce atrophy and absorption; occasional pressure may, and usually does, produce hypertrophy and thickening. All the thickenings of the cuticle are the consequences of occasional pressure,—as the pressure of shoes in occasional walking, tools occasionally used with the hand, and the like: for it seems a necessary condition for hypertrophy, in most parts, that they should enjoy intervals in which their nutrition may go on actively. But constant pressure, whether from within or from without, always appears to produce absorption: and there are here many interesting examples of its effects.

These vertebræ† illustrate very well the results of pressure by aneurisms and tumors. So far as themselves are concerned, the pressure of the aneurism was from without inwards; yet they are atrophied,—not ulcerated, but hollowed out, and remodelled in adaptation to the shape of the aneurismal sac.‡

So, also, the pressure of this loose mass of bone in the knee-joint§ was from without inwards; but its result was atrophy,—the formation of a deep pit at the lower end of the femur, in which it lay safely and almost tightly lodged.

Again, we have here one of the cases in which one of the lower incisor teeth of a rodent animal has continued its growth after the loss of the corresponding upper incisor; and, being no longer worn down by attrition in growing, has achieved a most unnatural length. It shows very well the consequences of constant pressure; for its extremity, turning round so as to form nearly a complete circle, has come into contact with the side of the lower jaw, and (like, as they tell, the Fakir's finger-nails growing through the thickness of his clenched hand) it has perforated the whole thickness of the jaw,—the absorption consequent on its pressure making way for its onward course.*

Here [shewing the base of a skull] is, perhaps, a stranger case still. It was taken from the body of a woman in the dissecting-room of St. Bartholomew's Hospital, and tells itself all the history that can, or perhaps need be given. She had an aperture in the hard palate, and for remedy of its annoyance, used to wear a bung, or cork, in it. But the constant pressure of so rough an obturator, produced absorption of the edges of the opening, making it constantly larger, and requiring that the cork should be often wound round with tape to fit the widening gap. And thus the remedy went on increasing the disease, till, of all the palatine portions of the upper maxillary and palate bones, nothing but their margin or outer shell remains: the rest is all absorbed.†

Lastly, let me show this as an instance in which, in the same part, permanent pressure produced atrophy, and occasional pressure hypertrophy. It is a Chinese woman's foot:‡ the bandaging, and constant compression in early life, produced this diminished growth; but afterwards, when, with all the miserable doublings up and crowding of the toes, it was used in walking, the parts of pressure became all seats of corns.

These examples, then, may suffice to show what I have said—that constant pressure on a part produces absorption: occasional pressure (especially if combined with friction) produces thickening or hypertrophy: and these, whatever be the direction of the pressure. And yet, let me add, that Mr. Hunter was not far wrong—he never was; for nearly all pressures from without are occasional and intermittent, and nearly all pressures from within, arising, as they do, from the growth of tumors, the enlargement of abscesses, and the like, are constant.

I will conclude this subject by showing some specimens, which have, perhaps, little direct communication with hypertrophy, yet may, in some measure, illustrate it.

We have seen that the tissues produced in hypertrophy are always those properly be-

* Hunter's Works, vol. 3, page 466. Pathological Catalogue, page 4.

† From the College Museum, No. 121A.

‡ A further description of these vertebræ may be found at page 53 of the Pathological Catalogue of the College Museum, vol. i. In proof that the hollowing out which these bones present is not the result of ulcerative absorption, their cancellous tissue is not exposed; being covered by a complete thin external layer of compact tissue.

§ Prepar. 955, in the College Museum.

* The specimen was exhibited from the Physiological Museum of the College of Surgeons.

† "The antrum is on both sides obliterated by the apposition of its walls, its inner wall having probably been pushed outwards as the plug was enlarged to fit the enlarging aperture in the palate. Nearly the whole of the vomer also has been destroyed, and the superior ethmoidal cells are laid open."—*Catalogue of the Anat. Mus. of St. Bartholomew's Hospital*, page 51, No. 232.

‡ From the Museum of St. Bartholomew's Hospital.

longing to the part, or are healthy perfect tissues, however highly organised the part enlarged may be. And this at once distinguishes them from the direct products of a morbid process, for a highly organised tissue is very rarely, indeed, formed in a diseased process. Such an instance, however, I have now to mention; and in this a tissue is produced by disease, which appears to be even more highly organised, and is of more complex structure, than that in which it is formed.

The case I refer to is that of ovarian cysts. These, you know, often contain fatty matter or tissue, hair and teeth, and other organised structures, either attached to thin walls, as if growing from them, or lying loose in their cavities. But, till Dr. Köhlrausch* examined them with the microscope, it was not, I think, known that the fat and hair are produced in a truly cutaneous structure growing on the inner surface of the cyst. In this†, and in other specimens, I have had opportunity of verifying his observations, and of finding, as he describes, that (as in the diagram) the prominent substance in which the hair grows is really a piece of skin, having a well organised, tough, and thin layer, like the firm outer layer of cutis; that this rests on true adipose tissue, arranged like the subcutaneous fat of the common integument; and that the cutis thus formed is covered by well-organised epidermis, and contains embedded in it hair-follicles and sebaceous glands as well formed as on the proper integument. He adds, that it also contains sweat glands: but these I have not seen.

* Müller's Archiv, 1843, page 365.

† Prepar. 164A, in the College Museum: described at page 69 of the Pathological Catalogue, vol. i. Other portions of the same cyst are preserved in preparations 165A and 165B.

This specimen existed in part of a very large multilocular cyst, the other divisions of which contained some fatty matter and loose hair; others, various fluids: others, secondary and tertiary cysts. And this is commonly the case; the cysts are so large when they come to be examined, that we cannot tell their origin.

But here is one*, a virgin ovary, with a cyst, the small size of which, as well as the structure of its walls, and the mode in which they are connected with the surrounding substance of the ovary, leave no doubt that it is a simply enlarged Graafian vesicle. Yet it contains a small mass of fat, exactly resembling the subcutaneous fat, with its tough fibro-cellular partitions.

So, then, we may conclude concerning these cysts, that they are Graafian vesicles, enlarged and diseased, and yet retaining that marvellous formative energy which, even independent of impregnation, and under only morbid excitement, can produce in them well-formed tissues, which may bring to perfection growths imbedded in them.

* From the Pathological Museum of the College of Surgeons.

LECTURE V.

Atrophy—definition of the term—implies deficiency, not cessation, of the formative process—two kinds of atrophy: one characterised by simple decrease, the other by degeneration, of tissue—these two usually concur, though either may exist alone—the most common form of degeneration of tissue is into fat—exceptions to this.—Fatty degeneration of a part probably always the result of atrophy—evidence for this view afforded by the frequent occurrence of such degeneration in an emaciated part—by its often ensuing after circumstances which in other instances give rise to mere reduction of size—and more strikingly by the phenomena of senile atrophy—formative process defective in old age — senile atrophy, as exhibited in the two classes of old persons, the fat and the lean.—Gradual disappearance of the nucleus coincident with the fatty degeneration of a fibre or cell—this phenomenon not observed in simple atrophy—importance of the nuclei in the formative process—shewn by their invariable presence in developing cells—and by their frequent persistence and occasional higher development after the cell or fibre is perfected.—Fat an organic substance of the lowest order—John Hunter's views of it.—General conclusions respecting atrophy with fatty degeneration.

Conditions leading to the occurrence of atrophy—some are the opposite of those inducing hypertrophy—examples illustrating the effects of these conditions—and of others which interfere with the process of healthy nutrition.—In some cases atrophy of a part seems to occur spontaneously—and then usually manifests itself as fatty degeneration—most common seat of this form of atrophy—adaptation in size of the blood-vessels and nerves to the degree of atrophy of a part—the oily matter in fatty degeneration probably not a new deposit in, but a transformation of, the tissue.— o necessary connection between the fatty degeneration of an organ and general obesity—fat formed within, not that accumulated round, a tissue, constitutes disease.

I PROPOSE now to consider the subject of Atrophy,—the very contrary of the hypertrophy which I endeavoured to elucidate in the last two lectures.

By Atrophy is commonly implied, not the cessation or total privation of the formative process in a part, but its deficiency; and, as I limited hypertrophy to the cases in which an increased power is acquired for a part by the growth, or by the development, of healthy tissue; so shall atrophy be here taken to mean only that process by which a part either simply wastes and is reduced in size, with little or no change of texture, or else, gradually and regularly degenerates into a tissue naturally existing in some other part of the body—as the fibro-cellular, or the adipose.

By the terms of this limitation it is implied, that, as there are two kinds of hypertrophy—the one with growth, the other with development,—so there are two kinds of atrophy—the one with simple decrease, the other with degeneration, of tissue. In both these forms, alike, there is a loss of functional power in the part; but in one, this loss is due to the deficient quantity, in the other to deteriorated quality, of the tissue. But, as in hypertrophy the development and the growth of the affected part usually concur, so, in atrophy, a part which becomes smaller, usually also degenerates, and one which degenerates, usually becomes smaller. Still, one or other of these—either the decrease or the degeneration—commonly predominates; and we shall see reasons why the distinction is very necessary to be made.

When tissues degenerate in atrophy, the product is most commonly fatty matter, in the form, sometimes, of organised adipose cells, but oftener of oil-drops lying loose in the interstices of the tissue, or in its cells or tubules.

A few tissues, indeed, as the cartilaginous, appear to degenerate into fibro-cellular tissue: such is the process in the fibrous degeneration to which the cartilages are liable, and in which we trace (so far as my observations yet extend) the gradual splitting of the intercellular substance of the cartilage, and the disappearance of its cells. Then, as it splits in finer and finer portions, the finest are gradually transformed into bundles of true cellular tissue, which, however, are of no long continuance, and are rubbed away in the friction of the joints.

Certain morbid structures—as adhesions, the fibrinous deposits in the arteries, fibrous tumors, and the walls of cysts,—degenerate with deposits of earthy matter, or calcification. But I am not sure that this occurs in natural structures; and the fatty degeneration is so much more general, that the observations which I shall now offer will relate almost exclusively to it, and to the atrophy by simple decrease or emaciation.

In the first place, it may be necessary that I should shew the reasons for believing that fatty degeneration of a part is always to be regarded as of the nature of an atrophy—as a diminution, rather than as a perversion, of the nutritive process. And I will endeavour to do this in some detail, because, ever since Mr. Bowman* discovered the fact that, in fatty degeneration of the liver, the fatty matter is collected within the true secreting cells of that organ, the disease has been constantly acquiring, by the observations of Dr. Johnson† and others, more interest and importance, and seems, at length, capable of being described in accordance with general laws.

The reasons, then, for believing that the fatty degeneration of a part is of the nature of an atrophy, are principally these:—

First, its frequent coincidence with diminution of size, *i. e.* emaciation, in a part. In the limbs, the most common form of atrophy from disease is manifested in diminution of size, together with increase in the fatty matter combined with the muscles and bones. Such is the condition displayed by the bones of these lower extremities‡, and such was the state of the paralysed muscles that were attached to them; such, also, is the condition of the majority of atrophied stumps after amputation, and of many other cases.

Secondly, the fatty degeneration of a part is commonly seen as the consequence of the very causes which in other instances give rise to simple wasting or emaciation of the same part. Thus, when the function of a part is abrogated, from whatever cause, the part may in one person shrink, in another degenerate into fat. The emaciation of a paralysed limb is a familiar object: but here are some of the muscles of such an one, hardly reduced in size, and all transformed into fat§. Here is a pancreas, with a cancerous tumor pressing on its duct, and all behind the part obliterated is degenerated into fat; and here another pancreas, the duct of which was obliterated, and is now in part dilated into a large sac; but in this, the part behind the obstruction is simply shrivelled, dry, hard, and scarcely lobulated.‖ Here, also, are bones atrophied in bed-ridden persons; some are exceedingly light, small, and dry: others are not small, but very greasy, full of fatty matter. Either of these results, also, or the two mingled in various proportions, may result from defective supply of blood; as in the cases of atrophy of parts of bones after fractures, as described by Mr. Curling,* to which I shall have again to refer. So that from these, and from other cases hereafter to be mentioned, we may say generally, that nearly all the ordinary causes of atrophy may produce, in any part, in one case reduction of size, in another, fatty degeneration.

But, thirdly, by far the most striking evidence of this is to be found in the phenomena of old age. In all real old age—and infirmities speak more plainly of the old age I refer to than do the years a man may have counted,—the formative power is defective: the power which was dominant over the waste of the body in childhood and youth, and maintained the balance in mature vigorous manhood, now fails—as the tide, after a flood and a period of rest, turns and ebbs down. Thus, atrophy is a uniform concomitant of the infirmities of old age; but the results of senile atrophy are not the same in all: rather, you find among old people—you might almost thus divide them into two classes—the lean and the fat; and these, as you may see them in any asylum for the aged, personify the two kinds of atrophy I have spoken of.

Some people, as they grow old, seem only to wither and dry up—sharp-featured, shrivelled, spinous old folks, yet withal wiry and tough, clinging to life, and letting death have them, as it were, by small instalments slowly paid. Such are the "lean and slippered pantaloons," and their "shrunk shanks" declare the pervading atrophy.

Others—women more often than men—as old and as ill-nourished as these, yet make a far different appearance. With these the first sign of old age is that they grow fat; and this abides with them till, it may be, in a last illness sharper than old age, they are robbed even of their fat. These, too, when old age sets in, become pursy, short-winded, pot-bellied, pale and flabby; their skin hangs, not in wrinkles, but in rolls; and their voice, instead of rising "towards childish treble," becomes gruff and husky.

Now, these classes of old people, I repeat, may represent the two forms of atrophy—of that atrophy by decrease, and that by degeneration, of tissue—to which we shall find nearly every part of the body liable. In those of the first class you find all the tissues healthy, hardly altered from the time of vigour. I examined the muscles of such an one lately—a woman, 76 years old, very lean, emaciated, and shrivelled. The fibres

* Lancet, Jan. 22, 1842, p. 560.

† Medico-Chirurgical Transactions, vol. xxix. 1846.

‡ Exhibited from the Museum of St. Bartholomew's Hospital, Series 1, Sub-series A, No. 151.

§ Two specimens were exhibited: one from the Pathological Museum of the College of Surgeons, No. 9: the other from the Museum of St. Bartholomew's Hospital, Series v. No. 1.

‖ The first of the above specimens was exhibited from the Pathological Museum of the College of Surgeons; the other from the Museum of St. Bartholomew's Hospital, Series xx. No. 2.

* Medico-Chirurg. Trans. vol. xx.

were rather soft, yet nearly as ruddy and as strongly marked as those of a vigorous man; her skin, too, was tough and dry; her bones, slender indeed, yet hard and clean like this skull*: her defect was a simple defect of quantity.

But in those that grow fat as they grow old, you find, in all the tissues alike, bulk with imperfect texture; fat laid between, and even within, the muscular fibres, fat about the heart, the kidneys, and all the vessels; and the bones so greasy that no art can clean them: the defect of all these is the defect of quality.

Now, I do not pretend to account for this great difference in the concomitants of the other infirmities of old age in different people. The explanation probably lies far among the mysteries of the chemical physiology of nutrition, of the formation of fat, and of respiratory excretion; and we may hope to find it when we know why, out of the same diet, and under all the same external conditions, one class of men, even in health and vigour, store up abundant fat, and another class excrete the elements of fat. For it is particularly to be observed, that these diversities of senile atrophy are in but a slight measure determined by external circumstances: we see them in poor-houses, and in all asylums for the aged, although the diet and every other condition of life are alike for all.

Now, the conclusion which we may draw from these facts concerning the atrophous nature of fatty degeneration, is remarkably corroborated by the anatomical condition of parts which have suffered the degeneration; namely, that when the accumulation of fat exceeds a very small amount, the nucleus of the cell, or other elementary structure containing it, is pale and indistinct, and, when the fat is abundantly collected, disappears completely. I have noticed this so often in fatty degenerations of the liver, kidney, and muscles, that I can speak of it almost certainly as a general fact.

The diagrams [exhibited], which were all made from nature by Mr. Aldous, are chiefly destined to illustrate the fatty degeneration of the heart, of which I shall speak further in the next lecture. But, in illustration of the fact just mentioned, I may refer to these representing muscular fibres of the heart after immersion in acetic acid. The effect of the acid is, as you know, by making the other constituents of the fibres more transparent, to bring into clearer view the nucleus, on which the acid exercises apparently no other influence than that of making its borders darker, as if by corrugating them. The result of thus immersing them in acid is, that the healthy fibres of the heart always display a succession of nuclei at nearly equal distances from each other, and usually lying in the middle of the presenting surface of the fibre. Such nuclei are, so far as I know, peculiar to the heart-fibres; they are large, reddish-yellow like blood-globules, especially when the heart is strongly developed; their form is elongated, oval, or nearly parallelogram, and at each of their ends one almost always sees tapering groups of isolated, small, yellowish granules, like particles separated and departing from the nucleus. But, in the degenerated fibres—when the change is least marked, and but little fatty matter has collected within the sarcolemma—the outlines of the nuclei look dim, and they lose their colour. In a further advanced stage the nucleus of the fibre cannot be seen at all; its former place is indicated, if at all, only by some out of the narrow column of yellow granules; and in a yet later stage, or when the sarcolemma appears nearly full of fatty particles, all trace of both the nucleus and these granules is lost.

The same may be said of the fatty degeneration of the renal and the hepatic cells. Neither in these, nor in the muscular fibres, is the nucleus concealed by the collection of the globules of oil; turn the cell as you may, and watch it as it rolls, yet you will find no mark of nucleus; it is either gone, or is itself transformed into one of the oil-globules. Like the nucleus of the muscular fibre, it disappears gradually. When but a few small oil-drops are in the cell, the outlines of the nucleus grow dim; as they increase it vanishes, or, as I am inclined to think, a part of its constituents are transformed into oily matter, and it constitutes one of the drops of oil, perhaps the largest, within the cell.

Now this is, I think, a very significant fact in regard both to this fatty degeneration, and to the general physiology of the nucleated cell. It appears the more so from these facts: that in the atrophy with mere decrease, this disappearance of the nuclei does not occur—a fact which I have been able to observe in cirrhosis, and in simple emaciation of the heart; and that, notwithstanding the great change in the nucleus and the contents of the cell or the tube, the wall of the cell itself, and of the tube—that is, in the cases just adverted to, the cell-membrane and the sarcolemma—remain apparently unchanged. So do the neurilemma and the membrana propria, in cases of fatty degeneration of the nerve-fibres, and of the tubules of the testicle.

The peculiar interest of the fact is in the corroboration it gives to the other evidence

* The skull of an old edentulous person, in which the results of this form of senile atrophy by simple decrease are well illustrated. Prep. 8 in the Pathological Museum of the College of Surgeons.

which has been gradually accumulating towards proving that these bodies—which we call nuclei when they lie in cells or tubes, and cytoblasts, or cell-germs, when they lie loose, or without envelopes—that these, more than the cells, are the organs through which issue the strength and the direction of the formative process. At the lowest estimate, they seem to show that the existence of the nucleus is always essential to what is commonly called the formative power of the cell, or the organ developed from it; and that the office of the nucleus does not, as Schwann implies, cease when the formation of the cell is perfected. But beyond this, facts now seem to prove that we ought to ascribe to the nucleus a much greater power and influence in formation, than to the cell.

It would be out of place to enter now into a long discussion of the physiology of the nucleated cell; yet I may briefly mention the reasons for ascribing an essential and principal formative power to the nucleus.

And first, there is, I think, no example of development, in either structure or composition, effected in the animal organism by cells which have no nuclei; while there are many instances in which nuclei, whether contained in cells or without them, appear to assume higher forms, or to be centres and sources of formative and reproductive power.

It may suffice to refer especially to the researches of Professors Henle* and Goodsir†. Those of Henle bearing on this point relate especially to the formation of what he has named "nucleus-fibres," including those which, with the general characters of elastic tissue, are variously interwoven with the fasciculi of cellular tissue, the fibres of involuntary muscle, the membranous coats of blood-vessels, and other parts; in all of which he may be said to have proved that these nucleus-fibres are formed, as their name implies, from nuclei‡.

The investigations of Mr. Simon§ also, on the glands without ducts, have shewn a wide extent of gland-function discharged, however obscurely, by cytoblasts alone or principally; and have confirmed all the evidence that they, isolated, or as nuclei to cells, are the chief agents in the elaboration of secretions. And the observations of Professor Goodsir‖, in his several papers on Centres of Nutrition, on Secreting Structures, and on the Structure of the Serous Membranes, prove the power of the nucleus both in the production and multiplication of cells, and in the formation and storing of secretions; and afford, I think, a fair ground for his ingenious hypothesis that it is their office, "as centres of nutrition," to "draw from the capillary vessels, or from other sources, the materials of nutrition, and to distribute them by development to each organ or texture after its kind*."

To these, which are in many respects confirmatory of the best observations of Dr. Martin Barry,† and which are themselves confirmed by Kœlliker‡ and many others, I may venture to add my own observations on the development and growth of tumors.§ They shew that the tumors which grow most rapidly are formed, not of cells, but of cytoblasts, or nuclei (as we should call them if they were enclosed in cells); that when cells are found they are not transitional but terminal forms, not giving origin by further development to any other structures; and that when the most perfect fibro-cellular and fibrous tissues exist, they appear very certainly to be formed under the influence of cytoblasts alone—cells having no existence in the structure.

Lastly, I may refer to what was said in a former lecture‖ concerning the abundance of cytoblasts in all growing tissues, and to their persistence especially, in tissues, such as the muscular, in which, because of constant action, constant and peculiarly quick nutrition must go on.

Now, while these among other facts make it nearly certain that the nucleus, whether of the fibre or the cell, is the chief seat or source of formative, reproductive, and secretive power, it is surely interesting to find that in those changes in which, by all their conditions, defective nutrition is most evidently indicated, the nucleus is absent or imperfect. I am not, indeed, yet prepared to prove, as beyond a doubt, that it is the failure of the nucleus which brings about the degeneration of the cell or fibre. At present I can only see the concurrence of the two changes, and the frequent existence of instances in which the nucleus appears pale and fading, before any fat is deposited in the cell; but it will be very strange if we do not before long find enough to prove that the defect of the nucleus is the first defect, and the essential condition of the disease.

* Allgemeine Anatomie, 1841, p. 192-9.

† Anatomical and Pathological Observations, by John and Harry Goodsir, 1845, Art. "Centres of Nutrition."

‡ For the mode of formation and arrangement of the nucleus-fibres in the different tissues, as described by Henle, see Henle, loc. cit. p. 194; or Report on the Use of the Microscope in Human Anatomy and Physiology, by James Paget: Churchill, 1842, p. 8.

§ A Physiological Essay on the Thymus Gland. London, 1845, 4to.

‖ Loc. cit.

* Loc. cit. page 1.

† Philosophical Transactions, 1841, &c.

‡ Schleiden und Nägeli's Zeitschrift, Heft. ii. 1845.

§ Report on the Progress of Human Anatomy and Physiology in 1844-5, page 35; published in No. xliii. of the British and Foreign Medical Review.

‖ Lecture iii. Medical Gazette, vol. xl. page 55.

It will now be the more interesting to enter on the consideration of some other characters of this fatty degeneration, if, while we do so, we keep in mind their connection (whether in coincidence or by consequence) with the loss of that power which results from the mutual action of the nucleus and the cell-wall, or which is derived from the nucleus alone.

In this degeneration, then, we see that the parts do not die—they degenerate; they are, as it were, paralysed in their formative power; they form, or admit into themselves, an excretion of the lowest order, structureless, ternary, crystallizable. For such, indeed, is fatty matter. As Hunter says, in the brief dogmatic style which he commonly adopted for his catalogues: "Fat is no part of an animal: for, first, it is not an animal substance; secondly, an animal is the same without it as with it,—it is to be considered as an adventitious matter; and, thirdly, it is found both in vegetables and minerals, and therefore it is a substance common to every class of matter."*

The sentence might serve as a text for a whole discourse. "Fat is not an animal substance;" *i.e.* not one peculiar to animals; "it is found both in vegetables and animals;" it is but one of the great class of principles in which hydrogen and carbon are the chief elements, which include both animal and vegetable oils and fatty matters; and to which are nearly related, ether, alcohol, the carburets of hydrogen, and other substances which stand at the very borders between organic and inorganic matter.

And, again, "an animal is the same without it as with it;" the hybernant is the same through all his life, whether he be storing up fat for his winter's sleep, or laden with it when his sleep begins, or emaciated by its removal to maintain his warmth while his sleep and fasting lasted. It is to him almost as extra clothing is to us—a thing to put on and off—no part of his constant self. "It is to be considered as an adventitious matter;" one which, so far as the animal's self is concerned, might as well be clean cast out as an excretion, and which is so cast out whenever the supply of the hydro-carbon constituents of the food is not sufficient for respiration and the maintenance of heat.

Such is the substance which these tissues, when the nucleus is away or imperfect, admit or form within themselves; a substance which, as compared with the proper contents of muscle- and nerve-fibre, is structureless and powerless; and which, in regard to its chemical composition, is inferior even to most of the normal constituents of the excretory bile and urine; for these — taurine, urea, uric acid—are quaternary, or yet more compound; and, therefore, in comparison with them, fat more nearly resembles the inorganic compounds, and bears more of the general character of an excretion

To sum up, then, what concerns this fatty degeneration considered as a form of atrophy—

1. It is very often coincident with the atrophy which manifests itself in decrease of a part.

2. It may ensue as a consequence of any of the ordinary causes or products of atrophy.

3. It is a common form of change in the imperfection of the formative process attendant on the infirmities of old age.

4. It is attended, or preceded, by the imperfection or loss of the elementary organism which we have every necessary ground for regarding as the chief source of formative power in the tissues.

5. It is, itself, a deposit or formation, and a storing up away from all influence on the system, of a substance which has the characters of an excretion of the lowest order.

On these grounds we may regard fatty degeneration as always an expression of atrophy—of defective, not perverted, formative power. And we may hold this, even though the formation of fat be attended with increase of the bulk or weight of the part; for as the mere growth of a part, though it be great, is not so sure an expression of a strong formative power, as even a little development is, so no increase of size can counterbalance the evidence which a part gives of its degenerateness when its tissue changes to one of lower function.

Following, now, the same course as in speaking of hypertrophy, I will endeavour to explain the conditions in which atrophy may ensue. They are many more than those in which hypertrophy may originate.

Some of the causes (if they may be so called) of atrophy are the very opposites of those of hypertrophy. Thus, as we have seen that when a part is, within certain limits, over-exercised, it is over-nourished; so, if a part be used less than is proper, it suffers atrophy. For instance, I have here the heart of a man 50 years old,* who died with cancer of the stomach in extreme emaciation. You see its small bulk; it weighed only five ounces four drachms; whereas, according to the estimates of Dr. Clendinning†, in a healthy man of the same

* Gallery Catalogue of the Museum of the College of Surgeons, vol. iii. p. 185.

* From the Museum of St. Bartholomew's Hospital, Series xii. No. 57.

† London Medical Gazette, vol. xxii. page 450.

age it would have been upwards of nine ounces. But, small as it is, this heart was adapted to the work it had to do; and in this adaptation we have the purpose of its atrophy. For, because of his cancer the man had less blood, and needed less force of the heart to propel it: so that, in direct opposition to the course of events in hypertrophy, here, as the quantity of blood diminished, and the waste of the heart by exercise in propelling it diminished, so the repair of the waste diminished somewhat more than the waste itself did; and the heart, though less wasted, became smaller, till it was only large enough for the propulsion of the scanty supply of blood.

The same may be said of the heart of which this drawing represents the natural size: it was in a woman 22 years old, who died with diabetes. It weighed only five ounces; yet, doubtless, it was enough for her impoverished supply of blood.

Again, I showed instances in which the increased flow of healthy blood through a part produced hypertrophy, and I spoke, in a former lecture, of some examples of complete failure of nutrition in consequence of an obstructed supply of blood. Now, as examples to prove merely defective nutrition in consequence of a diminished supply of blood, I adduce some specimens of change first described by Mr. Curling.* They are sections of a fractured femur and other bones shewing atrophy of that portion which, by the fracture, was cut off from the supply of blood through the great nutritive or medullary artery. The consequence of the withdrawal of so much of the blood from the upper or lower fragment, according to the position of the fracture, is not death: for the anastomosis between the vessels of the wall and those of the medullary tissue of the bone is enough to support life, though not enough to support vigorous nutrition; and the frequent consequence of the fracture is, therefore, the atrophy of the part thus deprived of part of its ready supply of blood.

Moreover, as an excess of the constituents of which a tissue may form itself may produce hypertrophy of that tissue, so may defect of those constituents produce atrophy; though of this I can give but one example, in the fat, the quantity of which diminishes even below what is natural to the several parts, as often as the fat-making constituents are deficient in the food, and therefore in the blood.

In these instances we see that conditions contrary to those giving rise to hypertrophy produce atrophy.

But there are many other conditions from which atrophy in a part may ensue,—defects of the constitution of the blood, defective or disturbed nervous influence, and many things beside. In short, whatever interferes with or interrupts any of those conditions which I enumerated as essential to healthy nutrition, may give rise to atrophy. I referred, in a former lecture,* to one of these, and now refer to it again, as having application to some of the cases I shall hereafter speak of,—namely, the effect of inflammation in a part. When a part has been inflamed, it often, as the inflammation recedes, shrivels and becomes atrophied. Much of the diminution depends, no doubt, on the contraction which ensues, in the organised product of inflammation (as it does also in cicatrices); and this contraction, by its pressure on the proper constituents of the organ, may produce wasting atrophy of them, though they themselves did not concur in the morbid process of the inflammation. But, in some of these cases—I may adduce those of chronic inflammation of the muscles, the liver, and the kidney—we may find little or no shrinking of the organ, but fatty degeneration. This concurrence of the two changes—the organization of the inflammatory product, and the degeneration of the proper texture of the part—will be found in many cases. It is shown in the heart, which I exhibited before; I have seen it also in cirrhosis, and in the enlarged brawny state of the liver: and I have little doubt of its occurrence in some of the cases of fatty degeneration of the kidney. Its explanation, I presume, is, that the process of organizing the morbid product interrupted or excluded that of repairing and replacing the proper fibres and cells of the part; hence, as in the ordinary course of events, they degenerated, and so remained.

But, besides all the imaginable instances in which atrophy of a part may thus arise as a secondary process, there are others in which we are so unable to trace, in the remotest degree, the conditions out of which the atrophy of a part results, that we are tempted to speak of it as primary, or spontaneous,—in the same sense as we might so call the natural wasting of the Wolffian bodies, the thymus, and other temporary glands. It is as if an atrophy of old age, instead of affecting all parts simultaneously, took place prematurely in one; as if there were a suspension, or annulling of the affinities, if we may so call them, on which the nutrition of a part immediately depends.

Whatever the true explanation may be, most of the parts of the body appear to be subject to this seemingly spontaneous atrophy; and it generally manifests itself in the form of fatty degeneration. Its most frequent seats are the heart and arteries, the

* Medico-Chirurg. Trans. vol. xx.

* Lecture I. Med. Gaz. vol. xxxix. p. 935.

bones, the liver, and the kidneys; but it occurs also in the pancreas and the salivary glands, and in the testicle. It may, moreover, occur in morbid products, as in the fibrinous deposits on the interior of arteries, and, as I believe, in tumors. For Rokitansky* alludes to a change which he names Saponification of cancer, as one of the means by which spontaneous cure of the disease may be effected: and in a case, which I lately examined with Dr. Ormerod, some masses of what we entertain no doubt were, or rather had been, firm medullary cancers of the liver, consisted almost entirely of oil-globules, such as are found in fatty degeneration of the natural parts. In a case of cancer of the spleen, also, occurring in connection with hard cancer of the breast, I found many of the large nucleated cancer-cells containing little oil-globules, just like those found in the cells in commencing fatty degeneration of the liver and kidney. And I have since found the same in several other cases of both innocent and malignant tumors.

Such are the conditions out of which atrophy may arise, and such the probability that some cases may deserve to be called spontaneous. From what has been already said, it appears that the condition, of which atrophy is the direct consequence, does not usually determine the mode or form of the atrophy. Constant pressure almost always produces wasting; and the atrophy which seems to arise spontaneously, usually takes the form of fatty degeneration: but defective exercise, decrease of blood, old age, and the rest, may be followed by either decrease or degeneration.

We may, again, contrast the states of hypertrophy and atrophy in regard to the mode in which the vessels and nerves adapt themselves. As a part becomes atrophied, so its blood-vessels diminish,—as the contrast of the kidneys in this specimen shows†. And, when a muscle, or any other organ, suffers atrophy, its nerves are consequently and proportionally changed. So, in atrophy of the eye, the optic nerve diminishes; and so, in a case of fatty degeneration of the adductor muscles of the thigh, in consequence of disease of the hip-joint, I found corresponding atrophy of their nerves, which atrophy of the nerves must have been, in this case, secondary: the course of events must have been inaction of the muscles in consequence of the disease of the joint, then atrophy of them in consequence of their inaction; and, finally, atrophy of the nerves, following that of the muscles.

* Patholog. Anat. B. i.

† Prep. 3, Pathological Museum of the College of Surgeons. The specimen, which consists of the urinary organs of an Argus Pheasant, was exhibited and briefly described in the last lecture (MED. GAZ. vol. xl. page 97.) The difference in size between the renal artery supplying the large hypertrophied kidney, and that supplying the shrunken and atrophied one, is very striking.

As to the very nature of the wasting atrophy, and the exact mode in which the quantity of a tissue is decreased, we really know, for certain, extremely little. For explanation of the mode in which the fatty degeneration takes place, I before suggested that fatty matter is probably one of the products of the spontaneous transformation of the tissues at the end of their period of vigorous existence; and that this form of atrophy only represents the state of a tissue remaining unrepaired after it has fallen into the ordinary course of degeneration. The possibility of fatty matter being formed in the transformation even of protein compounds is certain from the observation of Wurtz,* that butyric acid is one of the compounds formed by the decomposition of fibrine in the open air.

And that the fat which we find in the muscles and gland-cells is really not a deposit put into them from without, but one of the products of the change of their own contents, is made probable by the frequency with which, in muscular fibres, we find the fat-particles arranged in the same manner as the proper constituents of the fibrils,—sometimes in transverse, sometimes in longitudinal rows. Indeed, one is constantly tempted, in the examination of these specimens, to think that we can trace all the transitions from the "sarcous elements"† of the muscular fibre, and the "granules" of the gland-cell, to the little oily particles, which, by clustering, and then fusing with others, at length make the great oil-globules which fill the cell.

What we can see in the degenerating normal tissues is fully confirmed by the corresponding changes taking place in anormal products; of which Rokitansky adduces eleven classes of instances, in which protein compounds are replaced by fatty matter in such conditions that it is hardly possible to assume anything but that the fat is one of the products of spontaneous transformation of the higher compound. In some of these, indeed, the fat is found in parts to which exudations from blood-vessels could scarcely gain access; as, for example, in the substances enclosed in old shrivelled sacs with non-vascular walls; and in most of them it is found most abundantly in the centres of parts—such as coagula in the blood-vessels—which are most remote from the supply of blood.

* Mulder's Physiologische Scheikunde, 1843, page 351.

† The term applied by Mr. Bowman to the elementary particles of which striped muscular fibre is supposed to consist.

In conclusion of this subject, it may be proper to state that there appears no necessary, or even frequent, connection between the fatty degeneration of any organ in particular, and that general tendency to the formation of fat which constitutes obesity. No doubt a person who has a natural tendency, even when in health, to become corpulent, would, *cæteris paribus*, be more likely to have fatty degeneration than to have a wasting atrophy in any organ which might fall into the conditions in which these changes originate. And, as a general rule, spirit-drinking, and the excessive use of other hydro-carbonous articles of food, while favouring a general formation of fat, does, also, often give rise to special fatty degeneration in the liver, or some other organ. Yet, on the other hand, one commonly finds the proper elements of all the tissues—the heart, the liver, and the rest—quite healthy in men who are very corpulent. The muscular fibres of the heart, or of the voluntary muscles, may be imbedded in adipose tissue, and yet may be themselves free from the least degeneration. So, also, the hepatic cells may be nearly free from fat within, though there be much oil around them. Fat accumulated in tissue round a part is a very different—probably an essentially differen—thing from fat within it; the one is compatible with perfect strength, the other is always a sign of loss of power. In the muscles of some fish—the eel especially—it is hard to get a clear sight of the fibres, the oily matter round them is so abundant: but the fibres are peculiarly strong, and, in their own texture make a striking contrast with the fibres of a degenerate muscle, in which the fat is, in great part, within.

The same essential distinction between general and local fat-formation, though they may often coincide, is shown in the fact that the local formation very often happens in those whose general condition is that of emaciation. It was so, in the cases of paralysed lower extremity with diseased hip; of the fatty pancreas,—in a case of osteoid tumor, with fatty liver,—and in the cancer of the spleen in a patient emaciated with cancer of the breast.

On the whole, therefore, we must conclude that something much more than a general tendency to form fat, or a general excess of fat in the blood, is necessary to produce a local fatty degeneration. The general conditions are favourable, but not essential, to this form of atrophy.

LECTURE VI.

Atrophy as manifested in the principal organs and tissues.—Atrophy of muscle—that of voluntary muscle manifested by wasting, or by fatty degeneration—the degeneration may be almost uniform—or, which is more common, only partial—varieties presented by the degenerated fibre—and by the cellular tissue between the fibres—distinction between formations of fat outside, and those within, the fibres.—The most common condition leading to atrophy of muscle is inaction.—course of events in such a case—experiments of Dr. John Reid—suggestion founded thereon for the treatment of paralysed muscles.—Spontaneous atrophy of muscle.—Atrophy of the heart—most commonly manifested by fatty or "granular" degeneration—general and microscopic characters of these two forms of disease.—Cases illustrating the morbid anatomy and fatal termination of "granular degeneration" of the heart.

Atrophy of bone—may show itself in simple wasting—or in fatty degeneration—specimens illustrating the disease in each of these forms—fatty degeneration of bone identical with ordinary mollities ossium—simple softening of bone shown in the rickets of adults—relation between fatty degeneration of bone and rickets of early life.

Fatty degeneration of the liver—reasons for supposing that the liver, in such cases, is not in active function—but that it is in a state of atrophy—relation in which the functions of the liver stand to those of the lungs.

I HAVE, in the next place, to request your attention while I speak particularly of atrophy manifesting itself in some of the principal organs and tissues of the body.

First, of Atrophy of Muscles. The muscles with transversely striated fibres exhibit in the most marked manner the two forms of atrophy—by wasting, and by degeneration into fat. In a wasted muscle—such as one sees, for example, in the limbs of those who are only emaciated—the fibres may appear almost perfectly healthy, rather paler indeed, and softer, and more disposed to be tortuous than in the natural state; yet with well-marked transverse striæ, and all other their characteristic features. It is an adapted muscle; and, though bearing only indirectly on the point, I show this example of adaptation by diminished muscular growth in the case of a fractured arm, with excessive shortening of the humerus.*

In a muscle atrophied with fatty degeneration, those several forms will, in different stages, be seen of which I spoke briefly in the last lecture. The whole muscle may appear pale, bleached, or of some yellowish or tawny hue, soft and easily torn. But a more frequent appearance in the voluntary muscles is that in which fasciculi in the healthy state, and others in various degrees of degeneration, lie in parallel bands, and give the whole muscle a streaky appearance, with various hues intermediate between the ruddiness of healthy flesh, and the dull, pale, tawny yellow, or yellowish-white, of the complete degeneration. In such a case (and this may appear remarkable) healthy primitive fibres even may lie among those that are degenerated; and of these latter, some, in place of the transverse striæ, present dark minute dots arranged in transverse lines; in others, the whole fibre has a dim granular aspect, with no definite arrangement of the granules; in others, little oil-globules are seen adhering to the interior of the sarcolemma; and in others, such globules are collected more and more abundantly, and to the proportionally greater exclusion of the proper constituents of the fibres.

In all the fibres advanced in the degeneration, the perfect, unaltered appearance of the sarcolemma, and the absence of the nucleus, will be noticed.

In the examination of different examples of fatty degeneration of the voluntary muscles, you may find much diversity in the characters of the tissue between the fibres and fasciculi. In some instances the interspaces between the fibres are filled with cellular tissue both more abundant and tougher than that in healthy muscle, so that it may be hard to dissect the fibres for the microscope. With this there may be no unusual quantity of fat; but in other cases the quantity of fat between the fibres is very great, and the fibres themselves may seem empty, or wasted, as if overwhelmed by the fat accumulating around them. In such a case, when the accumulating fat has coalesced with that which before surrounded the whole muscle, it may really be difficult to find where the muscle was; for the whole of what belonged to it, even after its degeneration, may be gone, and in its place there may

* Museum of the College: Phys. Div. No. 42.

remain only an obscure trace, if any, of fibrous arrangement, dependent on the position of the principal partitions of the new fatty tissue.

I cannot yet speak positively in explanation of this diversity in the state of parts between the fibres. But I am nearly sure that the increase and toughness of the cellular tissue (when not the product of organized inflammatory deposit) exists only in atrophied muscles which have had to resist stretching, after the manner of ligaments; as, for example, when their antagonists are not as powerless as themselves; and that the increase of fat is found only when a muscle has been very long atrophied, and has remained completely at rest, and the fibres themselves, after degenerating, are being removed, and giving place to a formation of common adipose tissue which collects in every part that they are leaving, just as it does about shrinking kidneys, cancers of the breast, old diseased joints, and other parts similarly circumstanced.

In either case we must distinguish between these formations of fat outside, and those within, the fibres; they are in no necessary connection with the proper atrophy of the fibres, but appear generally subsequent to it, and when they attain their highest degree they are not to be regarded as degenerations of the muscular tissue; for they are not, in any sense, formed out of it, though they occupy the place from which it was removed.

The condition in which atrophy of the muscles by far most commonly ensues is inaction. Whenever muscles lie long inactive, they either waste or degenerate; and this whether the inactivity depend on paralysis through affection of the nervous centres or fibres, or fixation of the parts they should move, or any other cause. The degenerative process may be so rapid that, in a fortnight, muscles paralysed by hemiplegia may present a manifest change of colour.

Now, the course of events in these cases appears to be, that the want of exercise of the muscle, whether paralysed or fixed at its ends, makes its due nutrition impossible; and the atrophy thus brought about is the cause of the loss of irritability of the muscle, *i. e.* of the loss of its capacity for contracting.

For, the experiments of Dr. John Reid* plainly shew that loss of contractile power in a paralysed muscle is due, directly, to its imperfect nutrition, and only indirectly to the loss of connection with the nervous centres. When he divided the nerves of a frog's hind legs, and left one limb inactive, but gave the muscles of the other frequent exercise by galvanising the lower end of its nerve, he found (to state the case very briefly) that at the end of two months the exercised muscles retained their weight and texture, and their capacity of contraction, while the inactive ones (though their irritability, it might be said, had not been exhausted), had lost half their bulk, were degenerated in texture, and had also lost some of their power of contracting. In other cases, too, he found the loss of proper texture always ensuing in the inactive state before the power of contraction was lost.

And it is doubtless the same in man. A muscle which, by no fault of its own, but through circumstances external to itself, has been prevented from acting, becomes shortly incapable of acting even when the external obstacles to action are removed. Hence, I think, we may deduce a rule which ought to be acted on in practice. When a person has had hemiplegia, one commonly sees that long after the brain has, to all appearance, recovered its power, or even through all the rest of life, the paralysed limbs remain incapable of action,—as motionless as at the first attack. Now it is not likely that this abiding paralysis is the consequence of any continuing disease of the brain: rather, we must ascribe it to the imperfect condition into which the muscles have fallen during their inaction. So long as the state of the brain makes voluntary action impossible, the muscles are suffering atrophy; then, when the brain recovers, they are not in a state to obey its impulse—they are degenerate; and thus, their inaction continuing, they degenerate more and more, and all remedy becomes impossible. If this be true, Dr. Reid's experiments suggest the remedy. When muscles are paralysed through affection of the nervous system, we ought to give them artificial exercise: they should be often put in action by electricity or otherwise; their action, though thus artificial, will ensure their nutrition; and then, when the nervous system recovers, they may be in a condition ready to act with it.

You will find this suggestion ingeniously supported by my friend Mr. W. F. Barlow, in a paper published by him in the Lancet. In one case, in which I could act upon it, the result was encouraging. A little girl, about eight years old, had angular curvature and complete loss of voluntary movement in the lower extremities. This had existed some weeks, but as I found she had reflex movements, the legs twitching in a very disorderly way as often as the soles were touched, I advised that the limbs should be put in active exercise, for about an hour two or three times a day, by tickling the feet, or in some similar way. The result was, that when, several weeks afterwards, the spinal chord recovered, and she could again direct the effort of the will to the lower limbs, the

* Edinburgh Monthly Journal of Medical Science, May 1841.

recovery of strength was speedy and complete; more so, I think, than if, in the paralysed condition, the muscles had been left to the progress of the atrophy.

The hindered action of muscles is not the only condition from which their atrophy may ensue. They waste, together with all the rest of the body, in most emaciating diseases; as, for example, in phthisis. And, this specimen of an excessively fat mutton chop* shews that they may degenerate into fat, in concert with other tissues, in a general defective nutrition; such as, I believe, is not very uncommon in sheep, but such as I have never seen in man.

But, besides this general fatty degeneration of muscles, we find it sometimes apparently as a primary or spontaneous affection of one or more muscles. Thus I believe it may occur in a voluntary muscle. We find sometimes one of the muscles of an extremity or of the back thoroughly atrophied, while the others are healthy; and no account can be given of its failure. Perhaps its history would have been like that of a case to which Rokitansky† briefly refers as a spontaneous fatty degeneration of the muscles of the calf with extreme pain. Mr. Mayo‡ has recorded two cases of, apparently spontaneous, atrophy of the muscles of the shoulder, in which, in a few weeks after severe pain, but no other sign of acute inflammation, all the muscles about the shoulder became simply, but exceedingly, atrophied.

It is not unfrequent to find a portion of the lower and posterior part of the recti abdominis muscles in a state of fatty degeneration. I can give no account or explanation of it, more than by saying that I have seen four or five cases in which about as much of the back part of each of these muscles as corresponded with the pyramidales in front, was in complete fatty degeneration.

A similar change also is mentioned by Dr. Budd§ and Rokitansky‖, as occurring in the gall-bladder. Something of the kind may also be found in the urinary bladder of old people. But most of all, the fatty degeneration appears both frequent and important in the heart; and, with your leave, I will enter into some detail respecting the atrophy of this organ.

Atrophy of the heart may appear in either wasting or degeneration. Of the former I shewed examples in the last lecture, in the heart of a cancerous man, 50 years old, which weighed only five ounces four drachms; and that of a diabetic woman, 25 years old, which weighed only five ounces one drachm. Both these had deviated from the general rule of enlargement of the heart with advancing years, in adaptation to the diminished quantity of blood, and the general diminution of the body.

In these cases there is a uniform decrease of the heart: its cavities become small, and its walls proportionally thin. In other instances the cavities are dilated, without proportionate thickening, or, it may be, even with thinning of their walls. This may be considered as occurring in cases of such increased obstacle to the circulation as might in other persons, or in other conditions, engender hypertrophy of the heart. Or, more probably, the dilatation is the consequence of wasting in a heart that had once been large and strong.

But I wish to speak particularly of that form of atrophy of the heart which consists in fatty degeneration; and of examples of it which in their early stages might be called "granular degeneration," though later the fatty degeneration may be manifest.

Extreme instances of fatty degeneration of the heart have been long known and well described. The whole, or the greater part of the heart, in such cases, may seem reduced to fat,—the fat which occupies the place of its proper tissue having coalesced with that which lies on its surface, and the degeneration being accompanied by thinning and softening of its walls.

In like manner, the cases have been well known and described, in which fat accumulates in unusual quantity in those parts of the exterior of the heart in which it naturally exists and is found, though often emaciated and very soft, even in the thinnest people; viz. along its transverse furrow, the furrows in which the coronary vessels run, and others. From these positions, the fat dipping more and more deeply may nearly displace the fibres, and lead, it may be, to a secondary degeneration of them.

But these conditions, and their frequent combinations, are too well known to need that I should describe them, or refer particularly to any of the specimens of them, except to this, which is a heart from a sheep.* It exhibits a great accumulation of fat on its surface; its walls are thin, and particularly fatty; and the greater parts of the cavities of the ventricles and of the left auricle are occupied by large lobulated growths of suet-like fat. The weight of the fat here added to the heart is 25 ounces, and it is said that there was besides a large accumulation of fat about the kidneys. But no other history of the case is extant than that

* Prep. 10, Pathological Museum of the College of Surgeons.
† Patholog. Anat. B. 2. S. 348.
‡ Outlines of Human Pathology, 1836, p. 117.
§ Diseases of the Liver, 1845, page 191.
‖ Patholog. Anat. B. 3 S. 368.

* College Museum.

the sheep was inactive, and had dyspnœa on exertion.

These cases of extreme fatty degeneration of the heart are much rarer than those of which I have now to speak.

The most common form is that in which you find, on opening the heart, that its tissue is in some degree paler and softer than in the natural state, and lacks that robust firmness which belongs to the vigorous heart. But what is most characteristic is, that you may see, especially just under the endocardium, spots, small blotches, or lines, like undulating transverse bands, of pale, tawny, buff, or ochre-yellow hue: thick set, so as to give at a distant view a mottled appearance. These manifestly depend, not on any deposit among the fasciculi, but on some change of their tissue. For, at their borders, you find these spots are gradually shaded off, and merging into the healthy colour of the heart; and when you examine portions of such spots with the microscope, you never fail to find the fatty degeneration of the fibre. In the least degree of the degeneration, you may see only minute black dots, within the sarcolemma, partially obscuring the proper substance of the fibre: but as these dots grow larger, so their centres grow bright, and they manifest themselves as particles of oil, which, still increasing both in size and number, may, at length, almost completely fill the sarcolemma, or even may, in some degree, distend it. They may be irregularly scattered, or may lie in longitudinal transverse rows; and various appearances, such as it would be tedious to describe, may be produced by the various sizes of the oil particles, and by their lying in different focal distances, so that some may appear like black dots, and others may present the many aspects which, according to their distance, we find in any specimen of minute drops of oil. The main fact is, that in portions—even, taking them altogether, considerable portions — of the heart, the proper muscular tissue is gone, and in its place you have tubes full of fatty matter—therefore powerless, wholly incapable of exercising the proper function of the muscular fibre.

In regard to the pathology of the disease, it is important to remember that it is, from the first, an affection of the fibres themselves; it is not the result of an encroachment of the natural fat of the heart upon them, although it sometimes, yet I think seldom, exists together with increase of the external fat of the heart. Its chief seat—near the inner walls of the heart's cavities, and on the fleshy columns, where is little or no fat in the natural state—would prove this; and the microscopic examination leaves no doubt, for you may not find more than the usual quantity of fat outside the fibres. The fat is nearly all within them, and the paleness, or complete absence of the nucleus, declares the nature of the case. Neither is it at all necessarily connected with general fatness of the body.

The yellow spotting, or transverse marking of the heart, may exist in the walls of all its cavities at once, or may be found in a much greater degree in one than in the others. My impression is, that it is less common in the auricles than in the ventricles, and that when it exists simultaneously in all, it is less advanced in the auricles. I think, also, that it is more common in the left ventricle than in the right; and in the left ventricle it is commonly most advanced on the smooth upper part of the septum, and in the two large prominent fleshy columns. Indeed, it may exist in these columns alone; and when, in such a case, the rest of the heart remains strong, may account for the occasional occurrence of rupture of the columns; or, as Rokitansky suggests, by their imperfectly holding the valves, may give rise to murmurs.

The affection I have just described is one of the vast number of discoveries in pathology which we owe to the extraordinary labours of Prof. Rokitansky, of Vienna; and he has very accurately described it in one of its most interesting aspects, as occurring late in the course, or very near the close, of cases of hypertrophy of the heart. It is common to find enlarged hearts thus diseased; and thus, no doubt, it often is that death comes in. For, for a long time the heart will contend against the increased obstacles to the movement of the blood; and its reserve-power of nutrition will be exercised with continually refreshened force, strengthening it in every part, or especially in that on which the chief stress of difficulty falls: and thus the circulation may for a long time be maintained tolerably. But good general health, and the concurrence of all the conditions of healthy nutrition, are necessary for this growth; and, when they fail, as sooner or later they do through the complication of the disease which may first have affected only the organs of circulation, their growth is no longer possible, — atrophy ensues, and death, through the effects of the obstruction of the circulation, which had been long striven against.

The atrophy thus ensuing may produce mere wasting of the muscular substance of the heart; and hence, perhaps, as already said, the supervention of disproportionate dilatation after healthy hypertrophy of the heart. But I think it more often assumes this state of degeneration; and it does so, not in the heart alone, but in other hypertrophied organs, as in the urinary bladder.

All that I can add to the practical interest of Rokitansky's description of this discase is, in the fact that the fatty matter is not upon or between the fibres, but in their interior; and that the disease appears to be much more common in hearts of ordinary size than his account would lead one to believe. The yellow spotting is certainly a common affection in the hearts of persons of all ages. Dr. Ormerod has seen it even in those of children. And though it may not be possible yet to assign its characteristic symptoms, yet, when we consider that the fibres in which it exists must be absolutely powerless, it cannot be an unimportant affection, at the least as a complication of other diseases.

But, besides this yellow spotting, Rokitansky also mentions, but too briefly, another appearance produced by fatty degeneration of hypertrophied and dilated hearts, which has for some time past engaged the attention of both Dr. Ormerod and myself as an exceedingly important affection in hearts which appear not previously or otherwise diseased. It is to this form, since it appears desirable to distinguish it by some name, that I would apply the term of "granular degeneration" of the heart,—indicating thereby both a general granular aspect seen with the naked eye, and the granular appearance which the fibres, when examined with the microscope, derive from the crowds of little oil particles within the sarcolemma.

Let me first state briefly the particulars of three cases of this disease, the terminations of which were so similar that they are probably characteristic examples of the course of events.

I was requested to assist in the examination of the body of a woman, about 60 years old, who was wrongly supposed to have been killed by an overdose of morphia, given for the cure of some spasmodic pain to which she was subject. She had been a healthy person except for these pains, and except that for two or three years she had been growing fat. On the night of her death she took half a grain of acetate of morphia, which was twice as much as she was used to, but it did not produce deep sleep, and there was certain evidence that four hours after taking it she was awake, and talked sensibly with those around her; but, after thus talking, she went to sleep, and three hours afterwards was found dead. She had died in her sleep. On examination, we found nothing whatever to account for death, except this fatty degeneration of the heart.

The next case I observed was in a member of our profession, an intimate friend, 56 years old, whose apparently perfect and robust health, and whose power of resisting cold and most of the ordinary causes of disease, were remarkable. He was, besides, so watchful of his health, that I feel quite sure he never had a sign of affection of the heart such as he could either feel or in any other way observe. One Friday he began to complain of illness, and Dr. Burrows, who saw him about fifteen hours after, found him suffering with what he anticipated would develope itself as typhus fever; and he observed that his pulse was so labouring, and his breathing so slow and sighing, that he at once apprehended serious mischief at hand. These fears were confirmed by some aggravation of the symptoms next day, for the patient seemed more depressed, though nourishment and stimulants were freely given; but on the Sunday some improvement took place, and he slept soundly for some hours, and awoke so refreshed, that on the Monday morning he took food with appetite, sat up, and talked of leaving his bed and going down stairs; but he had scarcely finished speaking, before he leaned back, and in less than two minutes was dead. His body was most carefully examined by Dr. Ormerod, and the only morbid change of any moment that he could find was the fatty degeneration of the heart. The heart was uniformly diseased in every part; yet the change was such as I think none but a practised eye could have discovered, and nothing but microscopic help could have enabled us to describe or understand.

In the next case, a strong man, between 30 and 40 years old, addicted to very hard drinking, received a slight injury of the head. He paid no attention to it, and continued his work for four days; then, having headache, and feeling ill, he laid up, and left off all strong drink. In three days, signs of delirium tremens commenced, and he was brought to the hospital. In the course of the second day after the beginning of these symptoms, while they were pursuing an ordinary course, he took 140 drops of laudanum, but no beer or spirits, till in the evening, when, the opium seeming to have been sufficiently administered, brandy was given him, and beef-tea. In about two hours he went to sleep, and he remained dozing, and apparently improving in condition, all night. But in the morning a new nurse came to him, who wished to change his bed-linen. For this purpose she took him out of bed, and set him in a chair; but he had hardly been removed before he appeared to be dying, and he died before he could be again placed in bed. In his body, the only changes were fatty degeneration of the heart and of the liver.

Here, then, were three cases of sudden death, all the result of a similar disease of the heart, the existence of which had been completely unsuspected, and in all probability, at least in the second case, had not been attended with any signs that could have attracted even scrupulous attention. The condition of the heart was alike in all, and very characteristic, though, indeed, to an unpractised eye, it might seem unimportant.

There is no increase in the quantity of fat on the exterior of the heart, and the whole organ has its natural size, shape, and general external appearance; but it feels soft, doughy, inelastic, unresisting, and may be moulded and doubled-up like a heart beginning to decompose long after death: it seems never to have been in the state of *rigor mortis*. These appearances are more manifest when a section is made through the wall of the left ventricle. Then, if the wall be only partly cut through, the rest of it may be very easily torn, as if with separation of fibres that only stick together; and the cut surface of the wall looks, as it were, lobulated and granular, almost like a piece of soft conglomerate gland—an appearance which is yet more striking when observed with a simple lens of about half an inch focus. In colour, it has not on its surface, much less on its section, the full ruddy brown of healthy heart, a colour approaching that of the strong voluntary muscle,—but is, for the most part, of a duller, dirtier, lighter brown, in some parts gradually blending with irregular marks or blotches of a paler fawn colour.

When a portion of the muscular wall (let it be cut however it may) is dissected in the ordinary way, or even very gently, with needles, for the microscope, it is found that all the fibres are broken into short pieces, some twice, some five or six times, as long as they are broad. The broken ends of these short pieces are usually squared, but some are round, or irregular, or cloven, and broken off lower down. The pieces are almost always completely separated, having no appearance of even cohering at their sides, and they lie scattered disorderly.

In some pieces, the transverse striæ are still well seen and undisturbed, appearing quite as in health. In more, they are interrupted or obscured by dark particles, or glistening particles with shady black margins, like minute oil-particles scattered without order in the fibre. Where such particles are few, they appear to lie especially, or only, in contact with the interior of the sarcolemma; but, where more numerous, they appear to occupy every part of the fibre, leaving the transverse striæ discernible only at its margins, or even completely obscuring or replacing them, and making the fibre look like a gland-tube filled with dark granules and larger glistening dark-edged fat particles. Where these particles are very numerous in a fibre, they appear also generally larger, and more generally glistening and black-edged, like larger oil particles.

There are no oil-drops floating about, no fat-cells, scarcely even any of the minute particles which are seen in the fibres, appear out of them,—the field of the microscope is perfectly clean. No morbid product, cytoblasts, or others, can be seen as a deposit between the fibres, nor is there any apparent increase of cellular tissue.

As a general rule, the palest parts are most advanced in the disease; but even in microscopic portions some pieces of fibres appear hardly changed, while those all round them are completely granular.

Besides the characters assigned above, these diseased fibres differ from healthy ones, in that there are no nuclei lying among them as among healthy heart fibres, and that they rarely split in filaments, though often obscurely marked longitudinally.

Such is the fatty degeneration of the heart not otherwise diseased—an affection which seems of importance to us all, because it may fatally interfere with the ordinary progress of a case, whether surgical or medical.

Let me add, for caution, that serious as the effects of the disease are, the change of structure may escape any but a very careful, and practised, examiner. For, often, the change is hardly manifest to the eye, though, while it affects the whole heart, it may have destroyed life; it perhaps never proceeds to the yellowness seen in the spots of fatty degeneration which constitutes the first form I described; yet, extreme as the degeneration in these spots may be, it is comparatively unimportant, because existing in only portions of the heart's substance, whereas, generally, this latter form affects the whole heart at once, and almost uniformly.

I do not pretend to trace the clinical history of these affections: I hope it will be done by Dr. Ormerod, who has helped me greatly in investigating their morbid anatomy; I may, however, remind you of the principal character which all these cases seem to present; it is, that they who labour under this disease are fit enough for all the ordinary events of calm and quiet life, but are wholly unable to resist the storm of a sickness, an accident, or an operation. And let it not be said that one learns little in learning too late the existence of an incurable disease; for, beyond doubt, very often the death that has come from such a disease as this has been ascribed to a wrong cause, and has spoiled confidence in good men and their good measures.

Let me pass now to the account of atrophy of bone, which, like that of Muscle, shows itself in the two forms already often referred to.

The simple wasting, or reduction of size, of a bone, with no considerable increase, if any, of its fatty constituents, is a most common change. Examples have been already adduced in connection with the subject of unequal length of the limbs, and with that of the effects of pressure. And the Museum contains so many examples of it,—all, on some ground, possessing interest,—that the difficulty has been to choose among them. The most striking is the skeleton of the hydrocephalic patient from the museum of Mr. Liston; it is the more remarkable, because while all the bones of the trunk and limbs are reduced, by atrophy, to exceeding thinness and lightness, the bones of the cranium are as exceedingly enlarged in adaptation to the enormous volume of their contents.

This skull* has interest because fitted up by Hunter to show the movements of the edentulous lower jaw, as he has described them in his Natural History of the Teeth. And it shows the atrophy not only of the alveolar margins, but of every part of the jaws, and even of their palatine parts, and those of the palate bones, which are quite thin and transparent.

A rare specimen of atrophy of the jaw is shown in this case of complete osseous anchylosis of both temporo-maxillary articulations, from Mr. Howship's museum.† Similar atrophy of bone in its extreme state is illustrated by this example of anchylosis of the knee,‡ from the case described by Mr. Thurnam§; for here considerable apertures are formed in the wasted walls of the bone, which were covered in only by the periosteum; the whole thickness of these portions of the walls having been removed in the progress of the atrophy.

Here is a specimen‖ in which simple atrophy of the femora led to such fracture as is called spontaneous, being effected by a slight force. The atrophy of these bones occurred coincidently with extreme emaciation of all the other parts, as well as of the skeleton; an emaciation which was to be ascribed more to starvation, I believe, than any thing. The shafts of the femora are exceedingly small, and their walls are so thin that, although their texture appears healthy, they could not resist the force of the muscles acting on the articular ends. They broke: and, as one may say, in the emergency, fresh formative power was put forth, and the fracture was united with new bone formed when all the old bone was wasting.

I might greatly multiply examples of such simple wasting atrophy of bones; let these suffice, that I may speak now of fatty degeneration of the bones.

I have already said that it is common, in many atrophied bones, to find an excess of this fatty matter; and I shewed old bones laden with fat as examples of that form of senile atrophy. But it is now to be added, that the bones, like other organs, are liable to a fatty degeneration, which, because of the obscurity of its origin, we must be content to call spontaneous; and this fatty degeneration of the bones is the disease which most English writers have described as Mollities Ossium.

The time allotted for the lecture is so nearly spent that I must be content to do little more than invite you to examine the remarkably rich collection of specimens of this disease—fatty degeneration, the English mollities ossium—contained in the museum: a collection embracing specimens from nearly all the cases with whose histories we are most familiar.

As a well-marked example of the fatty degeneration, I may show these bones,*—femora fractured by a slight force, and, in their dried state, light, very greasy, mahogany-brown, and so soft you may crush many parts of them with the fingers. Their excess of fat is evident; but no more of them is known than that they came from an elderly, if not an old man,—an Archbishop of Canterbury.

This specimen is a section of a humerus†, affected, as many other bones of the same person were, with extreme fatty degeneration: and the Catalogue contains, with its description, a reprint of an essay, by Mr. Hunter, which escaped even the careful search of the editor of his works—Mr. Palmer. His essay is entitled, "Observations on the Case of Mollities Ossium described," &c., by Mr. Goodwin, in the London Medical Journal.‡ It was communicated in a letter to Dr. Simmons, the editor of that journal, and I will quote one passage to show both what was the original appearance of the bones and how completely Mr. Hunter's description confirms the opinion that this mollities ossium was really a fatty degeneration of the bones. He says, speaking of this humerus, "The component parts of the bone were totally altered, the structure being very different from other bones, and wholly composed of a new substance, resembling a species of fatty tumor, and giving the appearance of a spongy bone,

* Prep. 8, in the Pathological Museum of the College of Surgeons.
† Prep. 966 in the College Museum.
‡ Prep. 384 in the same Museum.
§ London Medical Gazette, vol. xxiii. p. 119. October 20th, 1838.
‖ From the Museum of St. Bartholomew's Hospital.

* Prep. 400, from the College Museum.
† Prep. 398, College Museum.
‡ Vol. vi. 1785.

deprived of its earth, and soaked in soft fat."*

Nothing can better express the character of the change, or its similarity to the fatty degenerations of other organs, in all of which we find the proper substance of the part gradually changed for fat, and the whole tissue spoiled, while the size and outer form of the part remain unaltered.

The same characters are shown in the often-quoted case by Mr. Howship, of which specimens are here preserved.† The last of these specimens shows what remained of the upper part of a femur after boiling,—scarce anything besides a great quantity of white crystalline fatty matter.

It is the same with this femur,‡ lately presented to the museum by Mr. Tamplin, in the examination of which I first obtained the conviction of the nature of the change which constitutes what we call mollities ossium. This has the same characters as the specimens already shown, and the medulla of the bone had the bright yellow, pink, and deep crimson hues, which are so striking in many instances of the disease. But the constituents of this apparently peculiar material were, free oil in great quantity,—crystals of margarine free, or enclosed in fat-cells,—a few fat-cells full of oil as in health, but many more, empty, collapsed, and rolled up in strange and deceptive forms. The pink and crimson colours were owing to part of the oil globules, and to the nuclei and granules in the collapsed fat cells being thus coloured ; and there was no appearance whatever of an excess of blood in the bone, or any of its contents.

From this examination, therefore, as well as from all the other facts, I concur entirely in Mr. Curling's opinion respecting this disease, as expressed by him in the 20th volume of the Medico-Chirurgical Transactions. This§ is a specimen from the case on which he chiefly founded his opinion, and which he has very accurately described. He proposes the name " Eccentric Atrophy of Bone" to express one of the principal characters of the disease ; and I would have adopted it, but that it seems desirable to class this affection with others to which it bears the closest analogy, by giving it the same generic name—fatty degeneration of bones.

The cases to which I have now referred include the principal examples of the disease observed and recorded in England under the name of mollities ossium ; and to these I have very little doubt I may add the case described by Mr. Solly in the 27th volume of the Medico-Chirurgical Transactions, for the appearances presented by this femur* are strikingly similar to those in the specimens already referred to, and the material filling its medullary cavity contained abundant fatty matter.

* Catalogue of the Pathological Museum of the College of Surgeons, vol. ii. page 28.
† Preparations 401-2-3, in the College Museum.
‡ Prep. 403B, College Museum.
§ Prep. 403A, College Museum.

You might ask, then, what is the real mollities ossium ? or, is there such a disease different from what these specimens show ? I could not certainly answer such a question ; for I have never seen a specimen which appeared to fulfil in any degree the general notion of mollities ossium, as a disease consisting in the removal of the earthy matter of bone and the reduction of any part of the skeleton to its cartilaginous basis. Yet I am loth to disbelieve what some others have written of such an affection. Of this alone I am sure, that these English cases are not such simple softenings of bone, but fatty degenerations ; and if there be cases specifically different from these, I think they will prove to be some of those to which Rokitansky refers under the names of Osteomalacia, Malakosteon, Knocheneiwerchung, and Rachitismus adultorum. For he gives as a characteristic of the disease that it affects the bones of the trunk, or a part of them, much more often, and more severely, than the bones of the extremities, and occurs especially after child-bed. Now, in the cases which I have endeavoured to illustrate, the extremities, not the trunk, are the chief seats of the disease ; and there is no evidence of the fatty degeneration occurring more often after delivery than in any period or condition of life. So that, on the whole, I think we may consider there are two diseases included under the name of mollities ossium,—namely, the fatty degeneration which these specimens show, and the simpler softening of bone, or rickets of the adult, to which Rokitansky's description alludes, and in which the bones are flexible rather than brittle, and appear reduced to their cartilaginous state. I am disposed to think the case recently described by Dr. Bence Jones and Mr. Dalrymple† may be an instance of this latter affection.

[The Professor next endeavoured to show the relation of the fatty degeneration of bones to the rickets of early life, by comparing the change of structure in the skull of a patient,‡ whose case is described by Mr. Solly,§ with the change exhibited in the skulls, and other bones, of ricketty children and animals. And then tracing the changes through which such skulls pass in

* Prep. 403c, College Museum.
† Philosophical Transactions; and Dublin Journal, vol. ii. 1846.
‡ Prep. 395, in the College Museum.
§ Medico-Chirurgical Transactions, vol. xxvii. page 437.

their progress towards the healthy state, suggested that some of the strangely thickened, porous, and heavy skulls, preserved without histories in most museums, belonged, in life, to those who had had mollities ossium in one of the forms which had been described.

All this part of the lecture would be unintelligible without the specimens by which it was illustrated: and it is the less necessary to insert it, because much of what was said is embodied in the 2d volume of the Catalogue of the Pathological Museum of the College, just published, pp. 16 to 25.]

The last example of fatty degeneration to which I shall refer is that observed in the liver. The condition of the hepatic cells in this disease has been so well known since Mr. Bowman's discovery of the fatty particles within them, that I need not at all describe the morbid changes characteristic of the affection: nor need I do more than state that the fatty degeneration of the cells is found, not only in that which is called especially the "fatty liver," but in many examples of cirrhosis of the large, pale, heavy, and indurated brawny liver; and of some other affections not yet admitting of exact description, but commonly referred to under the vague names of nutmeg-liver, granular liver, and so on. Omitting these points, I will only offer reasons for rejecting the explanation of the disease which seems generally admitted, and which is, that the fatty liver is one actively discharging its office as vicarious to the lungs, secreting the hydrogen and carbon which the lungs, by reason of some defect of their structure, cannot discharge.

The arguments against this account of the disease are these:—

1. The connection between fatty liver and disease of the lungs is not general. In many who die phthisical, the liver is healthy. In many who have no disease directly obstructing the function of the lungs, the liver is fatty. I may refer to the last three cases of fatty liver that I have examined. One was an osteoid tumor, with only small masses of osteoid disease in lungs otherwise quite healthy: another was a cancer of the breast and spleen, with healthy lungs: the third was a case of delirium tremens with sound lungs. And many of you will at once confirm this statement.

But, 2dly, there is no evidence that the fatty liver does excrete an unusual quantity of carbon and hydrogen; for the fæces of patients with this disease have not yet, I believe, been examined.

And 3dly, if the carbon and hydrogen supposed to be formed in extra quantity in the liver be not in the fæces, then the lungs would only be damaged by the excessive formation of those elements in the liver. For the function of the liver, at least in the warm-blooded animals after birth, is preparatory to that of the lungs. Of all the bile secreted, only 1-11th at most passes off with the fæces, and this fractional portion does not contain those principles in which most of the carbon and hydrogen are combined. The rest is reabsorbed, and reabsorbed that the greater part may be excreted by the lungs. The contrast between the fœtal meconium and the bile of the young child indicates this very plainly. Meconium contains all the principles of the bile; for while respiration is comparatively inactive, all, or nearly all, the bile is excreted *directly*. But the fæces of the young child, like those of the adult, contain only the resinous and colouring matters of the bile, and perhaps some of its fat. The rest of the bile is reabsorbed, not because it is really less an excrement than it is in the fœtus: it is reabsorbed and combined with oxygen, and so excreted *indirectly*, as carbonic acid and water, with the advantage of contributing to the maintenance of animal heat.

So, then, the connection of the liver with the lungs of the warm-blooded animal after birth is, that the former prepares material for the function of the latter. It would be a strange compensation, if the function of the former were to be increased, while that of the latter is diminished by disease.

And, lastly, all the conditions of the fatty liver show that it is an inactive organ—one which is discharging less than its ordinary function, and the less the more general the fatty degeneration of its cells. In proof of this we have the analogy of all fatty degenerations, the absence of nuclei in the fatty cells, the absence of all appearance of the colouring matter of bile in them, the large size of the liver indicating a tardy or obstructed removal of its cells, the paleness and defective supply of blood, and the frequent coincidence of other morbid changes such as would naturally hinder the proper activity of the organ.

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