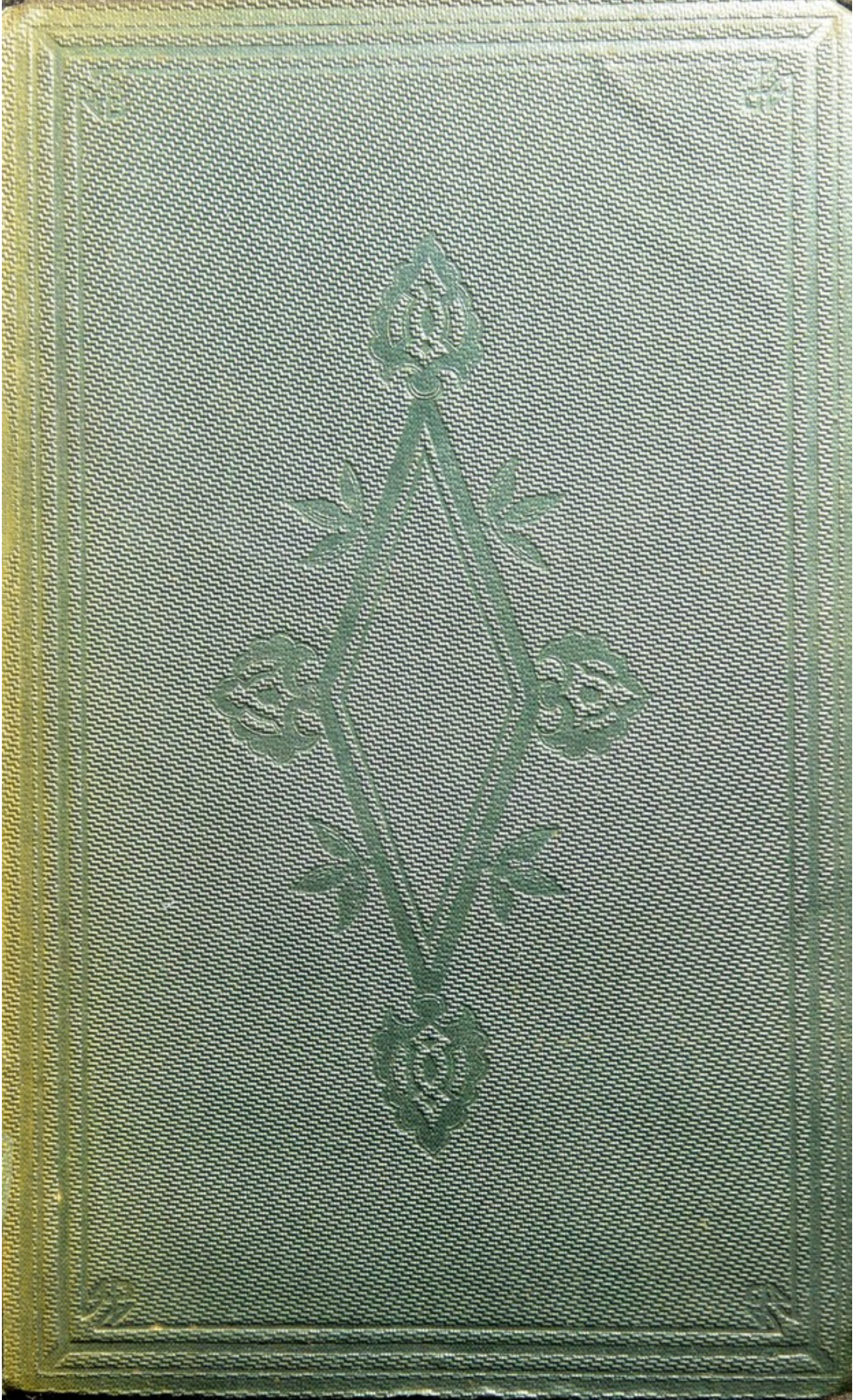
Six lectures on materia medica and its relations to the animal economy / by John Spurgin.



SIX LECTURES

ON

MATERIA MEDICA

AND ITS RELATIONS TO

THE ANIMAL ECONOMY.

DELIVERED BEFORE

THE ROYAL COLLEGE OF PHYSICIANS

IN 1852.

BY

JOHN SPURGIN, M.D., F.C.P.S.,

AND FELLOW OF THE COLLEGE.

ἡ γὰρ ψυχὴ πάσης σαρκὸς αἷμα.

Levit. xvii. 11. LXX. *Interpp.*

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PREFACE.

Some years ago an annual Course of "Six Lectures on Materia Medica" was founded by the Royal College of Physicians, for the purpose not only of explaining the sources, preparations, and properties of medicines, but also of unfolding the principles which should be observed in their administration.

The title given to these Lectures might seem, at first sight, to indicate but a very limited field of enquiry; but if by Materia Medica we understand Medical Science in general with its manifold relations to human pathology, the subject is one of vast extent and importance.

In undertaking therefore the delivery of the Lectures during the past year, in the Theatre of the College, it was my wish to consider the subject somewhat in this light, and to examine certain principles and laws which the Animal Economy presents to our observation, and

by the operation of which it is constantly preserved and perpetuated.

The views which I have advanced on some very important points differ materially from those generally received. They claim no value on the mere ground of novelty, but as the mature convictions of many years' professional practice, based upon extensive observation and careful research, they are, I trust, not unworthy of the present state of Medical Science. With this hope I submit them to the impartial judgment of the reader.

73, Guildford Street,

January, 1853.

MATERIA MEDICA.

LECTURE I.

Mr. President, Fellows, and Gentlemen,

The subject upon which I am to address you in the course of Lectures which I shall have the honour to deliver from this place, is, I need perhaps scarcely state, *Materia Medica.*

To my present audience it would be superfluous to dwell upon the vast importance of this branch of medical science; for Materia Medica, regarded in a truly philosophical point of view, refers to the whole extent of animal being, and to the various laws and principles by which its economy is regulated and preserved.

I shall not, therefore, regard it merely as a collection of materials to be employed either

arbitrarily or empirically in the treatment of disease; but I shall endeavour rather to contemplate it in its widest relations and most extensive significance, as comprehending, in fact, every particular that relates to the preservation and well-being of our physical existence.

This view of the subject will consequently suggest to us the rich productions that are contained in the great storehouse of nature, embracing the wonderful, the manifold properties of air, earth, and ocean. For indeed all these productions must be viewed as the indispensable requisites of animal life. They are, therefore, obviously suited to meet all its necessities under every possible circumstance, and would seem to be expressly provided for this purpose by the wisdom of an all-beneficent and omnipotent Creator.

It is on this ground that I feel I shall perhaps perform more satisfactorily the task I have undertaken, if I proceed, in the first place, to investigate generally, with all possible caution and deference, and as extensively as the occasion will permit, the laws which are observable in the animal economy. Such investigation is the more necessary, since it is to these laws that the

laws of the whole material world are throughout evidently subordinate.

In every department of science which has attracted more than an ordinary share of investigation, or attained any degree of perfection, we observe a tendency to establish some general principle, or to seek for some universal law to which all its phenomena may be referred. This tendency has naturally given rise to a multitude of mere theories and hypotheses; and though it may be said to find no direct sanction in the present age of experimental and practical philosophy, it will, nevertheless, be found to influence the mind of the experimentalist now as much as at any former period. The very nature of the human mind and of all its operations appears indeed to involve this tendency. Consistently, therefore, with this position, it would seem to be impossible for a system of philosophy to exist, or for a department of science to be developed, as the result of mental labour, which did not, indeed, owe its entire origin and value to this source.

System is professedly the object at which the man of science aims; all the faculties of his nature unite together in the effort to realize

it, and hence, by their various functions and operations, the several particulars which serve to compose a system are more distinctly perceived, their relations more accurately discovered, and the perfection, unity, and order of the whole more fully understood.

Upon no other ground can we comprehend the necessity for that diversity of faculties which human nature exhibits. For, if one or two senses, or even five, were sufficient to afford us a knowledge of mundane things, there would then be a valid basis for the doctrines which insist on the all-sufficiency of facts and observation. Though, indeed, the five corporeal senses are indispensable to man in the acquirement of knowledge, we must bear in mind that they are by no means exclusively so. Other faculties of a more transcendent kind are equally essential. Thus, every faculty, both mental and corporeal, is required to perform its peculiar office, in order to maintain the perfection of the entire being; for this being is evidently adequate in itself to represent all the harmony of system, and therefore capable of comprehending that of the universe to which it stands every moment in the closest relation and most exact correspondence.

A certain order, therefore, in the existence as well as in the operation of the faculties both mental and corporeal, is essential to their well-being, and no order can be so perfect as that which exhibits a due subordination in the several parts of a system, and at the same time a right co-ordination of those parts into one whole, so as to constitute an absolute unity. And this, we find, is the order which pre-eminently distinguishes the faculties of man. May it not, consequently, be inferred that the system of the universe itself—the especial object upon which those faculties are exercised—exists also according to the same order, so that the nature of the one system may be viewed as correspondent with that of the other, not only in regard to the order, but also even to the mode of their existence?

Mention has been made of mental and corporeal faculties—not, however, with any view to raise the question whether they are distinct from and independent of each other—but to show that, whatever may be the kind of connexion between them, or whatever notions may be entertained respecting that connexion, there is necessarily a relation of order or of subordination

in the faculties in question; and further, that a system of physiology, which, with all its cognate subjects, would embrace the whole animal economy, must admit these faculties under both their denominations.

An investigation of the animal economy can only be entered upon, with any prospect of success, under the conviction that such an order of subordination prevails in the animal system. With this conviction, therefore, strongly impressed upon my own mind, I propose to pursue that order, in the hope of attaining a clear, consistent, and satisfactory knowledge concerning it.

The first question, then, that occurs at the very outset of the enquiry, is, To what common principle does the animal fabric owe its origin and existence; or, to what do all its constituent parts stand subordinate? By a definite and intelligible answer to this question, we shall be guided through most of the intricacies of our subject; and, as we pursue its different ramifications, we shall be introduced, in a legitimate manner, to the various compartments, both higher and lower, interior and exterior, of which the beautiful fabric consists; and, following the clue of the labyrinth, so to speak, we shall return at

length to the point from which we set forth, charmed with the remembrance of the wondrous scenes and the magnificent objects that had met our view at every step.

This common principle then, in the animal body, is no other than the blood, which, by its universal presence in the system, and in virtue of its being the very origin and source of every part, and thence of the whole bodily fabric, constitutes the very corporeal life and vital principle to which they all refer and are subordinate.

But, perhaps, this answer, instead of being definite and intelligible, may, at first sight, appear incongruous and unsatisfactory. If so, I would venture to ask, what can be substituted in its place as less indefinite, or as more intelligible? Irritability—excitability—life—*vis nervea*—*vis medicatrix naturæ*—*materies vitæ diffusa!* are, indeed, the replies which our philosophy would make; but who can say, that these terms admit of simple and intelligible definition? If we consult the volumes with which our libraries and colleges are stored, we shall find, indeed, these terms in frequent use, but we shall seek in vain for their exact meaning and definite signification. Conscious, then, of this fact, how can

we possibly hesitate about rejecting such terms as fail to embody any definite knowledge? Can we scruple to proceed, in conformity with my position, to investigate the principle itself upon which the entire animal fabric is founded? For myself, I confess, I see no alternative.

The blood, it is evident, presents itself to our observation, as a common or general principle, to which all the corporeal organs have reference. Consequently, by attaining a knowledge of the various particulars which it involves, or which enter into its composition—thus, by marking its various conditions, attributes, and properties—there will be a great probability of our arriving at a knowledge of those things which are derived from it.

Now, if it is true that all the organs of the body have relation to the blood, as their common principle and source, it is obvious that the nature of this relation can be no other than that of subordination. For the whole organized system is subordinate and subservient to the blood, precisely as that which is instrumental is subordinate and subservient to that which is principal; or, in other words, as an effect is subordinate to its cause.

In harmony then with this view, whatever phenomenon the organized body exhibits, bears reference to the blood. For, whether the body be regarded as to its functions, its operations, and its changes of condition, or whether it be viewed simply as an organized system, still, in consequence of its deriving from the blood its very existence and preservation, as well as all its power to perform its functions, it is plain that all the phenomena which it is capable of presenting, owe their existence in like manner to the same source; admitting the one, you must of necessity admit the other.

And a most important step, I venture to assert, is gained by establishing the existence of this order of relationship between the blood and the body. For we are thence enabled to discern the mode by which the permanence and renewal of the blood are secured. This mode consists, in short, in this most simple but most important fact, that the blood imparts to the organs, which are all formed from it, their ability to perform their appropriate and respective functions. And these functions refer essentially to its circulation, its renewal, and its preservation, from one moment to another.

That such is the established order of this relation and connexion, I can appeal to the testimony of every department of science. I should desire, indeed, for its confirmation, nothing more ardently than that an enquiry should be instituted throughout the whole animal kingdom, and that, in justice to the subject, it should be prosecuted in whatever direction true science can attract her votaries. For I hesitate not to state my firm conviction, that the nature of the world, and of its several kingdoms is, as it were, concentrated in the animal fabric. Hence, I believe, that an accurate knowledge of nature, throughout her subordinate parts, is the very best preliminary to that of our organized system, to which she shows herself to be strictly subordinate and subservient. Nor will it, I trust, be deemed out of place to observe, that I have not met with a single fact or circumstance which could be adduced as tending to subvert the doctrine here advanced; but, on the contrary, every fact with which I am acquainted, that is in any way connected with this subject, tends more or less directly to sanction and confirm it.

The next question, then, which arises immediately out of what I have advanced, is this:

What are the particulars involved in the general principle which I have stated? In other words, What are the elements which enter into the composition of the blood? This question, it is evident, cannot be fully answered so long as there remains in the blood any thing to be discovered by chemical research.

It may, nevertheless, be satisfactorily answered, by calling to our aid the evidence of experience, which is already recorded for our use, presenting certain general and very intelligible facts relating to the composition of the blood. Works, therefore, treating expressly on the subject of animal chemistry, or on the composition of the animal tissues and fluids, must be consulted for the purpose of obtaining the information required. But, at the same time, it must be borne in mind, that there is a very wide distinction between the specific information to be derived from these sources, and the opinions and speculations to which such information may give rise. And this is the more necessary when it is considered that the diverse opinions so frequently met with do not appear to be founded upon the same facts, but rather upon such as seem not merely to differ from, but even to contradict, each other.

It has thus become almost impossible to arrive at any valid or indisputable conclusion, upon any particular point of investigation.

Now, the component parts of the blood may, in general terms, be stated to be gaseous, saline and earthy. By gaseous parts are meant those which more commonly exist in an aeriform state, as oxygen, hydrogen, azote, and carbonic acid gas, which last is compounded of another element called carbon with oxygen.

By saline parts, are meant different kinds of compound substances, which are named according to their distinct component elements; as, for instance, chloride of sodium, or common salt, chloride of potassium, sulphate of potass, subcarbonate of soda, phosphate of lime, phosphate of iron, oxide of iron and others. These ingredients, together with a considerable quantity of water, are found in various proportions in the blood, or in that fluid which circulates through the organised body under this appellation.

But, it must be observed that these parts or elements do not exist in a separate and distinct manner, as a mere heterogeneous mixture and solution. On the contrary, they are amalgamated, blended, or arranged, according to some definite

law, or by virtue of some peculiar force or circumstance. And this is obviously the case in regard to the gaseous elements, the bases of which combine together in various modes and proportions, so as to form what chemists have designated albumen, fibrina, red globules, gelatine; all which, while circulating though the body, exist in the form of serum and red globules.

This arrangement of these ultimate constituent materials into new combinations, so as to exhibit what are very properly called animal matters, or, in one general term, the blood, merits the closest attention. This must be evident to every one when it is considered that these materials are derived from a source, which not only exists in the world of nature, but for the most part, constitutes it, primarily, indeed, from the mineral kingdom, through the medium of the vegetable kingdom, and from the atmosphere.

Nor is this the only point worthy of our consideration; for it is equally important to attend to the immense variety of products that arise from the blood. These are presented to us in a striking manner by the entire animal body, as well as by its individual organs; for these organs do not differ from each other in function only,

but also in chemical composition. Thus, in this respect, brain, muscle, glands, membrane, tendon, bone, skin, hair, nails, are extremely dissimilar. The secretions again, which have their source in the blood, and each of which owes its peculiar character to its own secretory organ, astonish us both by their number and variety. We have, for instance, the saliva, the gastric and pancreatic fluids, milk, bile, urine, sweat, and many others; all indefinitely referring to quality, quantity, colour, smell, and taste.

Again, the diverse substances received into the body as aliment present to us another consideration no less interesting than the two which we have already mentioned. For some of these substances are oily, some spirituous, some saline, some vegetable, and some animal; they are nevertheless speedily reduced, digested and compounded into the apparently homogeneous fluid, blood!—a fluid which, regarded in itself, affords no certain evidence of the kind of aliment from which it was formed. Still less does it reveal to us the particular kind of vegetable or animal that formed the aliment, or explain the multifarious secretions of which it is itself a very fruitful source; as, for example, milk, urine, and sweat.

Blood, it is well known, when drawn from the body, soon separates spontaneously into two parts, the one fluid, the other solid; the former being designated the serum, the latter the crassamentum.

With a view, therefore, to obtain a more particular knowledge of the component parts of the blood, it will be desirable to adduce the evidence with which chemistry supplies us concerning these two parts; and first, of the serum. Berzelius contended that there was little or no difference, in regard to chemical composition, between this and the more solid parts of the blood. "Chemical analysis," the celebrated Baron Liebig observes, "has detected the cause of the nutritive property of flesh in a manner free from doubt, by shewing that the fibrine of muscle and the albumen of blood contain the same elements in the same proportion; and that these two bodies stand to each other in the same relation as fresh albumen and coagulated albumen. In composition, *fibrine* is nothing more than albumen of blood solidified and in an organized form*." But there is one characteristic by which the clot and the fluid part of the blood

* *Familiar Letters on Chemistry*, Letter xxvi, p 346.

may be distinguished from each other, and it is this, that the latter requires a high temperature for its coagulation, whilst the former will at a low temperature coagulate spontaneously.

Berzelius states the composition of the serum to be 905 parts out of 1000 water, 80 parts albumen, 6 chloride of potassium and sodium, 5 soda and phosphate of soda, and 4 lactate of soda. Besides these ingredients, there are sometimes indications of the presence of sulphur, though not in sufficient quantity to enable the chemist to assign to it any precise amount; and, on the authority of Lecanu*, carbonate and phosphate of lime, magnesia and iron are also found in it. But, as Mr. Brande observes in reference to the analysis of serum, "the food and other ingesta greatly affect it, and in disease, abnormal substances are found in it†." And in regard to albumen specifically, Liebig hesitates not to affirm that "the great importance of albumen to the vital animal process forces itself irresistibly on our notice, when we reflect on the development of the young animal in a fowl's egg.

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* *Ann. Chem. et Phil.* xlviii, p 317.

† *Manual of Chemistry*, Vol. II., p 1765.

The albumen of the white and of the yolk in the egg contains sulphur and nitrogen, as does the albúmen of the blood. For every equivalent of nitrogen, both kinds of albumen contain eight equivalents of carbon, and they agree also in the proportion of hydrogen. They are identical bodies, not only in properties, but with the exception that the albumen of eggs contains a minute quantity of sulphur more than the other, in composition also."*

"We observe in the next place," continues Liebig, "that in the impregnated egg, by the influence of heat, and by the aid of the oxygen of the air, which has access through the porous shell,—under the influence, therefore, of those conditions which accompany respiration—all the parts of the animal body, feathers, claws, fibrine, membranes, cells, blood corpuscles, the material of the blood-vessels and lymphatics, nerves and bones are developed. It is obvious that albumen is the foundation, the starting point, of the whole series of peculiar tissues, which constitute those organs which are the seats of all vital actions. The elements of those organs, now possessing

* *Familiar Letters*, p. 345.

form and vitality, were originally elements of albumen. They are the products of certain changes which albumen has undergone, under the influence of heat and oxygen, in living organisms.

"In the same way as in the egg, the albumen of the blood holds the first place in the process of formation of the fœtus, to which it is conveyed from without.

"Everywhere throughout organized nature, we find the phenomena of life depending on the presence of albumen. The continuance of life is indissolubly connected with its presence in the blood, that is, in the nutrient fluid."*

Chemists, in treating of the composition of the serum, almost uniformly speak of it as consisting of a certain proportion of albumen. It will, therefore, be requisite to say something upon this substance, in order to furnish a sufficiently general knowledge of the chemical constituents of this part of the sanguineous fluid.

Dr. Bostock says that "albumen which has been coagulated by heat, or by other agents, differs in many respects from albumen before it

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* *Familiar Letters*, p. 346.

has undergone this change."* In other words, there has been produced by coagulation a change in the form, condition, and physical properties of the fluid called albumen, and this change amounts to a change in the nature of the substance. For being solidified by these means, the substance is no longer soluble in water or miscible with it, and is besides differently acted upon by chemical re-agents. The coagulation of this fluid by heat is considered by the same writer, "to be an effect *sui generis*, which at present it is impossible to refer to any general principle."† The proportion of the ultimate constituent parts of the albumen are stated by M. Thenard to be as follows: 50 carbon, 24 oxygen, 8 hydrogen, 15 nitrogen, in 100 parts of albumen, and in addition to these, on the authority of Mulder, there are present also sulphur and phosphorus. From this testimony it would appear that albumen is virtually the serum when the salts and other matters are mixed with it, and that the serum may retain the name of albumen as formerly given to it. Instead, therefore, of albumen being spoken of as one of

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* *Elementary System of Physiology*, vol i., p. 470.

† *Ibid.* vol i., p. 472.

the constituents of the serum, the two terms ought rather to be viewed as synonymous, the carbon, oxygen, hydrogen, nitrogen, salts and water being considered as the constituent parts of the serum. A great source of perplexity is thus easily avoided. For the serum, like the blood itself, may be regarded as a compound of gaseous, saline, and earthy parts, and hence susceptible of numerous changes arising from various influences and relations that are indicative of its nature, condition, and qualities.

The crassamentum, or more solid portion of the blood, presents itself next to our consideration. Here the question at once suggests itself, how is it that this clot, or soft solid, which a few minutes before was a red fluid, active, bright, and warm, should so soon become a fleshy mass, heavy, cold, inert, and devoid of all motion? It is as if, like its parent serum, its ingredients had acquired a new property from heat, the only difference being, that the heat of outward nature influenced the one, whilst heat from another source—animal or vital to wit—influenced the other. As, moreover, it was remarked by Dr. Bostock, in reference to the coagulation of serum, that the circumstance was inexplicable upon any

general principle of science, so, I may observe, in reference to the spontaneous coagulation of the crassamentum, that it is equally inexplicable upon any common principle of philosophy. That which Liebig terms serum, has, according to this interpretation, become something else. For though this great chemist says that under the influence of heat, and by the aid of oxygen, albumen developes the fibrine as well as many other things, yet the fibrine forthwith acquires the property of coagulating spontaneously, independently of the heat of nature.

The coagulum is elastic and tenacious, and in its general aspect, as well as in its chemical relations, greatly resembles pure muscular fibre. It is designated by several names, as, the coagulable lymph, gluten, fibre of the blood, and fibrina.

Experiments beyond number have been made for the purpose of ascertaining the circumstances peculiarly connected with this spontaneous change of the blood, or tending in any way to promote, to retard, or to counteract it.

It must be borne in mind that it is almost universally assumed, that this fibrine exists as such in the warm, active, and circulating con-

dition of the sanguineous fluid, and that it is indeed one of its chief constituent parts. Whereas we only know positively that red corpuscles and serum circulate in the form of blood. Fibrine, for all that we know to the contrary, may be merely a change in the blood as a consequence of rest, in the same way as albumen is so, in consequence of heat. The blood, more correctly regarded, is, in its circulating condition, rather to be viewed as made up of a globular and of a serous portion; the latter being evidently in the course of conversion, or ascent, so to speak, from chyle to the condition of globules. This is, in fact, confirmed by the aid of the microscope, which brings to our view globules circulating in a fluid.

The coagulation of the blood, according to the experiments of Mr. Hewson, is modified by various circumstances; as, for instance, by large bleedings, faintings, and other debilitating causes, which seemed to hasten or increase it. Even certain passions and emotions of the mind, appeared to him to produce this effect, more particularly the depressing passion of fear; on the other hand, whatever increased the vascular action, or, in other words, excited the body,

lessened very considerably the tendency to coagulation. He was therefore induced to think that the properties of the blood depended upon the action of the blood vessels; or, to use his own words, "that they have a plastic power over it, so as to be able to change its properties in a very short time."* But, as he further remarks, "when an animal had bled to death, or when the vessels are acting with the lowest degree of strength, the blood is found to be more and more disposed to coagulate, in proportion as the animal is reduced."† The contrary, however, is the case when the vessels are acting more strongly, or are under a state of inflammation. The temporary struggles of the dying animal seem to lessen for a short time this tendency to coagulation; for, as Mr. Hewson states, "the fibrine was altered thereby."‡ He thus reasons upon these extraordinary facts: "Although it must be admitted to be very difficult to conceive how the blood-vessels should do this, yet I hope that ingenious men will not reject my conclusion merely on that account, but will consider that,

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* *Experimental Inquiries into the Properties of the Blood.* Third Edition, p. 125.

† *Ibid.* p. 127. ‡ *Ibid.* p. 129.

as it is deduced from a number of experiments, as it agrees with all the appearances, and as it leads to an explanation of many of them, which otherwise cannot be accounted for, it may be well founded, although it is difficult to be conceived; for there may be powers in the animal economy that are not yet dreamt of in our philosophy."*

This writer devoted much time and thought to these subjects, and the results of his observations confirm the testimony of several authors of the last century, relative to the influence of certain salts, as sulphate of soda, chloride of sodium, and nitrate of potass, in counteracting the coagulation of the blood. This is strikingly confirmed, indeed, by what Dr. Bostock has advanced on this point. "If," says he, "either of these salts be added to a quantity of blood, in the proportion of rather less than one-twentieth of its weight, the coagulation will not take place."† This circumstance affords an insight into, at least, one of those relations subsisting between an important element of the animal economy and certain articles enumerated under the head

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* *Experimental Inquiries into the Properties of the Blood.* Third Edition, p. 131.

† *Elementary System of Physiology*, p. 440.

of *Materia Medica.* I mention these salts out of a number which have an influence on blood withdrawn from the body; but I may here remark that this class of substances has an important relation to the animal economy itself; for a very large proportion of the Materia Medica of our College, from which our Pharmacopœia is derived, consists of saline matters of different kinds, such, for instance, as are volatile, alkaline, acid, or mineral, the respective properties of which, in reference to the animal economy, it is the province of the physician to observe and record. They constitute, moreover, a most valuable portion of our Materia Medica, and, in the hands of the skilful and experienced practitioner, they are rendered available to all the varying conditions and requirements which this economy exhibits Of 270 articles enumerated in the Materia Medica, no less than 50 from the class of salts are recommended by the College. And the ground of this recommendation is supplied from the vast store of experience which is to be met with in the great treasury of Medical Science. Dr. Bostock also observes with regard to this remarkable effect produced by certain salts upon the blood, that "it

cannot be owing to any tendency in the salt employed to dissolve the fibrine, because the neutral salts do not possess this property; at the same time that potass, which is the proper solvent of fibrine, has less power in retarding its coagulation."*

Electricity or lightning, it is well known, destroys the coagulating tendency of the blood, which is accordingly found perfectly fluid in men and animals that have been killed by electric agency. Nor is this the only remarkable effect of this agency; for the muscles remain as flexible as ever, and the rigidity, which is the usual concomitant of death, does not take place. The same consequence results from a blow on the pit of the stomach causing sudden death; from the fatal bites of venomous reptiles; from fatal injury to the brain, whether by apoplexy or otherwise; from extreme emotion of mind, and great bodily exertion; and from vegetable poisons producing death.

In diseases also this coagulability of the blood is modified in various ways; it is, for the most part, indeed, greatly increased, presenting

* *Elementary System of Physiology*, p. 440.

a wide and most interesting field of research for the pathologist and chemical investigator. Again, if blood be received into different vessels at the same bleeding, it will sometimes happen that the portion contained in the first vessel will exhibit no buffish appearance; the second will exhibit it in a greater or less degree; the third the same; the fourth very much so, or even not at all. These changes and anomalies have been attributed to certain alterations in the state and action of the blood-vessels; and more recent observations have discovered that the same results may be brought about by the more or less free escape of the blood from the body; by the size of the orifice made in the vein; or even by the form and kind of vessel into which the blood is received. In short, these results tend to shew that the coagulability of the blood is modified by various internal and external causes, or affected by various influences; and I am induced to believe that the study of these manifold causes and influences will assist in guiding us to a clearer understanding of the principles which are involved in the still mazy science of Therapeutics.

The specific gravity of the crassamentum is

somewhat greater than that of the serum by which it is surrounded, though there is no absolute uniformity in this respect. And it is to this very diversity in all the characteristics of the blood and its several parts that I would beg especially to call your attention. These particulars, familiar to most of my distinguished audience, I am compelled to bring forward for the sake of the superstructure to be reared upon them; and they are sufficient to impress the diversity above referred to most strongly on our minds. For, whether we consider the composition, the fluidity, the colour, the weight, or the multifarious changes of the blood, in these and other respects, we shall find that the differences, even in every one of these several properties, defy all our calculation. Whatever, therefore, is advanced on the subject, can only be expressed in general terms, upon which alone, independently of other facts and phenomena, we can found no precise or positive theory; they are, in reality, nothing more than what the concrete is to the foundation that has to be laid upon it.

It would be both tedious and useless to describe the changes which are produced on the crassamentum by means of the stronger acids

and caustic alkalies. They demonstrate, in unison with those that have been already adduced, that though the blood is a compound of several chemical elements, it is, beyond all doubt, pre-eminently a fluid *sui generis*, and, moreover, requires other aids, besides those which the science of chemistry affords, to unfold and explain its real nature.

The chemical composition of the crassamentum deprived of the red globules, is stated by M. Thenard to be nearly $\frac{3}{53}$ parts carbon out of 100, 20 oxygen, 7 hydrogen, and 20 nitrogen. So nearly allied, then, in chemical composition are the two chief proximate constituents of the blood, as they are called. The only difference in the quantity of the several ingredients, which compose these two so-called proximate constituents, is represented by M. Thenard to be this, that 24 parts of oxygen, 15 of nitrogen, and 8 of hydrogen are obtained from albumen, whilst 20 of oxygen, 20 of nitrogen, and 7 of hydrogen, are obtained from fibrine. There is, he states, the same amount of carbon, or nearly so, in both.*

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* *Elementary System of Physiology*, p. 480.

From this account of the crassamentum, or fibrine of the blood, I must candidly aver, that I can see no satisfactory reason for following the hitherto beaten track, in order to investigate the properties of the wonderful fluid which performs the most essential part in the animal economy. For the more I examine its bearings, the more fully am I convinced that this track will lead those who pursue it, in a direction the very opposite to that which can terminate to the satisfaction of the sincere and honest lover of truth.

There may be a convenience in treating on proximate principles, such things as I have been discussing, and in designating them by distinct names. It may be of use in common discourse, or in writing, to speak of albumen and fibrine, in order to express those two forms of matter into which the blood is converted on being withdrawn from the body. But if, by the mention of these substances, in relation to the blood, an idea is conveyed to the mind that they exist as such in the state and form of blood, circulating in the living animal body, and that they are its proximate principles, I hesitate not to affirm, that the arbitrary and artificial adoption of names becomes a fruitful source of error, extremely

difficult to rectify and counteract. The chemist speaks correctly indeed, when he applies the terms albumen and fibrine to constituent parts of blood no longer identical with the source from which it was taken, and forming no part of the stream which continues to circulate through the animal body, imparting to it heat and life. But, if he applies the same terms to the blood in circulation through the living body, he must then assume that blood, whether coagulated or fluid, is one and the same substance; in other words, that the blood undergoes no change whatever, whether chemical or otherwise, by being withdrawn from the body; consequently to examine an insoluble clot, is the same thing as to examine one of the most fluid substances in nature, which the blood undoubtedly is when it is in free and healthy circulation through the body.

The notion that the blood is a compound of fibrine, albumen, and globules, is calculated to render it a matter of little moment to the anatomist, the physiologist, and even still less to the psychologist, in their investigations of the animal economy. But of what avail is this notion to the pathologist? Does it enlighten

him upon the diseased conditions of the fluids which in their complex are called blood? Does it at all approach to the sources of fever and its manifold varieties? Does it impart any thing like an idea even of the nature of those diseases which begin in obstruction, which mount up to inflammation, and quickly sink into mortification, gangrene, and death? Does it instruct us upon those disorders which, from a mere breath, or from the slightest contact, increase and spread themselves through the commonwealth of the bodily frame, and then through communities, less and greater, to the wholesale destruction of the race? Does it explain to us the reason of that sudden prostration and debility which usher in our more serious and alarming maladies? In fine, does it indicate the difference of nature which subsists between man and the lower animals, and between the races of the one, and the genera of the other, although there is not an atom of their respective bodily fabrics, which did not circulate as, and identify itself entirely with, the blood? Again, when the lightning's flash, the heat electric, has liquefied the blood, and dissolved the rigidity of death, who can then determine the relations and proportions of fibrine

and albumen in the now sanious fluid? In like manner, when the yet more subtle and potent agency of vital heat, melting matter down to the very elements of natural substances, subordinates, co-ordinates, and combines them together in obedience to certain laws; when, in thus controlling them, it imparts to them higher and nobler conditions of existence, forming them into spheres of action and fitting them for circuits of use; when, adorning them with crimson and purple vestments, it sustains and nourishes them with the glow of a Promethean fire;—who can then determine the proportions of fibrine and albumen —elements worthy only to be analysed in vessels of glass and iron, rather than to circulate through the arteries, veins, and nerves of the animal fabric?

Nor will this notion avail to instruct us concerning the relations of Materia Medica to the animal economy, more particularly, through the medium of the blood, or of the avenues and portals which lead to its ever-circulating stream and all-embracing vortex. Fibrine, albumen, red globules, as such, must share the fate of other substances, in order to be fitted for possessing the qualities and performing the uses of

blood. Like all other ingesta, they must be digested, or made to pass through successive stages of preparation, before they can be admitted to serve a purpose in the animal economy, and thence become liable, through accident, disease, or death, to fall back into their original condition. They are most valuable in the way of kindred and descent; they proclaim their origin, but they are out of the course and circuit of the living stock, and, therefore, they mingle with the more common of nature's elements, participating in their comparatively more lowly and ignoble fortunes.

LECTURE II.

In my last Lecture I detailed my mode of proceeding with a view to exhibit the relations of Materia Medica to the whole animal economy. I further endeavoured to show, in as convincing a manner as possible, that these relations are more clearly discernible from that point of view which is afforded by a comprehensive knowledge of the animal economy itself. This was the position I desired at once to occupy, and, in addressing you from it, I was anxious to direct your attention to the order observable throughout this most important subject, the domains of which are co-extensive with the domains of nature, penetrating even to the purpose, design, and determining law, which manifest to us their formative and plastic powers.

In illustration of this, I referred to the blood, which, by its universal presence in the body, and by virtue of its being the origin and source of all its parts, constitutes, relatively speaking, its pervading vital principle.

And in order to point out the adaptation of the blood to this wonderful agency, I proceeded to enumerate the leading particulars of its composition, its conditions, its attributes and properties, as well as the changes of state to which it is liable, indicating corresponding conditions of health or disease. This enumeration conducted us but a short way in our examination of the chemical composition and relations of the blood. This part of our subject comprises the whole category of facts which make up the science of animal, and even of general, chemistry. To this category I had no additions to make, nor indeed was I desirous of distinguishing myself in this way, surrounded as I am by those who are far more competent to teach, and from whom I am ever most willing to learn.

My chief object is rather to explain the conclusions that are deducible from indisputable facts, more especially as these conclusions are subservient to the great end and purpose of our common profession. For they are consonant with that liberal spirit which urges us onward in the acquisition of more extended knowledge, and in the employment of more enlightened skill for the general good.

The notion then to which I alluded in my last Lecture, that albumen and fibrine are the constituent parts of the living, circulating blood, suggests no inference that the blood can, as a volume of fluid, exist in a mixed condition. For instance, that a portion may be spurious, and useless for answering the purposes of the animal economy; that it may be depraved and vitiated, and charged with manifold impurities; or, that it may be ill-prepared, through defective digestion; or be affected in various ways through mental influences either of a depressing or of an irritating nature.

The testimony of Mr. Hewson has been adduced to show that strong mental emotions producing sudden death, prevent the coagulability of the blood, the very same result that follows upon a fatal stroke of lightning. Now this extreme effect may serve to indicate in either instance a closer relation both between the blood and the electric state of the atmosphere from without, and also between the blood and mental influence operating from within. From this it may be inferred that an *a posteriori* examination of the blood by the chemist, is rather an examination of those things into which the blood is converted,

on the cessation of the conditions requisite for the exhibition of its especial properties, namely, motion, circulation, and perpetual division of its parts. Such an examination indeed answers exactly to the dissection of a dead body by the anatomist, and is of similar value and importance; but it imparts no knowledge of the characteristics of the living individual, or of a thousand other attributes which equally pertain to the one and the other. I have made mention of the characteristics of the individual, because, in the case of the anatomist, the subject of his dissection exhibits structures which are adequate to those functions and uses which he *a priori* knew pertained to them. The chemist, in like manner, in the case of the little volume of the blood which he examines, testifies to its composition, its various ingredients, its whole structure in short, rendering it adequate to the multifarious uses which, he also knows *a priori*, are derived from it. But chemical examination would, of itself, never tell him that all the bodily organs, whatever be their functions, are derived from the blood; and still less that their functions will cease the instant it is withdrawn from

them. His examination of the blood then, is rather that of fibrine and albumen; the properties and relations of which, compared with those of living blood, are very limited, but which nevertheless owe their origin and existence to several elements occupying the greater portion of nature's domains, and playing a very essential part in them. They are, indeed, primary in the nature of the world and its several kingdoms; we know them and designate them as oxygen, hydrogen, nitrogen, and carbon. Together with the more leading members of the great saline family, they make up the material ingredients or components of the blood, and, specifically, of the albumen and fibrine into which the blood is convertible. And, as on the one hand, nature presents them to the animal kingdom, and more particularly to man, as its supreme head, in forms and substances, called seeds and fruits, agreeable to the eye, delicious to the palate, and enlivening to the blood; so, on the other hand, when they are appropriated and assimilated by a living power, they then come forth forms and substances of a higher nature, animalized, vitalized, and organized, as it were, into living seed, and productive

of living uses. These latter again are determined into circles of life, conformable with those living powers, which work from ends through causes to effects, and which secure a constant spring and harvest of fruits nourishing alike the intellect and the will of man.

I would here advert, for an instant, to the subject of Materia Medica, not merely as it is appointed for such specific purposes as refer to the maintenance of health, the removal of disease, or the alleviation of bodily suffering, but also as including the privilege of moral counsel, and the duty of human sympathy. For these form a most important part of the physician's mission—perhaps the most essential qualification of his high calling—and they impart a claim upon mankind for such confidence, respect, and support, as it is the mark of civilization and intellectual enlightenment to bestow. Materia Medica is placed in our hands; we have been trained to the trust; and, though bounteous nature has supplied us with an overflowing store, yet it is but in accommodation to the discriminating power with which the healing art must be ever exercised. This discrimination, while it notices the sources of disorder and disease, selects readily the remedies suited

to every emergency and requirement. Well then may the study of medicine, and of all its co-ordinate sciences, stimulate the love of light and liberty in our breasts; well may we be zealous in our vocation, and manifest a spirit of universal benevolence; well may we be jealous of empiric rivalry, when we know how debasing its influence is on the minds of its victims, when we see its wings, vampire-like, hovering over the doubting intellect, that doubts to the point of persuasion, because the promised good is so unreasonable, or so questionable, both in its origin and effect: well, I say, may we be jealous—almost even to contempt—both of agent and patient, when we are conscious, that the very comprehensiveness of our studies elevates us out of the mere semblances of knowledge, while we can still bow to the circumstance of death, as a law of nature, which skill would labour to postpone and with which honesty would scorn to tamper.

Apart from the wider acceptation of Materia Medica, as embracing every thing which conduces to the preservation of animal life, I cannot touch upon the subject as a mere collection of medicines only, without noticing the influence

which they have, more especially, upon the condition of the blood. In the first place, let me mention their claims upon our own confidence on the best possible grounds, that of *general experience.* And hence it must be borne in mind, that the blood is, in all practical points, to be regarded as something more than a compound of fibrine, albumen and red globules. The physician, indeed, takes all the advantage possible of the science of chemistry; and the last thirty years are remarkable for the investigations which have been pursued by a great phalanx of chemical philosophers, by whose labours almost a new science has been established. The science of organic chemistry, for instance, is contradistinguished from that of general chemistry: while both minister to that of medicine, though some of its votaries would accord it a paramount position and bearing. Were the animal body, and, indeed, the animal fluids, similarly circumstanced with other forms of matter, or could the properties of the organic substances be attributed to atomic relations and proportions, I should be most ready to rely on chemistry as a sure guide in the treatment of disease. But it is general experience that must direct our employ-

ment of medicine. Our Materia Medica is founded upon this secure basis, and from it derives all its value. The experienced physician, therefore, must surely be the best qualified to render Materia Medica most efficient in combating disease.

Experience indeed is the grand pretension of our profession; for, without it, all other qualifications, let them be ever so various and extensive, are of comparatively little worth; but with it, high qualifications are most powerful auxiliaries conferring superiority and honour—the superiority arising from the exalted use, and the honour conspicuous in proportion to the use performed. Armed with experience, then, and animated by the love of truth; sensible of a freedom to discover and reject error, and resolved upon a useful course of action; the skilful medical practitioner can watch the current of public thought, and the bias of its will. He can discern the rise and fall of theories which, meteor-like, attract but transient notice; he can observe the passing fashion which degrades our art to a shifting frivolity, and mark the quick succession of empirical inventions for beguiling, deluding, and deceiving mankind. Nay, more, he can deduce wise lessons from all such circumstances; and,

whilst he laments the easy credulity of the unwary, he indulges the hope that all pretensions to the healing power will at length be accorded to the higher claims—to claims which spring from an extended knowledge both of the animal economy, and of the natural sciences, which are subordinate and subservient to it.

To our common experience then, to our general knowledge, to our Materia Medica, I would refer for the proofs that we regard the blood as the especial object upon which they are respectively exercised in every effort to subdue disease. For it is there that disease begins, and it is thence that disordered action of the bodily organs proceeds. Our remedies, when properly administered, induce new conditions upon the vitiated blood—for the blood is subject to vitiation, from ten thousand causes; they remove or they neutralize the sources of mischief; or they alter the organic actions, stimulating or soothing them, or influencing them in divers ways. These effects and circumstances are so many auxiliaries to restore the health, a term which so well expresses the order that is natural to the animal economy, as contradistinguished from the disorder of which we have been speaking.

At the outset I stated that the animal economy exhibits in itself both co-ordination and subordination. The organs of the body are both co-ordinate with, and subordinate to, each other; they are at the same time subordinate to the blood, referring themselves to it as to their general principle; for out of it they came, and to it they return, in the course of their living actions. In like manner the blood itself, as a compound of divers materials, passes through its alternations and states, its periods of youth and age. It immolates itself, as it were, to its own organs and their functions, looking to them as the instruments for repairing the losses which it perpetually sustains for the common weal. For them it lives and dies, and phœnix-like it rises again from its ashes, performing in all this a wondrous circulation of life, the counterpart of death, and moreover, declaring its origin to be in and from a force to which it is itself subordinate. It is indeed this force that determines all its properties and qualities, through its instrumentality producing all the stupendous machinery of the bodily fabric.

This reasoning process brings me to the consideration of the globular parts of the sanguineous

fluid; for, as is well known, the blood presents a globular structure, not as an accidental, but as an essential part of its constitution. A liquid, the *liquor sanguinis*, as it has been very appropriately designated by Dr. Babington, is the material out of which the globules, spheres, or discs are formed, and it is in their formation that the red colour of the blood first appears. I shall here enumerate various particulars relating to the form, the appearances, the chemical composition and changes, recorded concerning these bodies by different authors; and I shall afterwards endeavour to deduce from them a law or principle which will account for the anomalies and peculiarities presented by these bodies to the observer, and which plainly indicates within them the presence of a force imparting their form, determining their direction, and ordaining their use.

The existence of the red globules would never have been discovered, had the powers of the microscope remained unknown, and we should thus have been left to form our conjectures or to build our theories upon the blood, as upon a subject altogether or to a great extent unknown. This practice has indeed prevailed on many subjects in all ages to a greater or less extent,

and it strikingly exhibits the strong tendency there is in mankind to seek for the qualities of things, regardless of the modes and forms by which they are manifested. This practice, however, is the direct counterpart of that which marks the materialist, the solidist, or the mere anatomist. For by them visible form—and that alone—is sought after and admitted; the consequence is, a stout denial of the existence of any other forms than those that meet the eye; or, in other words, a disbelief in the very existence of those forms and their qualities which, in fact, impart to the visible form, all its reality and efficiency, instead of resulting from it. Philosophers of this class, it must be allowed, have done eminent service to science, but they must be reminded that they have deserted the ranks of true philosophy. They have ceased to cultivate the faculty of abstract reasoning, which enables its possessor to discern that every form is the result of some determining force or power, and is, consequently, instrumental and secondary, subservient and subordinate to it. But the former class of philosophers, or those who form conjectures and build theories, without first ascertaining the constitution, structure,

or nature of their subject, can scarcely lay claim even to the merit of utility. For they have introduced into their philosophy a number of unmeaning and arbitrary terms, which have given an air of mystery to the plainest subjects of science, and thus tended to bewilder rather than to enlighten us. Hence it is that men's minds so often live, as it were, in a world of their own formation, which is to them an imaginary heaven, and which nothing but the omnipotence of truth will ever be able to remove. The terms to which I more immediately allude are force, power, action, irritation, nervous influence, &c. Such terms, I hesitate not to say, are as deceptive as the frequency of their use can possibly render them. For we do not think of the paramount necessity to enquire what is really and definitively known respecting them; but we are singularly content with the practice of establishing certain imaginary qualities, without assigning them any corresponding forms as their appropriate habitations. Strange paradox this, and absurdity; to deny form and therewith substance to those qualities which science acknowledges for its first principles! Surely, if there is a given quality manifested in nature, there must be the subject

in which that quality resides; and if there is a subject, there must be the substance of which it is constituted; and if there is a substance, there must be a form predicable of it; and, as a necessary consequence, there must be a quality according to the form, or if you will, there must be a form corresponding with the quality. These things are absolutely inseparable in themselves, though they admit of an abstract separation in idea; and in all creation nothing is so full of illustration of these positions as the animal economy, and at the same time there is nothing that so much requires their admission for the right and complete understanding of its high intent and wonderful capability.

These observations are here made for the purpose of shewing how indispensably necessary it is that we should possess an accurate knowledge of the subject itself, as to its real nature and structure, before we can possibly arrive at sound conclusions respecting the powers and properties inherent in it. The necessity of such knowledge applies indeed to the whole animal economy, and especially to the blood. For the blood, as we have seen, is the all essential element of the body constituting its universal principle. A thorough

knowledge therefore of the blood should be the primary object of our investigation, for without it we may err at every step as we traverse the wide field which it opens up to our view.

I have remarked that the existence of the globular part of the blood would have been unknown, but for the wonderful discoveries which the microscope has introduced. This fact is undeniable, and is of itself a sufficient proof of the incalculable services which this curious instrument renders to science. Still we must be well on our guard against placing implicit reliance upon it as an infallible authority. For, in the first place, as in the case of every other instrument, we require practice to become proficient in its use. 2—It is liable to communicate false impressions, both with respect to form and colour, in the event of any irregularity in the incidence of the rays of light upon the object examined. 3—The object itself may modify the light in various ways, so that the instrument magnifies the error. For some parts of the object may be transparent and others opaque, whilst some are more dense than others; whence it is plain that the effect of this diversity

must be to modify the light which is either traversing the object or reflected from it, or but partially transmitted through it, and that it will vary according to the state of the light itself, and the position of the object. 4—The descriptions of the same object given by different microscopic observers must vary in proportion to the diverse circumstances under which the object may be viewed, without reference to the competency of those who undertake observations of this kind. 5—A fruitful source of uncertainty in the evidence obtained by means of the microscope will be obvious, if we take into consideration the great and rapid changes which must take place in the object itself, even whilst it is under observation. For instance, should the object be a compound of different elements; should it be a fluid, or any thing else susceptible, from its very nature, of certain changes from slight causes; or should it be disturbed from its natural situation and relation, and subjected to new and unnatural conditions; in all such cases, the knowledge we should obtain by any microscopical examination whatever would be far from satisfactory, and therefore deserving of very cautious adoption.

All these considerations are applicable in their fullest extent to the blood, and particularly to its globular portion, as an object of microscopic investigation. We have only to revert to the five several causes mentioned, out of many more that might be adduced, affecting the evidence furnished by the microscope, if we wish to be convinced of the many sources of error to which every man is exposed, who undertakes an examination of these extraordinary bodies.

If we apply for instance the fifth ground of objection to microscopic evidence respecting the red globules, which present both rapid and remarkable changes, even in their natural situation in the living body, do we not observe that these minute bodies are composed of different elements, and thence liable in various ways to decomposition, subject also to new arrangements and sudden alterations in the relative positions of their parts? Are they not, from their very nature, susceptible of certain changes, from what we are too apt to consider slight causes; as for instance, from the states of the surrounding air; from the influences of heat and cold; and from the evaporation and escape of some of their more subtile parts? When placed upon a glass

in the focus of the instrument, and exposed at the same time to a strong light, are they not withdrawn from their natural situation and relation? Are they not subjected also to new and unnatural conditions, by being abstracted from the rapid circulation, the incessant motion, and the constant pressure, which are essential to their proper existence?

But, nevertheless, it is, we gladly allow, for the real good of science that the microscope was discovered. By its power alone, the existence of the red globules of the blood, as I have already observed, has been made known to us,—a circumstance of itself sufficient to establish its great importance. Its highest value consists in the evidence it affords of the perfection of things even to their minutest perceptible division, and in the inference which it enables us to draw respecting the perfection of things invisible. This will be very apparent as we proceed. If, however, one subject more than another can neutralize the objections to the use of the microscope, and vindicate its real merits, it is the one on which we are now engaged. These objections, indeed, are not so formidable as they may at first sight appear, since they originate either in

the defective use of the instrument, in the neglect of proper precautions, or in a want of observation of the circumstances and conditions connected with the object itself.

Physiologists have been of late engaged in a very minute microscopic examination of the red globules. It is, however, to be lamented, that their testimony on this subject, instead of being consistent and satisfactory, is contradictory and uncertain; but it tends nevertheless to corroborate the conclusions we have drawn *a priori*, with regard both to the sources of the uncertainty attaching to microscopic testimony, as well as to the misapplication of the instrument. For this examination has been almost exclusively confined to the red globules after their removal from the circulation, whilst they have been in a state of rest, exposed also to the influence of light and air, and thus to an unnatural temperature. Hence it is, that many of the results vary, as might be expected, being inconsistent with each other, and in reality of little or no value. In order, therefore, to find more satisfactory information than that which is furnished from a microscopic inspection of these bodies when withdrawn from the circulation, I must refer you to

the works of Leeuwenhoek,* who has given a description of the red globules as seen by means of the microscope whilst circulating in the living body, and consequently in a more true and natural condition, as well as under more favourable circumstances.

We are enabled to derive a much clearer idea of the circulation of the blood, and of the vessels by means of which it is effected, from the admirable observations of this writer. He states, for instance, that he saw, with no small degree of delight, the mode in which the larger blood vessels or arteries of a very small fish are divided, whilst conveying the blood from the heart into the most minute vessels at the very extremity of the tail. He further observed, that many of the smallest veins which returned the blood to the heart from the extreme terminations of the arteries, met at last in some larger vein. The agitation of the blood in its course through some of the vessels at their minutest divisions, was such, that it could hardly be conceived. In the larger arteries a continual propulsion or acceleration of the sanguineous current received

* Continuatio Arcanorum Naturæ, pp. 53, 54.

from the heart was distinctly perceptible; whilst in the smaller arteries, the motion of the blood seemed equable without any such propulsion; and though in the minutest vessels no colour was visible, yet in a larger vein or artery, even close to the end of the tail, the blood was distinctly red. The communications of the arteries with the veins were sometimes uninterrupted without their terminations becoming previously evanescent and not to be traced: indeed, he in some places could discern a very open communication between the arteries and the veins, where the blood was running towards the extremities through the arteries, and of the same diameter with them. This was discernible in no less than thirty-four different places, namely, in as many arteries and in as many veins; the current of the blood was therefore visible in sixty-eight vessels, although the animal was not half an inch in length; and yet these vessels were very far from being amongst the most minute.

Since then such are the wonderfully minute ramifications and subdivisions of the blood vessels, let us now turn our attention to the blood itself by which they are traversed, and especially to the red globules. On this subject,

the most curious, and at the same time the most satisfactory account is to be found in Mr. Baker's useful work on the microscope, whose testimony may be relied upon implicitly, as he devoted a great portion of his time to microscopic researches, and was an eminent fellow of the Royal Society.

I shall in the first place mention some of the experiments that were made with a solar microscope of a peculiar construction, by Mr. Baker and his friend, Dr. Alexander Stewart, Physician to the Queen-consort of George the Second. After making all allowance for the defects in the method which they adopted, we find the evidence they obtained from it peculiarly strong and clearly given. But Mr. Baker shall speak for himself:—"Our object" he says, "was a frog, whose limbs being extended and fastened on a frame, we opened the skin of the belly to the greatest extent possible; it was then stretched out with care before the microscope, and presented on the screen a most beautiful picture of the arteries and veins in the skin, with the blood circulating through them. In the arteries we could plainly perceive the blood stopping, and, as it were, receding a little at each dilatation of the heart, and

then immediately running forwards again at each contraction, whilst in the veins it rolled on in a continual current with inexpressible rapidity."*

In a note appended to this description of the circulation Mr. Baker observes that "when the arteries were magnified very much by removing the screen to a considerable distance, the alternate expansion and contraction of their sides were very perceptible." "After considering this," he proceeds, "as long as we thought needful, we opened the abdomen, and, extending the muscles before the microscope by the same means as we had done the skin, we had the pleasure of viewing their structure, which we found to consist of bundles of transparent strings or fibres, lying parallel to one another, and joined together by a common membrane. These strings or fibres appeared through their whole length made up of minute roundish vesicles, or in other words, seemed like rushes divided the long way. We could not be certain of any circulation through the muscles, though sometimes we imagined we saw a very slow motion of some transparent fluid. But, the object growing dry and rigid, we pro-

* *Baker on the Microscope*, p. 133.

ceeded to our last experiment, which was to draw out gently a part of the frog's intestines, in order to apply the mesentery to the microscope; and herein we succeeded so happily, that I believe the circulation of the blood was never before seen in so fine and distinct a manner. No words can describe the wonderful scene that was presented before our eyes! We beheld the blood passing through numberless vessels at one and the same instant; in some one way, in others the direct contrary. Several of the vessels were magnified to above an inch in diameter, and, the globules of the blood rolling through them, seemed nearly as large as peppercorns, whilst in many of the minutest vessels only single globules were able to find a passage, and that too not without changing their figure into that of oblong spheroids.

"We saw, likewise, much better than we had done before, the pulsation and acceleration of the blood in the arteries, in the manner before described, and could clearly distinguish two or three vessels lying over one another with currents running different ways. In short, it appeared like a beauteous landscape, where rivers, streams and rills of running waters were every where dispersed. During this examination we took

notice of a vessel extremely minute, issuing from the side of a larger, and turning backwards from it in a curved line. We perceived at unequal intervals, sometimes one, sometimes two, and sometime three, colourless globules dropped or squeezed out of the larger vessels into this minute one, and gliding through it singly and very slowly. We observed likewise that, as the animal grew languid, and near expiring, the blood in the arteries would stop on a sudden, seem as it were coagulating and then run backwards for some time, after which it would again recover its natural course with a great deal of rapidity."

Leeuwenhoek corroborates a very important statement contained in this extract, with regard to the change of form—from simple spheres to oblong spheroids—which the globules undergo in the very minute vessels. He observed that this elongation of the globules and their increased flexibility were proportionate to the health of the animal, and might be reduced to an oblong form with their length increased to three times their thickness. He adds that " the particles of the blood, are for the most part globular, and are sometimes changed into a

threadlike form in consequence of the minuteness of the artery containing them; they recover, however, their globular form on coming to a vessel of larger dimensions."*

This description of the red globules, of their circulation in their own peculiar vessels, and of other natural conditions connected with them, suffices to prove that they possess not only a globular form, and consequent adaptation for motion, but also a high degree of elasticity. They are therefore adapted to transmit any force communicated to them from whatever source, whether it be from the heart itself, or from the vessels through which they circulate. To this must be added their readiness to adapt themselves to the calibre of the minutest vessels by assuming an elongated spheroidal form.

These are properties of no small importance to be taken into the account at a more advanced stage in our discussion, but their value will be rendered more strikingly apparent, if we refer to the testimony of later writers on the subject, in order that we may compare such evidence as refers to the globules in their natural condition

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* *Phil. Trans.* No. 117, pp. 134–5.

with that which is obtained by a view of them under circumstances most unnatural to them; when, for instance, they are removed from their native vessels and subjected to numerous disturbing influences.

I have already referred to the discrepancies in the accounts which have been given respecting the red globules, and have, at the same time, endeavoured to account for their existence in the records of science. But how far my explanation may be admitted as just and conclusive, must be left to the judgment of those who are competent to decide. I may however state that, among modern physiologists, Hewson, Hunter, Monro, Young, and the Abbé Torré, differ very greatly in their description of the red particles of the blood.

They first described them as consisting of a solid centre, surrounded by a vesicle filled with a fluid, and sometimes assuming an elliptical form. Hunter never could discern this latter circumstance, nor does he mention either the investing vesicle or the central nucleus; and, what is singular, he never could discover them at all in some animals, as, for instance, in the lobster and

silkworm. He considered them as liquids possessing a central attraction which determined their figure. To Monro they appeared as circular bodies, but flattened like coins, with a dark spot in the centre, which he conceived was owing to a depression and not a perforation. The Abbé Torré stated them to be like flattened annular bodies or rings composed of a number of separate parts cemented together. Cavallo believed them to be simple spheres. The account more recently given of them by Dr. Young, agrees for the most part with that of Mr. Hewson. He remarks that, "if the globules are viewed by a strong light, they will appear like simple transparent spheres, but that if we examine them by a confined and diversified light we shall be better able to ascertain their real figure and structure."* But we find that the red particles of the skate, as being larger and more distinct than in other animals, are better fitted for such an examination: they are almond shaped, and appear to consist of an external envelope containing a central nucleus. This central nucleus appears to be indepen-

* *Introduction to Medical Literature*, p. 571—Second Edit.

dent of the envelope, for when the latter has been removed or destroyed, the nucleus still appears to retain its original form. By many authors the external envelope is believed to constitute the colouring matter of the globule, and it is supposed that the central nucleus is of itself devoid of colour. Dr. Young found that the envelope alone was soluble in water; and he pointed out a method by which the nucleus might be procured retaining its perfect form in water after the red part had been dissolved.

Recent microscopic observers describe the envelope of the globule as surrounding a central colourless nucleus, and as constituting the true colouring matter. But there are strong reasons for the belief that this is a mere appearance rather than a reality, and so many difficulties accompany such a view of the structure of the globule, that it becomes of the highest importance to discover the true cause of this singular appearance. We must, however, take care that our discovery does not militate against the microscopic evidence, but rather that it is confirmed by it, and at the same time in agreement with all the other facts and phenomena connected with the subject.

My reasons for regarding the views of various physiologists on the subject of this envelope, as founded upon a mere appearance, will be better understood, if I at once proceed to speak of the colour of the blood. Upon this subject I shall quote some very valuable and interesting testimony from a German author, Dr. Wedemeyer, in a work on the circulation of the blood, and particularly on its motion in the arteries and capillary vessels. This work was, at the time of its first appearance, highly spoken of by our own critics and reviewers, and acknowledged by them to contain, not only the most recent, but the best view of the subject under discussion. The author of this work, then, speaks of "*the undeniable fact, that the streamlets of blood which consist of a single string of globules are not red, or even materially coloured before the microscope, because the globules singly appear yellow, and acquire a red colour only when collected into masses.*"*

Now the Reviewer† of this work prefaces the above extract by a statement that Dr. Wedemeyer

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* *Untersuchungen über den Kreislaut des Bluts, &c. Von* Dr. Georg Wedemeyer. *Hanover*, 1828.

† *Edinburgh Medical and Surgical Journal*, Vol. XXXII, p. 86.

confirms the observations of other authors, as Haller, Spallanzani, Mascagni, and more lately of Oesterreicher. For these all affirm that the apparently colourless vessels which contain the globules are strictly capillaries of a yellow rather than a red colour, and that these capillaries, admitting only a single row of globules, are yellow in consequence of the small amount of colouring matter. The same testimony respecting the yellow colour of single globules occurs in authors of a much earlier date, and I was gratified to find that Dr. Wedemeyer had repeated and propagated the fact, because it induced me to withhold implicit credence from the statements of other writers on the supposed red colour of the envelope.

"Particulæ plano-ovales quidem nullum refersunt colorem," says Leeuwenhoek, "sed si plures invicem superponuntur, rubellam explicant tincturam."* And Boerhaave says, "Globuli in partes resoluti, pellucidi, flavescentis seri induunt ingenium, cujus varii colores sunt."†

Now granting that very minute bodies which

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* *Gulielminus de Sanguinis Naturâ et Constitutione*, n. 47.

† *Inst. Med.*, n. 225.

singly present a yellowish colour may, by aggregation, present a bright red, as in the case of the blood, still the presence of an envelope as the source of this colour, would give rise to the difficulty and even impossibility of accounting for the fact, that the globules become colourless on entering into their capillary vessels. Such a loss then of colour, it is plain, must either be ascribed to the supposed nucleus of the globule losing its envelope, or to some other change in the globule itself; which is, in my opinion, scarcely reconcileable with the existence of a membranous envelope in the form and manner commonly supposed. Dr. Young mentions the method by which he could separate the envelope from the nucleus—a method which consists in taking away the colour by simply stirring the globules in water. In this case, the globules, he says, remain insoluble in the water which merely receives the colouring matter and holds it in solution. But though Dr. Young could distinguish the nucleus or colourless part of the globule, yet he does not say that he could in like manner distinguish the envelope, which he only supposes to be immediately diffused through the water. My able and estimable friend, Dr. Owen Rees, who has made these bodies the subject of his

investigation, not only represents them as possessing a vesicular structure, but asserts that the contained fluid is red, and the containing membrane white; the latter statement being in direct opposition to that of Dr. Young, who speaks of the envelope as the seat of the colour. But I will quote the words of Dr. Rees himself from his late excellent work. After stating that he considers the blood in its physical relations, as liquor sanguinis containing floating coloured bodies designated blood-corpuscles or globules, he proceeds to say, "I shall first direct attention to the floating corpuscle. This body has been very differently described by physiologists; some have considered it as composed of solid matter—in fact, that it is a soft solid—while others consider it to possess a vesicular structure. There are considerable and important differences of opinion, however, existing even among those who agree in believing the corpuscle to be a vesicle; some regarding it as made up of a white membrane containing a fluid of a red colour, while others believe that the vesicle is red, and the contained liquor of a pale tint. The existence of a nucleus in the corpuscle of the human blood is also denied by many; and

the exact situation it occupies again divides the opinion of those who believe in its presence. In considering these conflicting opinions, it might at first appear a matter of extreme difficulty to resolve any part of a question depending so much on microscopical evidence: but though there are still many difficulties to contend with in the demonstration of a nucleus, we have fortunately obtained a means of determining pretty certainly two of the points in question: firstly, that the corpuscles possess a vesicular structure; and secondly, that the fluid contained within the corpuscle is red, and the containing membrane white."* Dr. Rees afterwards treats of these bodies as the subjects of endosmodic action; for he cannot resist the conclusion that the blood-corpuscle is truly a bladder or vesicle containing fluid.

Now, in minute investigations of this nature, it is very evident that the recorded results are discordant; nevertheless, it is possible to draw certain undeniable inferences from them, and such indeed as are conducive to the elucidation of

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* *On the Nature and Treatment of Diseases of the Kidney*, pp. 96, 97.

some important truths. Thus, it must be admitted that the blood-globule presents a vesicular appearance and structure; that it consists of divers constituent parts; that, if the action of endosmosis takes place here, in common with other membranous structures, there must exist a permeability as well as a capability of interchange of matter: that a movement, in short, is implied, which is controlled by some determining cause inherent in the globule itself, and even affecting its enveloping membrane, liable as this is to disruption and change from the slightest causes; for it may be collapsed or distended, or even entirely disintegrated, as Dr. Rees's evidence throughout seems to demonstrate. But how do the views generally entertained regarding either the envelope of the blood-globule, the colouring matter, or the nucleus, allow of comparison with what actually takes place?

For let us compare the foregoing testimony with what takes place in the capillary vessel. Is there here anything at all in accordance with such views? The globule that becomes colourless and circulates through a colourless vessel has not, we find, left behind it either its yellow

or its red coat, its nucleus, or its coloured contents! No traces of anything of the kind are to be found. So far from it, the globule has lost, not only all colour, but whatever was upon its surface, whatever in fact might in any way have tended to modify the rays of light so as to present an appearance of colour. To illustrate this point, let me call your attention to the fine vessels which ramify upon the conjunctiva of the eye, which in the healthy state of the organ are but few in number, are perfectly distinct, and are easily traced, till on a sudden they seem to stop, and to convey their coloured contents no further. A superficial observer would conclude that these vessels terminate at that point in some corresponding vein; but the truth of the case is, that these vessels are continued on, though their calibre has become so small that they admit only such blood as presents no colour whatever.

Now if we irritate the eye, we show satisfactorily that the vessels which convey red blood are continued on to those which convey blood devoid of colour; that they are in fact one and the same. For the effect of this irritation is, an injection of red blood into vessels previously colourless, and

hence the only rational conclusion to be drawn from this circumstance is, that under the natural and healthy state of the eye, the red globules, together with their containing vessel, on changing their dimensions become colourless by the change: it is moreover certain that they do this without losing any coloured envelope, which would be unavoidable, if an envelope existed in the manner supposed, admitting even that the globule, when abstracted from its natural situation, and subjected to new and abnormal conditions, presents such an appearance before the microscope.

I have referred to a familiar instance, furnished by the tunica conjunctiva of the eye; but, when it is considered that almost every part of the body is made up of capillary vessels; that the largest arteries were once, at their first formation and appearance, mere capillary tubes carrying colourless blood; that even the heart itself was then merely a tissue of colourless capillary vessels, but acting with a most wonderful rapidity and precision as the beginning of the circulation of colourless blood; that the insect world is a theatre in which colourless blood exclusively circulates; — all which con-

siderations will be proved in their proper places—I may surely claim your attention in the way of anticipation, and likewise receive your admission of a probability at least, that as, on the one hand, the blood in its primordial condition was colourless, so, on the other hand, when it reaches its ultimate destination, it loses the colour which it received as the result of aggregation, and circulates through a very large proportion of the capillary system of vessels, presenting there phenomena of action which are designated vital processes, on the right performance of which the well-being of the whole depends. I shall however have an opportunity of saying more upon this part of our subject when I come to consider the distinction between arterial and venous blood; at present, I would only observe that we must endeavour to bear in mind the true source of colour. For though we may, for the sake of convenience, speak of colouring matter as existing in the composition of things, yet we must remember that every object owes all its colour to the circumstance of its parts modifying the rays of light which fall upon it, and not to colour existing as an independent substance.

Such points as these, I am aware, are viewed by modern physiologists as of minor importance, in any investigation of the animal economy, and more particularly of the nature of the blood. This is evidently the case, if we judge from the general omission of them in ordinary descriptions of minute structures, and from the singular neglect of the possible sources of error to which such researches are constantly exposed. I must however insist, that so remarkable, and, at the same time, so constant a phenomenon as the red colour of the blood, demands most careful observation.

LECTURE III.

At the conclusion of my last Lecture, I remarked that the results of minute investigations of the globular portion of the blood, as recorded by microscopic observers, were very discordant. With regard also to the chemical composition or properties of these bodies, strange as it may appear, no definite or concurrent testimony is to be derived from the numerous authors who have made them the subject of investigation. They still, indeed, remain debateable ground; for the results obtained from a great number of experiments are so discordant, that they admit of no decisive conclusion.

Mr. Brande also has remarked, that there is much contradictory evidence in the chemical history of the blood-globules; and that all that can certainly be said respecting them is, "that they contain iron, a peculiar colouring principle, and a proteine compound very analogous to albumen."*

Liebig also, as quoted by Brande, observes "that

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* *Manual of Chemistry*, p. 1769.

the leading characteristic of the red globules is, that they contain a compound of iron found in no other constituent of the body, and that they have the power of combining with gases, as evidenced by the change of properties which they suffer when exposed to their action."*

The chief point, however, in which all agree, and which is to me at least most satisfactory, is the statement of Berzelius, "that there is no material difference between the chemical composition of these bodies and that of the other parts of the sanguineous volume."† Consequently, they consist of certain proportions of oxygen, hydrogen, carbon, and azote; whilst there is good reason for believing that the various salts before mentioned which form constituent parts of the serum enter also into the composition of the globule. The experiment of Berzelius consisted in his placing thin slices of the crassamentum on blotting paper to absorb as much of their moisture as possible. He then found after drying the substance thoroughly, that out of 400 grains of it submitted to incineration, there was a residuum of 5 grains of ashes.

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* *Manual of Chemistry*, p. 1769.

† *Medico-Chirurgical Transactions*, Vol. III., p. 212.

These ashes afforded the following analysis:—

Oxide of iron	50.
Sub-phosphate of iron . . .	7.5
Phosphate of lime, with a little magnesia . . .	6.0
Pure lime	20.0
Carbonic acid and loss . . .	16.5

Now the fibrine of the crassamentum is, as before stated, composed of oxygen, hydrogen, carbon, and azote; consequently these metallic and earthy salts belong rather to the globule.

Again, a 1000 parts of serum, according to Dr. Marcet, consist of

Water	900.
Albumen	86.8
Chloride of potassium and sodium .	6.6
Muco-extractive matter . .	.4
Subcarbonate of soda . . .	1.65
Sulphate of potass . . .	.35
Earthy phosphates . . .	.6

This statement coincides remarkably with that of Berzelius, with the exception, that he makes no mention whatever of a metallic salt; consequently the metallic and earthy ingredients pertain to the globule. And further, Berzelius has observed that these particles cannot materially

differ from the other parts of the blood except in their colour, and in the circumstance that a quantity of the red oxide of iron is found after combustion among their ashes.*

Chemists appear to have given their chief attention to the supposed envelope of the blood-globule, and have thus neglected to ascertain the composition of what they call the colourless nucleus. Mr. Bauer, however, and MM. Prevost and Dumas have made some interesting observations which render it probable that the colourless nucleus is in reality convertible into fibrine. But the testimony already adduced is sufficient to show that the globule itself contains precisely the same component parts or elements that are to be found in the albumen and fibrine. I must, however, here repeat my protest against the doctrine advanced by chemists that fibrine constitutes an element—much less a proximate element—of the blood.

A somewhat similar view of the effects of coagulation which renders the blood a different substance, and consequently does not indicate, as is commonly supposed, a mere resolution of

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* *Bostock's Elements of Physiology,* Vol. I., p. 459.

the fluid into its constituent parts, is to be found in an interesting paper by Dr. Benjamin Babington,* who states, "that if the blood be drawn in a full stream, from a person labouring under acute rheumatism, into a glass vessel, and filled to the brim, by close inspection, a colourless fluid will be immediately perceived around the edge of the surface, and after a rest of four or five minutes a bluish appearance will be observed, forming an upper layer on the blood, which is owing to the subsidence of the red particles to a certain distance below the surface, and the consequent existence of a clear liquor between the plane of the red particles and the eye. If a spoon moistened with water be now carefully immersed into the upper layer of liquid by a gentle depression of one border, a liquid may be collected quite free from red particles which will be found to be an opalescent and somewhat viscid solution perfectly homogeneous in appearance. This apparently homogeneous liquid, however, will after a time separate into two parts, viz. a clot of fibrine which takes the precise form of the vessel in which it was collected, and

* *Med. Chir. Trans.*, Vol. XVI., p. 293.

a clear serum possessing all the usual characters of that fluid." This liquid is evidently the coagulable lymph of Hewson and others.

After remarking that healthy blood is similar to blood disposed to form the inflammatory crust, with the only difference that the former coagulates more quickly than the latter, Dr. Babington infers from the above experiment, that the liquid so collected is a uniform homogeneous fluid, and no mere mixture of fibrine and serum; and further, from the same and other experiments, he believes that fibrine and serum do not in these forms exist in circulating blood, but that the fluid, which he designates the liquor sanguinis, when it is removed from the circulation, and is thus no longer under the influence of its original condition, has then —and not till then—the property of separating into fibrine and serum.

From such testimony, then, as well as from numerous other facts which it is unnecessary to adduce on this occasion, it is abundantly evident, that the component parts of the blood are arranged according to some definite and precise law, and not as a mere accidental mixture; that the sanguineous stream whilst circulating in its

native vessels possesses two distinct parts, the one fluid, the other globular. It is further evident that the globules are either colourless, or red, or yellowish, according to the degree of their aggregation; that whatever exists in the serum exists likewise in the globules; and lastly, that the globular part may be in the strict sense regarded as the blood—the fluid or the serous part supplying the materials for its formation, in the same manner as the chyle supplies the materials for the production of the serum.

The chemical properties and relations of the blood-globules are no less remarkable and curious than their composition. But these properties and relations are connected for the most part with the constituent elements themselves; consequently, they are not to be confounded with other extraordinary properties which are manifested by their means, as for example, their heat, their elasticity, their divisibility, their fluidity, and their vitality.

The globules exhibit the singular phenomenon of changing colour on exposure to certain gases. On being withdrawn from the veins, they first come forth of a dark and dingy hue, but they speedily assume a brighter and more florid

appearance, which is to be ascribed to their coming in contact with the oxygen of the atmosphere. Carbonic acid and azote, on the other hand, produce the contrary effect: they convert bright scarlet blood to a dark purple colour. In the living body, indeed, the blood is continually undergoing a change in its colour, which varies from a dark purple to a bright scarlet, or the reverse. When it is of a scarlet colour, it is, as is well-known, termed arterial blood, because it is found, with but one exception only, in the arteries: when, on the contrary, it is of a purple hue, it is designated venous, because it is then found, with but one exception only, in the veins. It is rendered arterial by being exposed to the air which is admitted into the lungs, that is to say, by the process of respiration. It would seem at this stage to attract oxygen from the atmosphere, and to throw off carbonic acid. It is rendered venous by being placed under the influence of various agencies at the extreme terminations of the arteries, as will be explained hereafter, as well as by an accumulation of carbonic acid in the system, according to the commonly received notion.

Great discrepancy exists also in regard to the

size of the blood-globules. They have been stated by some authors to be $\frac{1}{1700}$ of an inch in diameter, by others $\frac{1}{5000}$ and even $\frac{1}{6000}$. The general testimony, however, seems to assign them a mean diameter between these extremes. If I may be allowed to state my own conviction, I am inclined to believe that they differ in size, and that in a proportional manner, though it is doubtless almost impossible to assign them any strictly relative magnitude.

My reasons for entertaining this opinion will be given when I come to consider the capillary circulation. Before I dismiss the subject of the chemical composition of the blood, it may be useful to state the results of what has been termed the destructive distillation to which this fluid has been submitted. This mode of examination was most commonly resorted to by the earlier chemists, and its results differ but little from those of a more modern date. "When blood," as Dr. Thomson observes, "is dried by a gentle heat, water exhales from it retaining a very small quantity of animal matter in solution, and consequently having the odour of blood. If it be then introduced into a retort and distilled, there comes

over first a clear watery liquor, then carbonic acid gas and carbonate of ammonia, which crystalizes in the neck of the retort. After these products, there come over a fluid oil, carburretted hydrogen gas, and an oily substance of the consistence of butter. By the same process, and by increasing the heat, a light smoke is emitted which affects the eyes and nose, has the odour of prussic acid, and reddens blue vegetable colours. At a more advanced stage of the process, denser fumes arise, which on examination possess the properties of phosphoric acid. The residuum amounted to 180 grains; it had a deep black colour, and a metallic brilliancy, and its particles were attracted by the magnet."*

To do justice, however, to the philosophers of the last century, it must be confessed that but little more is known of the proximate elements of the blood at the present day than what the result of their enquiries affords us. And whilst some slight addition has been made to our knowledge on this subject, some important facts known to the physiologists of that period, have been brought forward by recent investigators as

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Thomson's System of Chemistry, Vol. IV., p. 390.

new discoveries. The illustrious men to whose labours I more especially refer, are Leeuwenhoek, Lancisi, Boerhaave, Gulielmus, Malpighi, Ruysch, and Heister.

Leeuwenhoek, for instance, speaks of the spontaneous formation of globules in serum that has been removed for some time from the body, and separated from the clot. This formation, as Sir E. Home informs us, was first seen and described by Mr. Bauer: its existence was afterwards confirmed by Professor Faraday. The doctrine again that the globules arranged themselves into right lines and formed fibres, was held by Leeuwenhoek; though it has been regarded as the result of recent observations in science.

Enough perhaps has been said to convince us that the facts which chemistry reveals are by no means sufficient to perfect our views on this important subject. To this end, it is indispensable that we should be acquainted, at the same time, with the structure and functions of all the organs and viscera of the body, with the principles of most of the physical sciences, as well as with those pathological facts which constitute our knowledge of disease. Nor is this all, for we ought likewise to keep in mind, the changes of condi-

tion which are induced on the body by numberless influences, both external and internal; for instance, by climate, the seasons, and the states of the weather; by food and medicine; or again, by the passions of the mind, according as these may be in an orderly, or a disorderly condition. In short, it is not too much to say that the whole circuit of science in its very widest range, its height and its depth, must be explored, in order to arrive at a more complete and satisfactory knowledge of this wonderful fluid—the blood.

Much indeed of the uncertainty which prevails respecting the true nature of the blood is to be ascribed to the very limited view that has been too often taken of its properties and modifications. This arises from the fact that the physiologist has devoted his attention to the phenomena which the blood presents when removed from the body, rather than to those which it exhibits when circulating as a warm, living, active fluid through the corporeal system.

I have thus endeavoured to show, as clearly as I could, that the blood, as a general principle, involves numerous particulars; or, in other words, that it is made up of various constituent parts,

which it derives from the world around us, especially from the mineral and vegetable kingdoms. And these parts admit not only of being so arranged and combined as to constitute this extraordinary fluid, but also of being further arranged and combined to an inconceivable and indefinite extent; so that, by these means, the whole bodily fabric, with all its diversity of organs, is continually produced, sustained and renewed.

Nor can the truth of this be questioned upon any rational ground; for it harmonizes with what may be termed an almost self-evident proposition, that nothing exists in the body which did not first exist in the blood. As a general principle then the blood may be regarded as the all in all of the body. Invested with this character it permeates and animates every part of the animal frame, for every part exists in subordination to it and is dependent upon it.

We often speak of the functions of the body, and of its various organs; but, let me ask, is there one function performed by any single organ of the body, that is not constantly dependent upon the blood for its very existence? Nay, is there a single sensation that is not equally indebted to

the same ubiquitous agency? Even the brain as the seat of perception and the very origin of motion cannot be excepted. What then, let me further ask, must be the nature of that relation existing between the blood and the body? and, by what terms can this relation be expressed? To these questions, I would venture to submit, no other intelligible answer can be given, than that by *virtue of the blood the body lives, and by living, acts: in other words, that the blood imparts to the body the ability to feel and to act.* The life of the body then, as consisting in the ability to feel and to act, I regard as distinct from the sensation and action themselves, and the mind will, upon a little reflection, readily perceive this distinction.

It is plain that what renders the body or any of its organs capable of sensation, must be the blood; for, without it, the body can neither feel nor act: nor again could any action whatever result, were there no organ adapted for its performance. And hence, in philosophical language, the relation between the blood and the body is that of a cause principal to a cause instrumental; the latter deriving all its efficiency from the presence and influence of the former. This is, in fact, the relation of subordination, to which I adverted at

the outset, as being the order by which the existence and preservation of the animal economy are secured. And here I hesitate not to avow my firm conviction, that the due recognition of this order is essentially necessary to enable us to discern that most important truth, that there is,—that there can be,—but ONE LIFE, which is, in reality, not only the original, but the perpetual source of all capability and power.

To illustrate this point, I will take some organ of the body: it is immaterial which organ is selected for the purpose, since the same doctrine is equally confirmed by them all. The brain then, as an assemblage of parts arranged into a wonderful form, and as performing functions essential to the well-being of the body, not only depends momentarily upon the blood, but also derives its origin and preservation from the same source. It performs all its functions precisely according to the soundness and perfection of its structure, by any modification of which these functions are necessarily affected. But let that structure be as unimpaired and perfect as it may, still the functions, which it is adapted to perform, cannot even exist without the agency of the blood. But, once introduce this efficient agency,

and the functions which the cerebral structure is intended to perform, are instantly in full activity. It is therefore evident that the power, by virtue of which the brain performs its functions, is perfectly distinct from its structure; for structure alone is inert, inefficient and powerless, deriving from the blood all its energy. From this consideration we can understand how it is that certain changes in the quality and condition of the blood affect the brain in a corresponding degree. The relation between the structure and the power is this, the power is essential and principal, the structure instrumental and efficient. It is however possible, that the distinction between the blood and the organ through which it circulates may be admitted, whilst the relation which we are endeavouring to establish between them is inverted. For instance, instead of the blood being regarded as that which is principal and essential, and the structure that which is instrumental and efficient, the very opposite arrangement may be adopted. And this is precisely the mode of reasoning employed by a large class of philosophers, who are not improperly designated Solidists; with them the structure is *primary*, and the blood *secondary*. Appearances, are doubt-

less, much in their favour; but appearances, we are taught by the highest authority, are frequently fallacious. The noblest mission of our intellectual powers is to detect fallacy and to banish it even from our most cherished theories. It is, we know, an appearance, that the sun revolves around our earth, and every view we take of the heavens favours the fallacious notion. The unfettered exercise of reason, despite the trammels of authority, detected this fallacy and banished the delusion, imparting as it were a new existence to the science of astronomy.

Again, appearances countenanced the idea that the blood was contained exclusively in the veins, and that the arteries conveyed nothing but air. This was the doctrine universally received down to so late a period as the seventeenth century (1628). It was founded on the appearance, that after death the arteries contain no blood, whilst the veins are full. And so strong, indeed, was the resistance made to the discovery which exposed the falsehood of this doctrine, that not one Doctor of Medicine who had then passed his fortieth year would renounce the error and embrace the truth.

The Solidists who, as I have said, regard the

organized body as primary and essential, and the blood as secondary and instrumental, are, it may be fearlessly asserted, deceived and misled by appearances. All the evidence, for instance, which they adduce in support of their doctrine, consists of mere appearances of truth, the fallacy of which it is the province of sound reason to detect.

Some of the leading facts with which we are acquainted concerning the relation which exists between the blood and the organized body, require due consideration in order that sound conclusions may be drawn from them. They may be stated as follows:—

1. There is nothing in the body which did not previously exist in the blood: *i. e.* every part of the body was originally fluid.

2. The first traces of organized animal matter from a fluid in the higher animals, are found in the form of brain, as the commencement of a nervous system: the next traces are found in the form of heart, as the foundation of a vascular system.

3. The nervous and vascular systems enjoy a kind of omnipresence in the body; since that which is truly a part of the body must have nerve and blood-vessel, as essential contributors to its structure.

4. No organ, or part of an organ, can, without the presence of the blood, perform its appropriate function, whether it be a function of sensation, of motion, of secretion, of excretion, or of absorption.

5. The materials composing the various secretions, such as the saliva, the gastric juice, the pancreatic fluid, and so forth, are derived from the blood.

6. These secretions minister to the formation and renewal of the blood.

7. The organs of digestion cannot, in their entire series, perform their functions without these secretions, the organs being instrumental in the process, whilst the secretions are principal; in the same manner, the organs of secretion are instrumental, and the blood, from whence the secretions are derived, is principal.

8. The digestive organs are not essential to the existence and formation of the blood; since, in the fœtus, the blood exists before the digestive organs are formed; and further, the digestive organs, in the perfect animal, are not the exclusive agents in the formation of blood, their functions referring, for the most part, to the conversion of the aliment into chyle.

9. The blood receives increase, not only from the digestion of suitable food, but also from the materials deposited in the form of fat, in various parts of the body. This adipose matter is absorbed according to the requirements of the system, and without the intervention of the digestive organs.

These facts then evidently indicate that the bodily organs are wholly derived from the blood; that they are formed to be subservient to it, and incessantly dependent upon it. They are moreover instrumental to its preservation and circulation; for, in all their functions, they bear a more or less direct relation to it. And further, these facts indicate that in the blood are contained the very means by which the animal is enabled to live. It is, I am aware, easy to impart a different colouring to one or to all of these prominent facts, and to deduce from them even opposite conclusions. It may be argued, for instance, that the fœtal blood, since it exists before the formation of the digestive organs, must owe its existence to the maternal placenta. But it is evident that such is not the case, for the fœtal side of the placenta is distinct from the maternal, and merely derives from it such matters as are

suited to the nature and requirements of the fœtus. Nor again, has any vessel ever been discovered connecting the two sides of the placenta, so as to countenance, in the smallest degree, the notion that the mother's blood is identical with that of the embryo. Again, with regard to the chick in the egg, it might be argued, that the white and the yolk, as materials from which the blood of the nascent animal is formed, were derived from the blood of the parent hen; and that therefore the organization, by which the white and the yolk were prepared, was essential and primary, not only in the production of these fluids, but also in that of the blood of the chick derived from them. But in contradistinction to the mere appearance, the fact is, that the impregnated egg differs essentially from the unimpregnated; and the difference consists in this, that the former is endowed with power to form blood out of the materials supplied for the purpose, but the latter is a mere assemblage of materials destitute of the formative faculty.

But, in reply to this, it may be urged, that the impregnating influence was derived from the male organization, and that, consequently, the

organization, in this case, must be essential and primary. And the appearance, at first sight, warrants the conclusion, but sound reason detects the fallacy by comparing the facts, and drawing from them sound conclusions. For, to return to our former position, the organization without the blood is powerless; it is inert, and motionless, and dead. Surely, then, it would be utterly at variance with sound reason to deny that that which communicates the power is, and must be, the essential and the primary in every action, operation, and use.

Again, although the organization without the blood is powerless, we shall find on the other hand, that the blood, without the organization, is not so. For the impregnating fluid which may be virtually and pre-eminently regarded as blood, inasmuch as it is the continuous agency in the production of blood, has within it an inherent power, forming, as it were, the starting point of a new creature. But I shall reserve this most interesting and important subject until I come to investigate the formative process of animal being. I would however observe, that the distinction for which I have been contending has not received that degree of attention to which it is most justly

entitled. The neglect would seem to have arisen from the too limited exercise of those wonderful powers of discrimination with which the human mind is endowed.

Anatomists have indeed well distinguished one kind of structure from another, describing the numerous differences with accuracy and precision. But with regard to the functions and uses of organic structure, especially of what may be termed the various elements of any entire organ, it can scarcely be said that the same amount of accurate discrimination is observable.

For the organic elements, by which are meant, the nerves, the arteries, the veins, the absorbents, the cellular tissue, and every thing else which enters into the structure of an organ, require distinct consideration, when we investigate the use of the organ to which they belong. So, likewise, should the differences between the organs themselves be duly attended to; for though the same organic elements enter into the structure of them all, yet no two organs are alike in form, quality, or use. Thus, arteries, veins, nerves, absorbents, cellular membrane, may be regarded as constituent elements of liver, kidney, spleen, pancreas, lungs, and many other organs. But there

is, it is evident, a very wide difference in these organs in regard to their forms, their qualities and use. This difference is evidently owing to a different arrangement and determination of the organic elements; and hence, before we can fully ascertain the uses of an organ, or their connexions with those of other organs, the origin of each component part or element, the relation in which it stands to the rest, and thence its comparative importance, are points which must be well considered and carefully distinguished.

And, as an example of what I mean, I will adduce the liver, which is connected with many other organs both contiguously and continuously. It is connected contiguously with the diaphragm, stomach, duodenum, colon, peritoneum, &c.; and continuously with all the abdominal viscera, by means of the peritoneum, by the vena portarum, by the sympathetic and pneumogastric nerves, and the absorbents. And again, the liver is connected continuously with the heart, by means of its arteries and veins; and, with the medulla spinalis and brain, by means of its nerves, besides other contiguous and continuous connexions which it would be tedious further to

enumerate. This then is the kind of discrimination which the anatomist and physiologist must employ, in order to obtain a clear insight into the functions and uses of any organ of the body, and thence into the nature of the animal economy. And it is this kind of discrimination which will eventually demonstrate the exact relation subsisting between the blood and the body, and its numerous organs. For the blood is a fluid, not of one nature, but of many; not unchangeably the same in quality; not a simple, uniform mixture of various parts and ingredients; not alike in all its unities, but amazingly diverse. And for these reasons it is that there are divers organs to perform divers uses, the use of each respectively having reference to some especial requirement of the blood. Thus the uses of the kidneys refer more especially to the conditions of the serous parts of the blood; those of the liver, to the conditions of the chyle and incipient blood; and those of the lungs, to the serum and globules; those of the brain to offices connected with still more intimate and higher conditions of the blood, and so on. These in short, ac-

cording to their several abilities, all contribute their respective shares of duty and use towards maintaining the healthy condition of the blood, so as to secure the higher characteristics of a living body, namely, sensation and volition. For it is in proportion to our knowledge of the relative uses of the various parts of the body, that we are enabled to perceive the great general principle to which they all ultimately refer, and to comprehend that high and unanimous purpose which they severally answer. Most natural also is it, to suppose that the numerous organs of the body should have respect to that source from which they derive their origin; that they should depend upon it as their common sustainer, and be subservient to it as their universal parent.

A still further advantage is to be derived from making a proper discrimination in viewing the functions of the several parts of the body, and especially those of every individual organ; for this advantage implies a knowledge both of the wonderful subordination of all the constituents, more or less universal, which form the whole animal fabric, as well as of their co-ordination into one harmonious system. The vascular system, for example,

relatively to the nervous, holds a subordinate rank; and hence, any change induced upon the latter is, of necessity, indicated by the former; for it is well known, that scarcely an emotion or a thought can exist in the mind, which is not instantly conveyed through the nerves, down to the vascular system. Here it affects in various ways the arterial pulse, and produces a thousand changes in the state of the blood-vessels, reddening the cheeks, and even the whole surface of the body, or, imparting to them the pale cold aspect of death.

We have another example in the muscular system, which is subordinate both to the nervous and the vascular; for a change of condition in either of these latter systems instantly produces a change in the activity of the muscular system. Certain affections of the nervous system, as is well known, paralyse the muscles, or produce tremblings, startings, and convulsions of various members of the body. By obstructions also in the circulation of the blood through any leading trunk to a limb, or, what is the same thing, by certain derangements of the vascular system, the muscles of the limbs are paralysed.

We have seen then that the body is the offspring of the blood; and further, that the body

is momentarily sustained and preserved by it. We have contemplated the blood as a general principle which pervades every part of the system, and consequently involves, in potency, all that is producible from it. For it may with truth be said, that it involves, in potency, the whole body and its divers organs, since we have seen that these are not only produced from it, but are also liable, as to the materials of which they are composed, to be again resolved into it. The blood thus exhibits a circulation which commences in fluidity, passes on to solidity, and returns again to fluidity. Now this, to some extent at least, harmonizes with an idea of the justly celebrated John Hunter. "It appears to me," he says, "to be evident that the blood's fluidity is only intended for its motion, and its motion is only to convey life and living materials to every part of the body. These materials when carried, become solid, so that solidity is the ultimate end of the blood as blood."* Such is the doctrine of John Hunter.

But the inference "that solidity is the ultimate end of the blood as blood" is by no means self-

* *Treatise on the Blood,* Vol. I. p. 161.

evident; far otherwise, for the very solids which come from it exist as organs and structures, whose operations all tend to preserve the blood in its due quantity, quality, and fluidity. Only take as an example the most solid parts of the body, the teeth, which are derived from the blood. But for what purpose? Is it not to grind and masticate the solid aliment, in order to render it more manageable under the solvent power of the salivary and gastric fluids? In other words, is it not to make more blood, subject as the blood is to a thousand causes of diminution and waste? Take, as another example, the entire body: by its members it can perform those movements which are necessary to procure food: by its digestive organs it can perform those processes by which that food is prepared to become blood: by its vascular system the blood circulates through every corner of the frame, animating all its organs, and enabling them to perform their respective functions. All this refers more or less directly to the preservation and renewal of the blood, and of its various properties; among which properties may be ranked, as of primary importance, its fluidity. The fluidity of the blood is of essential moment to the well-being of the animal frame to

preserve, for by this property the blood is not only adapted for motion, as Hunter has observed, but it is able to permeate and to quicken the finest textures of which the whole body is but as a tissue. If fluidity then is allowed to be a property of the blood, how can solidity be the ultimate end of the blood? especially when the solids themselves are during life unceasingly returning to a fluid state.

The solids, as they are called, are all organized tissues, they are not coagulations; for they are constantly moving, according to the determination of a formative force, and therefore give no real support to the notion, that "solidity is the ultimate end of the blood as blood."

Fluidity, indeed, is a most distinct property of the blood, destitute of which the blood can be regarded only as a mere clot—a condition which it assumes in consequence of the loss of some other property. And this property, as will be shown in what follows, is its vitality, from which, as we shall see, it derives its real nature and quality. To say that the blood has a tendency to solidify or coagulate, is like saying that it has a tendency to putrify—a tendency which can be predicated only of a dead

clot, but certainly not of living blood any more than of a living body! The tendencies of a living body are manifold and various, but they are not antagonistic to one another. Self-preservation is one of the innate characteristics of a living being, pervading all the departments of corporeal structure, in some of which it is manifested by their adaptation to purposes of defence; in others, to nourishment; in others again, to propagation, and thus to the multiplication of the species. The tendencies inherent in the blood, are to renew and to replenish its own volume, and, by thus perpetuating itself, to counteract the opposing powers of inactivity and death.

The functions of the bodily organs cannot be performed without the presence, or, more properly speaking, without the influence of the blood; in order then that the blood may flow into the most minute recesses of the organic structures, it must possess the property of fluidity in a pre-eminent degree, and the preservation of this property is essential to the very existence of the animal fabric, for without it the life of the body could not for an instant continue.

It appears, in fact, that one great purpose of the bodily organs is, as before observed, to

maintain the blood in a fluid state. It is by virtue of its fluidity that their very formation was rendered possible. And this formation requires that the blood should admit, as it hastens on, of ready separation into its unities, from its state of aggregation in the larger trunks and branches of the vascular system. By these means it is enabled to diffuse itself, in the most astonishing manner, and, to be exalted, as it were, into a higher and purer region, where all its properties may be still better manifested. I here allude to that condition of the blood by which it is capable of penetrating and animating the minutest recesses of the capillary system—that extensive region, where, as in so many secret chambers, all the animal processes are performed; where animal nature finds a sanctuary from the unhallowed gaze of man; where chemistry puts forth her subtile powers as so many subservient means; where, in fact, all the sciences as ready handmaids minister their abundant treasures.

An animal body may be regarded as a compages of capillary vessels, which are to the larger trunks from which they proceed, what the blood-globules are to the mass of the blood. If,

therefore, we consider the blood-globule as the unit, and the capillary tube as the simple organized element, we shall probably attain a more distinct and definite knowledge of them both, as well as of their mutual relation.

Now it has been shown by the most undeniable evidence, that the globule possesses the property of elasticity. By virtue of this property, it admits of many modifications, and at the same time preserves its tendency to recover its natural form and original condition, whenever the modifying causes are withdrawn. The contraction of the capillary tube which contains it, may, for instance, cause it to assume an elliptical form, elongating to three times its natural diameter. Still on the relaxation of the tube, it will recover its spherical shape. The conclusions deducible from this fact are the following:

1. The globule admits of as many modifications in its forms as can be calculated to occur in a body whilst passing from a spherical form to that of an oblate spheroid. The intermediate forms and measurements being indefinitely numerous, are not for that reason insignificant in amount, though they may be so in the estimation of a sceptical philosophy.

2. The *vis impressa* which one globule may receive from other contiguous globules, or from the containing vessel becomes an actuating force, and is transmitted unimpaired to the other globules and the containing vessel.

3. Hence the globule enjoys a perfect power of action and re-action, acting indeed precisely as it is acted upon, whether from an intrinsic or from an extrinsic force.

4. The source of its natural elasticity cannot be any thing extraneous to itself, such as the temperature of surrounding bodies, but must be something more constant and uniform in its influence; for the temperature of the blood is nearly uniform under all the vicissitudes of atmospheric temperature.

5. Not only elasticity of a peculiar kind belongs to the blood-globule, but also divisibility. But on this point more will be said when I come to treat of the nervous system as distinguished from the capillary.

6. The blood-globule in exhibiting such elasticity, exhibits also changes of condition, as well as of form; and these changes produced by innumerable causes, both internal and external, whether compatible with health or otherwise,

affect its compressibility, its temperature, its mobility, and its composition.

It may nevertheless be premised, that the blood-globule enjoys a property of divisibility, or of separation into its constituent parts: so that under a new dimension, and in a higher and more refined condition, it is adapted to display corresponding qualities and powers indefinitely more active and perfect; and this condition is a necessary consequence of the removal of those hindrances which obstruct pure elasticity, such as composition and aggregation, these being the essentials of inertia and therefore antagonistic to motion.

The capillary tube then, and the blood-globule, would thus appear to possess reciprocal relations, one being formed for and existing by the other; and hence it is, that they manifest in common, the properties of elasticity, divisibility, and the like; and that from their joint operation, all the functions and uses of every organ are derived, seeing that no vital phenomenon whatever results from the one separate from the other. Their chemical composition also is remarkably similar. But several other steps must

be established before we can arrive in an orderly, safe, and legitimate manner, at the source from whence the various properties of the blood descend. For this purpose, certain points of a general nature must be submitted to rational and dispassionate consideration; under this condition, however, that facts alone—and those of the most indisputable kind—are to sanction and confirm our conclusions.

Now the ingredients which form this fluid, and are discoverable by the chemist, are for the most part common to the serum, the chyle, and the aliment; in short, to the animal, the vegetable, and even the mineral kingdom, including the atmosphere around us. But a knowledge of the materials alone of which any substance consists, affords but little aid in the discovery of its organization, its properties, and functions.

The chemical constitution of the blood, the relative proportions of its ingredients, with even the nature of their combination, might be most perfectly known; but the mere fact that the blood is fitted to supply materials for the construction of the body, would be all that could be deduced from it. The elasticity of the globules, or the fluidity of the blood, would not follow as

a consequence from such knowledge, much less should we be able to arrive at the causes of these phenomena. The observations therefore of the mere chemist upon the blood, if they are confined to the materials of which it consists, may be received as important authority; but into the properties of the blood they afford us no insight. As an illustration of this position, I would adduce the wonderful properties of the salivary fluids, which include the gastric, pancreatic, and biliary secretions. Many of these are well known to the physiologist, but who can affirm that this knowledge was revealed by chemistry? Chemistry has indeed detected their component parts, but it could not discover their specific qualities or properties. We might indeed as well hope to ascertain the attributes of a gland, or the functions of the brain, by a chemical analysis of the organ, as to arrive at the properties of the blood by similar means.

Our knowledge of every subject commences in that which is most general and indistinct; it is perfected by a comprehension of all the particulars which the subject involves. It is in this way alone that we can be said to enjoy an intimate knowledge of any subject whatever. Every sub-

ject therefore that engages the attention of man, undergoes this truly analytic process. But the subject which has invited the attention of philosophers in all ages, and which indeed, by reason of its universality, has relation to every other upon which the mind can be engaged, is matter. But still if we enquire of the most enlightened among them, if we enquire of them all collectively, what matter is, no definite answer will be given. For it is a question that never can be definitely answered; and the reason is, that the modes, the qualities, the powers, and the forms of matter, are indefinite in number, in variety, and in degree. The subject is thus, as it were, an ocean without a shore or limit, immeasurable as the universe, and unsearchable as its origin. And yet, with regard to it, certain truths are universally admitted, which serve as a basis for the mind to rest upon, and from which all its operations may proceed. The chief of these are, that matter is endowed with inertia; and that it exists under some form or modification.

From these most general and fundamental truths, it may at once be seen that matter does not originate motion; that the forms and properties, and modifications of matter, innumera-

ble and diversified as they are, do not owe their existence to matter, which is of itself altogether passive, but that the conatus by which matter is moved, bestows upon it not only its forms, but also the other qualities and attributes which are predicated of it. For we can only conceive of matter as existing under some form, and if it is not contemplated in this way, it is an abstract nonentity—an airy nothing! Its forms are, however, indefinite in number and variety, so also are its modes of existence with respect to the degrees of its perfection, and its corresponding qualities and attributes. The air, for example, is one mode in which matter exists, exhibiting astonishing phenomena, the perfection of which, relatively to many others, may be said to be transcendent.

These general observations upon the term matter have been advanced as preliminary to the reasoning which I am about to pursue, in order to attain a more rational and intimate knowledge of the blood—that fluid which not only has so many material elements entering into its composition, but which also exists as a form of matter capable of sustaining animal life.

Now to produce the fluid which is denomi-

nated blood, the materials composing it must be arranged in a certain determinate order and relation. For in the first place, the blood must be regarded as a fluid *sui generis*. It is not a mere natural result of the simple blending together of its elementary ingredients, but it owes its existence to the influence of some power which arranges these ingredients into a globular form, imparting to it all the properties which are assignable to it. Its component elements moreover form many other substances in nature, in each of which they exist in various proportions; but they cannot themselves determine in what proportion they must in each case combine in order to produce the appropriate results. In other words, they possess no inherent power to alter their own nature in the least particular; for, being entirely passive, their combinations necessarily imply the existence of a power by which that proportion is regulated; and further, the properties produced indicate that the same power determines also the form on which those properties depend. For, as has been before observed, properties, qualities, and all other attributes, are predicable only of a subject in which, as in their appropriate form, they reside.

In affirming therefore that the materials composing the blood require to be arranged in a certain determinate order and relation, we assert no more than what may be said of any other substance in nature; but it is not the less certain that the determining power in the two cases differs both in kind and degree. In the one there is what may be termed a natural order—such as obtains throughout the universe of nature—which it is the province of science to unfold, and of philosophy to comprehend within definite rules and axioms. In the other there is a power implying knowledge which human philosophy can scarcely dare to essay; for there is no arcanum or law, no phenomenon or accident, no substance or form, no quality or condition, existing in nature, but this power—cognizant of them and prepared for them—invariably adapts itself to their requirements. What then can such a power be considered but a vital or formative force, embracing all natural philosophy, and penetrating all physical science?

LECTURE IV.

It must be borne in mind that the subject of these Lectures is Materia Medica and its relations to the animal economy. To discern with clearness and satisfaction the nature and ends of these relations, I have ventured to investigate the animal economy in the first place, and to trace the outlines of the structure of animal being in general.

This investigation unfolds the order of subordination which prevails in the animal economy throughout, and is most apparent in the dependence of every animal body upon its blood, since nothing exists in the body which did not first exist in the blood. This fluid therefore admits of being viewed in the light of a general principle, for it comprehends within itself all the particulars which can serve to produce and maintain the body, and is on this account every where present in it. With a view then to a more complete understanding of the animal economy, and of those things which have relation to it, the

blood becomes the subject of a more special investigation, in which, in order to ascertain its real nature and properties, the method of analysis upon physical and philosophical grounds can alone be pursued with any prospect of success.

In my first Lecture I explained the plan upon which it was necessary to proceed, in order to arrive at a more intimate knowledge of this most wonderful fluid, enumerating several requisites for making the investigation full and complete. I observed that it was not enough to be acquainted with a multitude of particular facts relative to one department of knowledge, but that we should be familiar also with the general elements of many of the sciences. We must further discipline the mind to that kind of abstract or philosophical reasoning, which consists in accurately distinguishing between cause and effect, and in clearly perceiving the relation which subsists between a substance and the power which it is the medium of manifesting.

From the fact that all the solids and fluids of the body are derived from the blood, I observed that the blood in this respect may be regarded as the life and sustainer of the body; that the state and condition of animal life depend upon

the nature, constitution, determination, continuity, and quantity of the blood; and that the arteries and veins which, for the most part, make up the entire body, are to be considered as its especial development.

The chemical composition of this fluid was given in a general manner, for the sake of showing that it is a complex of many things existing in nature, and that on this account it may be regarded as the seminary and storehouse of whatever exists in the body. And I am happy to find that this view is confirmed by the illustrious Liebig; for, in the words of that eminently philosophic Chemist, "Physiology teaches that "all parts of the body were originally blood; or "that at least they were brought to the growing "organs by means of this fluid."*

The second Lecture consisted, in a great measure, of details respecting the chemical composition of the blood; the changes it undergoes when withdrawn from its native vessels; and the various circumstances which tend to accelerate or to modify and counteract its spontaneous coagulation. I quoted the opinions of

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* *Animal Chemistry*, p. 8

several very eminent authors with regard to its composition and colour, enumerating the discordant statements which exist concerning the size, form, origin, and use of the red globules. From the details then given, I ventured to remark, that the experience afforded us by one department of science—Chemistry for example—is not sufficient to perfect our knowledge of the blood, but that we should be acquainted with all the vessels through which it circulates, including all the organs and viscera, their functions and uses, and more especially with the pathological facts resulting from disease, or other disturbing influences. It is moreover equally important to keep in view the changes of state to which the body is subject from numberless causes both external and internal, such as climate, season, weather, food, and medicine, as well as from the passions of the mind, which may be either in an orderly or a disorderly condition. In short, the circuit of science in its widest range, its height and its depth, must be explored, in order to arrive at a complete knowledge of this extraordinary fluid; and hence we may readily perceive why so much comparative ignorance and positive uncertainty prevail respecting its true nature.

I concluded my last Lecture with some preliminary observations upon the fluidity of the blood, as one of its leading and most important properties. I had previously remarked that on the maintenance and preservation of this property, the very existence of the animal fabric and the manifestation of the powers of the animal economy depend, since without it animal life could not for an instant continue; and that one great purpose of the bodily organs is to maintain the blood in a fluid state. I further observed, that it is by virtue of this fluidity, that the formation of these organs is rendered possible; and that it could not be effected without a ready separation of the blood into its unities, as it hastens on from a state of aggregation in the larger trunks and branches of the vascular system, to the region of the most minute capillaries. For in this region, all the animal processes, whether of secretion, or of excretion, of growth and repair, of absorption and change, are momentarily performed. It is here, as I then observed, that animal nature retreats, as it were, from the searching gaze of man; that a chemistry unseen and inimitable puts forth her most secret powers, as so many

subservient agencies; and that the sciences, as her ready handmaids, minister their abundant treasures.

The source of the fluidity of the blood is an interesting point of enquiry; for, as this property existed antecedently to any solid bodily atom, whether denominated cytoblast, germ-cell, fibre, or even capillary vessel, it was independent of any such formation; nevertheless, the preservation of this property is derived from auxiliary powers, which are supplied by the simple organ formed from the blood. In this respect the auxiliary power is re-agent, and must be viewed as the secondary cause of all the subsequent stages of formation. If indeed it is viewed as the primary cause, when in truth it is but the secondary, it is only the determination and development, but cannot be regarded as the determining power or developing principle itself. This principle is in the blood, of which it is the all in all; and it is this principle which renders the material constituents of that fluid—whether these are saline, gaseous, or earthy—blood; it is this principle which imparts to it fluidity, and indeed all the other properties which in their complex make up its nature. It is moreover,

this principle which determines the direction of the formative power, and accompanies the forming process through every stage of development, regulating the quantity as well as the quality of every requisite, in order to bring its own designs and purposes to visible manifestation and full maturity. Whether then, cytoblast, or germ-cell, or nerve, or capillary vessel, be primary in organization from a fluid, the increase and multiplication of these, it is evident, are but products from a fluid. They are also instrumental in maintaining this fluid state; and not only so, but they assist in preparing materials for the further production of blood, whilst they are also designed and determined for other purposes, which are again subordinate to a prior intention and power.

But our argument at this time must bear more especially upon certain auxiliary powers, which preserve the fluidity of the blood. Now these powers exist essentially in the animal system itself, and are not exclusively derived from outward nature; for although water is found in very large proportion in the sanguineous volume, yet it does not prevent the blood from coagulating when withdrawn from the body, nor does the heat of the surrounding atmosphere.

The auxiliary powers which are in operation to maintain the fluidity of the blood, are circulation, respiration, and nervous influence. Of these, the nervous influence would appear to be the first in order, and the highest in universality, although it is the last that can be introduced on the ground of experience. Circulation and its organs commence visibly with organization, a fluid existing first and perceptibly flowing in a circle, the current, direction, and determination of which are exactly according to the nature of the determining cause, which is manifested by the organ or body resulting from the forming power. And as the fluid circulates, it is provided with means more and more ample for maintaining its own fluid condition, its circulation, commencing and terminating in vessels of exceeding tenuity and subtilty. These vessels gradually enlarge, till they become channels of supply to the whole capillary system, which is continued from them to the complete formation of the entire body. The blood during all this process continues its circuit, alternately aggregating to a larger volume, and separating again to the unities from which it sprung. The circulation of the blood contributes to this end, which is indeed one of its many purposes, whilst the

pulse of the circulation, which is continually emitted from the heart, also effects a similar purpose. Hence it is as if the heart with its pulsation was present at every point of the body, whithersoever artery can take it, its every throb communicating to the whole vascular field its own life and action. The part thus beats with the whole, and the whole with the part, each unit of the blood prêserving its own action, both severally and conjointly with the rest, and in this manner is the primitive fluid property maintained. All this is consonant with the statements of Leeuwenhoek and other authors, who state that they have seen blood in its course through the most minute parts of the small vessels of a fish's tail, agitated to such a degree as almost to surpass belief.

Mr. Baker says that he could "plainly perceive the blood stopping, and, as it were, receding a little at each dilatation of the heart, and then immediately running forward again at each contraction, whilst, in the veins, it rolled on in a continued current with inexpressible rapidity."* How perfect a contrivance then is this subdivision

* *Baker on the Microscope*, ut supra.

of the blood-vessels, down to the minutest capillary structures, for effecting a corresponding division of the blood? For it must be remembered that the greatest circulation is in the region of the smallest vessels, where animal nature celebrates her most active sports, and where collectively the blood abounds in greater quantity than in the trunks.

I must advert in the next place to nervous influence as an auxiliary power for maintaining the fluidity of the blood. The capillary system of vessels, it is well known, is most immediately and remarkably influenced by the varying states of the brain and nerves, and especially of the mind and feelings. These states affect the circulation in various ways, either stimulating it to increased action, or depressing it to apathetic languor. When, however, the depressing influences are at work, they become a fruitful source both of disorder and disease, and a condition of the blood opposed to fluidity is the more probable consequence. This condition reacts again on the brain; for from changes induced on the blood results are produced, which can affect the very sphere of thought. But in healthy states of the mind the influence of the nerves upon the ca-

pillary system of vessels, and, through them, upon the blood, is highly conducive to the health of the body also. This is effected by the maintenance of a natural and constant reduction of the blood to its unities, and its consequent fluidity in the capillary vessels; for, in proportion as this proceeds, the depending processes of secretion and excretion, of nourishment and purification, are preserved in their due and uninterrupted course. It is therefore incumbent upon the Physician to look to the mental condition of his patient, and to take an interest in its due adjustment, in order that he may impart hopes of recovery, and thus employ the resources of Materia Medica under circumstances more favourable to success.

But before I proceed to investigate the remaining auxiliary power which is in operation to maintain the fluidity of the blood, I would solicit your attention to some general observations by way of introduction. This is the more necessary, since the subject will be presented to your consideration under a novel aspect, and with reference to certain movements that play a most important part in the great theatre of nature, and are evidently subservient to the economy of animal life.

The subject to which I refer is Respiration—a subject highly interesting for the contemplation both of the philosopher and the physiologist, one point of its interest being, that, as a function of animal life, it is strikingly different from the functions which we have already considered. For these latter functions indeed are, in their nature, instinctive, and impart a capability of consciousness as distinguished from the faculties which spring from it. For instance, it is from instinctive action that the blood is formed; that the organic fabrics are derived from the blood; that the blood circulates through these fabrics; that the vessels of every order, *i. e.*, nerves, arteries, veins, absorbents, ducts, pores, and areolar tissue, are media for conducting this remarkable fluid through all its varying conditions to its most numerous and important purposes. It is from instinctive actions and operations that these results jointly constitute an animal fabric, and harmoniously conspire to impart and maintain the capability of consciousness, and with it, volition and sensation, as its joint and indivisible expression. For may it not be said that consciousness implies a sense of ability to will, as well as to think—thus embracing the powers of volition and intellect?

The instinctive functions again are the basis upon which the willing and knowing faculties momentarily depend, and are, therefore, independent in their degree relatively to the faculties dependent upon them; they also present phenomena which indicate most clearly a power to modify even the ordinary laws of nature, as well as an antecedent knowledge of these laws, and a preparation for their reception. In proof of the validity of this position, we may adduce the fact that every organ, whether of sense or motion, in the animal body, is prepared for its especial use before that use is brought into operation. Thus, for example, in the formation of the eye there is evidently an antecedent knowledge of all the laws of optical science, and a special reference to them. In the formation of the ear, again, we observe a distinct reference to the laws of acoustics, and similarly in every other organ of sense. The muscles, also, are formed with reference to the movements they have afterwards to accomplish; the heart, the arteries, and the veins, with reference to the laws and principles of hydraulics, and of other forces and motions; the brain, to the marvellous operations and powers upon which memory, imagination, reason, thought, and will depend. In short,

with regard to man, it may with truth be said, that he is a temple not made with hands, erected by Power Supreme, through the medium of an instinctive agency, to which, from the poverty of language, we cannot perhaps assign a more appropriate appellation than that of a formative force.

The same assertion indeed, though in a lower sense, may be made of every living thing, from the mammalia to the zoophyte, including even the cell race. In all these, however, the life exhibited is entirely instinctive and comparatively unerring, the wisdom of the structure being as great in the insect as it is in the elephant. The power which pertains to these forms of being is limited and unprogressive; in their successive generations ages produce no change; no faculty of comparison, or capability of reflexion is assigned to them. In man, on the contrary, the formative force produces a work, the completeness and perfection of which consist in its unlimited capability, and in the endless variety of its unfettered determinations. In both cases the blood, or the fluid under this denomination, is the agent by which the whole is effected. The world of nature supplies its substances to produce

the blood, and at the same time, by means of its active forces, influences it and all that is formed from it. This is strikingly evinced by the atmosphere, which, in the great process of respiration, not only supplies to the blood aerial nutriment, or its oxygen gas, but likewise presses upon the lungs with an amount of force sufficient to expand the innumerable air-cells of which they consist. By this expansion, the unities of the air and the blood are, so to speak, brought into juxta-position, for the more ready absorption of nutrition on the one hand, and the more complete expulsion of impurities on the other, the blood being thus prepared for a fresh round of uses in its great circuit throughout the body. In the lungs, therefore, the blood finds means to get rid of its carbonaceous, darkening, and thickening impurities, and to obtain renewed draughts of a heat-sustaining element, which imparts to it a genial warmth and a glowing colour, and enables it to permeate the minutest recesses of the system.

Nor is this the only mode by which respiration serves to maintain the fluidity of the blood; for we must bear in mind, that the air passes in and out of the lungs, along the air tubes and through

the innumerable cells, which may with propriety be called lungs of less dimension. In this operation, the air impinges on every point of the vast superficial expanse, producing on the walls of the cells a tremor or vibration, which is communicated in every direction to the continuous membranes and structures, and under all its varying modifications, admits of being accurately measured by the stethoscope. This tremor or vibration extends doubtless along every artery and vein, and through every membrane, sheath, and bone, although it is imperceptible to the ear, even when assisted by the stethoscope. It is the same with the pulse, which we perceive only in the larger arteries; but, by the aid of the microscope, we can discern its play in the minutest arterial capillaries. Now this tremor, it is evident, is not only imparted to the blood flowing in the pulmonary arteries and veins, and in all their minute capillary subdivisions, which are situate in and around the air-cells, but it is also thence transmitted to all the circumjacent regions, and even to the most remote parts of the body; so that the influence of the respiration pervades in this manner every globule of blood, at every point in the circulation. This tremor operates to keep

the blood in its state of eminent fluidity, and to facilitate its circulation and transit through all the minute recesses of the frame. But further, it cannot be denied that each globule also partakes of this tremor in its own little sphere, and derives from it a use which is appreciable only by a philosophy which descends to minute particulars, in order that it may attain a more intimate knowledge of the subject under investigation. For the knowledge of a subject implies a knowledge of the uses which the subject is designed to perform; and the only way to attain such intimate knowledge is to study its parts and unities.

If, for instance, we would know intimately the properties of the atmosphere, it is not enough that we are acquainted with the facts that its entire volume embraces and envelopes the earth, that it presses with a force according to the height of its column, that its pressure is equal in all directions upon every surface alike at similar altitudes, that it carries bodies lighter than itself, that its motions may be destructive whirlwinds, or soothing breezes. We must also know that it is charged with vapour and effluvia salubrious and noxious; that its temperature and

density, and sharpness, as well as its softness, vary indefinitely, all which conditions are so many accidents pertaining to it. We must more especially understand the nature of its individual parts or unities, or, chemically speaking, its atoms; for in this way only can we arrive at an intimate knowledge of its real and intrinsic properties as that compound substance, which manifests such important affinities and influences, and is the source of changes innumerable. For what wonderful results spring both from its oxygenous and its azotic elements, supporting combustion, promoting decomposition, or producing renewal —thus both nourishing and exhausting the vegetable world—in all which operations it ministers pre-eminently to the animal kingdom, and especially to the function of respiration!

In like manner, in regard to the blood, it is not enough that we are conversant with the accidents of its existence; that it provides for itself a course of circulation from the heart as a centre, going forth by the arteries and returning by the veins, so that the inertia of its materials is overcome by its passage through vessels of increasing subtilty, till they become commensurate with the globular atoms. It is not enough to know that

this fluid is determined and subdetermined to the multifarious bodily organs, through the ministration of which it rids itself of injurious matter resulting from impaired digestion or from unwholesome food; from worn-out structure, or from depraved humours; from saline substances no longer serviceable, from sharp acids, from the urea of the gouty invalid, or from the bilious, urinous, and vapid elements which liver, kidney, and skin have respectively to reject. It is not enough to be acquainted with its accidents of waste, of deterioration, of want of equable distribution, and of tranquil circulation; its liability to hæmorrhagic effusion and loss, to plethora, to serous exudation, producing dropsy in its several forms of anasarca, ascites, hydro-thorax, &c.; to diabetic, albuminous, and mucous discharges; or, to be vitiated by miasmata, by animal and vegetable poisons, and by infectious and contagious emanations—not to mention numerous other accidents which make up the great catalogue of bodily suffering. But we must more especially study, examine, and analyse its unities and component parts, even to its minutest atoms or globules, in which its properties and real nature reside, and in which its heat, its elasticity, its

vitality, and its chemical action, are especially developed. A familiar illustration of my meaning is supplied by the relations of the blood to the atmosphere, to which I have before adverted, and to which may be added the manifest benefit that not unfrequently accrues to the animal economy from the changes produced by air and climate. For the air we breathe may be considered as materia medica in an eminent sense, and as highly conducive to health. It is however to be feared that this source of health is monopolized too frequently by a class of men who insist upon vapour baths, water drenching, and wet sheets, as if they were the safest measures, instead of being, as they too often are, the most pernicious. For that these are hazardous measures at the best, and have proved in many positively injurious, I can testify from my own personal knowledge and experience.

I have adverted to the respiratory vibration which the stethoscope is employed to measure, and by means of which we ascertain the true state of the lungs; and I adduced it as the result of one of those natural forces which play an important part in the animal economy. I have observed that the force of the pressure of

the air operates upon the lungs, causing tremor or vibration. This effect is, as I remarked, obviously beneficial; and results from a species of motion which is observable in every substance in nature, and which receives a denomination according to the medium of its manifestation. Thus, for example, this species of motion in solid media is called oscillation, tremor, and vibration; in fluids it is called undulation; in the air, modulation; in ether, modification; in living beings, sensation, animation, and imagination. Modification, however, is the term that expresses all these varieties of the same species of motion; as, for instance, in the living body, the pulsations of the heart produce a modification or undulation of the blood; for a wave goes forth from the heart along the arteries down to their minutest divisions, and this with greater speed than the blood circulates. It is this wave that constitutes the pulse. The movement also, or animation of the brain—cerebral influence, as it is termed—produces, it is reasonable to conclude, a similar modification of the nerves, and of the fluid circulating in them. The respiration of the lungs is in reality a modification proceeding

along the continuous structures down to their remotest terminations. Thus these three sources of motion—the heart, the brain, and the lungs—unitedly contribute in an animal being to maintain the life of the body, or, in other words, to preserve the motion, the fluidity, and the heat of the blood; they are therefore three vital actions, which derive all their efficiency from the species of motion called modification. Even the five senses owe their existence to this species of motion, for they respectively take all their impressions from it. Thus the sense of touch is modified by the contact of bodies with the skin as the organ of touch; the eye is modified by the images that are conveyed to it by the rays of light; the ear is modified by the sound which enters in through the medium of the air, and so on. But let the blood cease to circulate through these organs of the senses, and they at once cease to be modified; no wonder then that such careful provision is made for the preservation of its fluidity—that property upon which its healthy circulation depends.

But this species of motion, whether expressed by the term modification or undulation, requires still further notice; for it comprehends the laws

of optics, music, physics, and physiology. It is excited by the action of distended membranes and sonorous bodies, and then transferred into the air; it is excited by subtle exhalations, and then transferred into the æther; it is excited by any substance thrown into water, and transferred to the rest of this element; it is excited by fluids, and from them again transferred into coherent and solid substances, in the same manner as it is conveyed by the tone of one string through certain media to other concordant strings, and from the ear to the internal organs of hearing and sight. It differs in the facility of its transfer, according to the density or elasticity, or the amount of vis inertiæ in the media through which it passes. It reverberates between numberless points, so that it is possible for it at the same moment to occupy a part of any circumference, of any radius, any centre—nay, and of infinite particular modifications, can, as so many units, ratios, or harmonies. form one common modification. There is in fact nothing in all nature more wonderful than undulation—nothing which includes a greater multiplicity of laws—nothing which is more worthy of our consideration, or of more im-

portance in physical and physiological studies. It is the one great subject which demands our special attention in the science of the animal economy, and to attempt to expound this science without any knowledge of this species of motion, is like attempting to explain geometry without lines and figures, or the art of navigation without the use of the rudder and compass. The whole animal organism indeed appears to be formed in accordance with this undulatory or modificatory motion. Much more remains to be considered in reference to this all-important subject, but it is unnecessary to say more upon it at present, than to repeat that it is exhibited in all the organic structures; that the organs of the five senses declare its action; that the membranes, tunics, and cellular tissues are incessantly influenced by it; that the arteries are formed in conformity with its laws, as exactly as the eye and the ear are respectively adapted to the laws of optics and acoustics; that the nerves, again, manifest it preeminently; and, that as the arteries are formed with reference to the undulation or modification to which the blood is subjected, so the nerves are formed in exact adaptation to the numerous modifications of the fluid which

traverses them. On the strength of these data with regard to the phenomena of this species of motion, I hesitate not to assert the existence of a fluid, which is to the nerves precisely what the blood is to the arteries; and I am gratified beyond measure by the observations and general testimony supplied by Dr. Carpenter,* to the science of the animal economy in reference to the tubular structure of the nerves, and the vesicular structure of the cortical or cineritious substance of the brain. It is of no consequence that the microscope presents no fluid in the tubes to our view, for these tubes doubtless resemble the arteries, which, after death, contain no blood,—a fact which misled the medical and physiological world for so many ages, until our immortal Harvey appeared to rectify the erroneous conclusions that were drawn from it. Would that this were a solitary instance of the pernicious consequences resulting to physiological science by drawing conclusions respecting living forms and their actions, from appearances that are to be found only on the dissecting table! Dead bodies innumerable are explored, and dead

* See Dr. Carpenter's *Principles of Human Physiology*.

structures submitted to the microscope, with the too common result of magnifying error as well as the distortions arising from disease and death—and this more especially in tissues the most delicate, and subject to change from even the slightest causes. Generations of most skilful anatomists, who were acquainted with almost every nerve and blood vessel in the body, but knew nothing of the circulation of the blood, were necessarily liable to error. And so it is in all times, and in all professions, our facts, as well as our theories, need revision and correction. I would not derogate one jot from the value of anatomical knowledge, but would rather see it prosecuted to its utmost extent, and I would require of every candidate for any position in our noble profession—whether of Physician or Surgeon—a proficiency in that science, which, whilst it makes him equal with his brethren, affords him a groundwork for a philosophy that true wisdom sanctions, and enlightened faith makes sacred.

LECTURE V.

The observations which I shall submit to your attention in this Lecture, are partly an extension of the views which I ventured to present to you in my last on the fluidity of the blood, and the causes, both essential and auxiliary, by which it is produced and preserved.

The essential cause, I alleged, is involved in the blood itself, as a vital force or principle, which imparts to it all its characteristic properties; the auxiliary causes, on the other hand, pertain to the three vital organs—the brain, the heart, and the lungs—as instrumental in its preservation. The modifications, again, which the organs of sense receive, are carried upward with equal accuracy to the sentient sphere in the brain, ascending from skin to cortex—the two extremes of the term—where the sensation is received with pleasure or with pain.

I observed that the celebrated Boerhaave, with many other distinguished men, recognised the existence of a nervous fluid; and it is but

just to that eminent man that I should submit to you his luminous observations on the subject.

"Whoever" says he, "considers the fact, that the medullary fibres most distinctly arise from the cortical part of the brain; the similarity of this apparatus with that of every other part of the body; the vast quantity of the finest, purest, and most mobile arterial blood, undespoiled of its subtlest part, that is drivèn hither with great force by the neighbouring heart; the exquisitely fine fluid that is everywhere discoverable by the unassisted senses of touch and sight, and more particularly by the aid of the miscroscope, within the medullary substance itself when dissected, and which fluid is oftentimes much increased in serious affections of the brain; whoever considers the veins returning the blood from the pia mater, and from the cortex of the cerebrum and cerebellum into the venous sinuses, and so through the jugular veins to the heart; the constant, regular, and proportional growth, nutrition, generation, and reparation of the stamina of this part, from the beginning to the end of life—whoever considers these various circumstances must conclude, that the medullary fibres

are delicate pervious canals, which receive the most subtle of all the fluids of the human body, a fluid which is prepared, secreted, and driven into these pipes, by the wonderful mechanism of the cortex, and so collected from every point into the medulla oblongata."*

And again he says, "Whoever will consider the character of the blood that is driven thither by the carotid and vertebral arteries, and how much it differs from all the rest of the blood; the exquisitely subtle structure of the little arteries arising from the carotids and vertebrals vanishing in a manner into a downy halitus, and as it were melting away spontaneously by reason of their softness, and by an inscrutable implication and contexture forming the substance of the cortex; the singular nature of this humor, which, contained in these canals, exhales with the greatest rapidity of its own accord, and is not coagulable by heat, but evaporates entirely, while all the other humors of the body either harden by heat, or leave behind them a considerable residuum; the force and celerity again which a careful observation of the effects dis-

* *Inst. Med.*, n. 274—275.

played in the nerves and muscles shew to exist in this fluid—whoever will consider these points, will have no difficulty in believing that the component parts of the fluid are the most fine, moveable, simple, of all the humours of the human body:" and he adds, "it is clearly evident, that the parts of this most subtle humour must be conceived to be immensely minute beyond what is commonly thought."* So far the celebrated Boerhaave, who in this manner contended for the existence of a nervous fluid; and why there should be among physiologists of the present day, so great an indifference to a subject of such vital importance in the animal economy, is to me quite inexplicable. But the admission of the tubular structure of the nerves will go a great way to establish the soundness of Boerhaave's views, and to promote a better understanding of the modes in which sensation and volition, and other functions of the brain are performed.

I shall now, with your permission, follow the course of the blood into a higher region of the animal economy; more especially as I have claimed for it, as one of its essential properties,

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* *Inst. Med.*, No. 276.

that pre-eminent fluidity, by means of which it is enabled to penetrate the most subtle organic capillary vessels that pervade the entire body, and constitute one of the chief elements of every organ.

The higher region to which I must accompany it is the brain. I have already adverted, though but slightly, to its circulation through the lungs and the rest of the body, for the sake of illustrating the nature of its fluidity, and of ascertaining to what cause this remarkable property owes its existence. We have seen that every organ, by its active forces, as well as by its specific uses, contributes its share to maintain this property, but still only as an auxiliary power. At the same time, I remarked that this was not a primary source of this property, for it existed antecedently to any organic element, properly so called, whether germ-cell, or fibre. The essential cause must therefore be sought for in the blood itself, that is to say, in a fluid which, in the order of time as well as of existence, precedes the appearance of red blood. This cause is identical with that which formed, compounded, and produced the blood, and which, whether it be denominated a vital or formative force, or whether it be itself a fluid or a substance of such a refined,

pure, and active nature, as to admit of being modified or animated by a determinate force, still it is pre-eminently fluid, and can, in its appropriate place, and with suitable means at hand, produce a type, an effigy, a repetition of itself.

This vital force then becomes the permanently efficient cause of the fluidity, even whilst it is concealed under the veil of the auxiliary powers; and further, as it assumed by degrees the condition of red blood, so it may also by degrees be reduced again to its original pure condition, and in this state circulate through a corresponding order of vessels, assuming the nature and claiming the title of a nervous fluid, sufficiently subtle to permeate the entire nervous system which is organized from it. Under this condition this same force exists as a pre-eminently vital and active fluid, and therefore capable of the infinite modifications which are comprised under the two great distinguishing signs of a living body, namely, sensation and volition. That the blood can be traced, without a break or interruption, to this condition of existence, is obvious enough when we follow the internal carotid and vertebral arteries to their termi-

nations in and about the cortical, cineritious, or vesicular substance of the brain. Arriving at this region, a condition of vitality, or of animating property, is entered upon; the fluid and the organ are then co-ordinate and co-operative; the activity of the former and the re-activity of the latter are to each other exactly as the active pressure of the blood is to the heart, and as the re-action of the heart is to the blood, the effect of which is the circulation of the blood through every part of the body. In like manner the cortical spherules, or vesicles of the cineritious substance, may be considered as so many little hearts expanding on the entrance of the blood from the arteries; and when so expanded they are in a condition to contract, and by this means to forward their animating contents to every point to which the nerves proceed.

And I am not singular in this view of the action of the cortical or vesicular substance of the brain; for, as a use may be deduced from structure, I cannot but avail myself of the clear evidence so ably furnished by Dr. Carpenter on the structure in question, and to which I have already referred. This view is indeed a

revival of that which was entertained by the celebrated Boerhaave, and which prevailed extensively in his day; but like the subject of the humoral pathology, it was exploded from our schools with undiscriminating condemnation. The ignorance that prevailed clouded and obscured all perception of the necessity of the case; hence false notions, strange conceits, and absurd perversions of the doctrine, helped to banish it from the field of careful investigation. The pathology of the fluids is now, however, occupying the attention of physicians and physiologists, and a fruitful harvest is the near prospect of their labours. The great advance of chemical science has led the way to this field of promise, which, after being so long fallow, is now cleared, and ready to receive more useful husbandry by the employment of the most delicate methods of research. May we not then hope for a similar advantage to accrue to the doctrine of the animal fluids, and of the forces and powers which they are the media of manifesting? Are all our improved views and increased acquisitions in the knowledge of magnetic forces and electric influences, for example, to be confined to the mere advantage of social existence? Is that wonderful power

which, by the medium of isolated wires, rivals the rapidity of thought, to be all but exclusively devoted to the mere benefit of civil intercourse and commercial pursuits? The great elements of nature, which rule by magnetic and electric agencies, as well as those which rule by atmospheric pressure and influence, are surely auxiliary to the laws of life, and even subservient to them. Their modifications, their attractions and repulsions, with all their other attributes, are manifestly within the cognizance of the formative force of animal being, and are therefore compelled to minister to its purposes. For these elements are the vehicles of support and nutrition to the more subtle constituents of animal nature, and they are sometimes the sources of its disorder and destruction. If they are not so, whence come those pestilential vapours and poisonous exhalations which make their way to the very penetralia of the body, inducing death almost before disordered action can be said to have set in? Yes, this wonderful fabric, an animated being, living its life with all the distinctness of a world—a little world in fact—has its more subtle as well as its grosser parts; by the former changing with the alternations of weather, and, in the case of the

lower animals, preparing itself for different seasons and for innumerable vicissitudes, with a foresight as clear as if consciousness were based upon the experience of centuries. Here however mere instincts play, while reason, thought, and perception, are as nothing in the comparison!

It was believed and maintained amongst the ancients, that man, as well as every individual living thing, is a microcosm—a little world—moveable, active, and living in the great world—the macrocosm—around it: for man, indeed, is furnished and endowed with his own proper powers and forces—with his own peculiar efforts and determinations—and with his own especial laws derived from his own order; so that he is, in fact, complete in himself, with all his faculties and experience within him, over which he rules with freedom and intelligence. Thus animated, he is self-dependent on those things that concern him, deriving the possibility of his existence in this state from the great circumambient world, and from the terraqueous globe which he inhabits. What stupendous skill does this design exhibit! Could we but explore the one twenty-thousandth part of its wonders, we should surely be overwhelmed with amazement, and from this

feeling alone adore the wisdom of the Creator! The pride of our own fancied wisdom would not merely subside, but fall prostrate to the earth in derision of itself; and yet He has filled the smallest insect with similar proofs of His divine wisdom and power!

But to return. There is a fluid circulating through the brain and nerves, and withal so susceptible of modification, that nature can present to it no image which brain, nerve, and muscle cannot at once imitate, and by the skill of the artist reproduce on the canvass or embody in the statue. And yet how little do we reflect on this astonishing faculty—a faculty so astonishing, that even the daguerréotype, with all its imagined accuracy, falls infinitely short of the master mind; and this is but one small instance of what the brain, as the instrument of mind animated by its own fluid, is able to execute. As then the body, by its appropriate organs, prepares the blood, and by this means, preserves its own life, so the brain in its sphere and complex prepares the fluid adapted to its own powers and requirements; and hence the movements of the brain produce corresponding modifications of its fluid, which again, with more than electric speed or magnetic

power, proceed to their several destinations. This fluid conveys at once the necessary action to the muscles, upon which—present, as it were, with a generous, or it may be with a malevolent intent—it exercises its resistless power. In this way, nerve and nervous fluid may be perceived to be everywhere present, everywhere provident, and everywhere cognizant in their little world, or microcosm. Here modification asserts its all-dominant sway, supplying a perception of every contingency in the body, and imparting that motion which finds no repose but in equilibrium.

I know no other way of accounting for the origin of the animation which the brain receives, and by which it is enabled, through the medium of the nerves proceeding from it, to animate the entire organic frame; for the animating principle is in the fluid, and the fluid animates the brain. If therefore the function of animation, both as an action, and thence as an influence, is performed by the brain, it must fall coincidently and correspondently upon the non-resisting parts of the body, and especially upon the muscles which are located on the walls of the chest. The contraction of these muscles necessarily causes

an elevation of the walls, which is assisted by the pressure of the air into the lungs. In this way the outward air is an auxiliary power to the brain that animates from within, and thus respiration is co-ordinate and coincident with animation. The auxiliary power conceals as it were the essential power, and life and nature coincide as causes principal and instrumental in maintaining animated being.

That the vesicular or cineritious portion of the brain is the sphere from whence motion emanates, and to which sensation rises with inconceivable velocity, is admitted by all physiologists. And if we reflect upon the great extent of this structure, as well as upon the circumstance of its being, on the one hand, the termination of the capillaries of the carotid and vertebral arteries, and on the other, the beginning of the medullary and nervous fibres, we must admit that it possesses a power to move, and that its motion is animation. We must also admit that in the same region, it is susceptible of impression, which takes the name of sensation, so long as a fluid is there present; and if it moves, it does so according to its structure and form, producing effects which are stamped upon

its body, insomuch that the latter is but the expression of the former, and bears the impress of the brain. Whatever activity therefore the limbs present, they derive it from the brain; whatever chemical process is performed by the digestive organs and by the glandular system at large, it is directed by the brain; and whatever form the features pourtray, it descends likewise from this region. The lungs even respire because the brain animates; they also give forth the sounds which are articulated at the brain's command, and in this way instantly give outward expression to thought and volition. The stomach, moreover, executes its functions in full accordance with the state of the brain. The skin and all the other organs of sense owe their respective sentient powers to the same cause; so that the brain is in fact the sensorium commune. No wonder then that the profusion of these vesicular or cortical spherules is so great, that they admit of being reckoned by myriads. They form indeed the entire circumference of the cerebrum; they occupy internally its amplest spaces; they fill the larger protuberances, as the corpora striata and the thalami nervorum opticorum. They enter here and there into the smaller nodules, as, the nates,

the testes, and the pineal gland; in the form of a tree with beautiful branches they penetrate the cerebellum; they run in layers through the medulla oblongata; they compose the entire axis of the medulla spinalis, and disappear only about the first vertebra of the lumbar region. They are so skilfully and wonderfully disposed, that, while they can all unanimously conspire, every part of their investing membrane, every single twig of the carotid and vertebral arteries, every single fibre of the centrum ovale, and every single particle of the entire body, can conspire with them, as all the phenomena of organization most clearly prove. That this close subordination of the body to the brain exists, is plainly evinced by the various accidents and diseases to which the latter is liable. For should these occur, the organic functions no longer proceed with regularity and ease, but we observe spasms, convulsions, paralysis, torpor, faintings, laborious and stertorous breathings, and many other dangerous maladies, which correspond for the most part with the seat and extent of the primary mischief.

The numerous causes also by which the blood is vitiated will produce similar effects; so that it

would be difficult for an inexperienced person to determine whether they did not follow from wounds and injuries inflicted from without. Let me also call your attention to the extraordinary symptoms produced by various poisons, whether animal or vegetable, mineral or gaseous; for these must be regarded as so many vitiating agencies in the blood, not acting upon it merely by chemical influence, but flowing in its stream to the cerebral region, the sphere of the vesicular compages, and hence proceeding along the nerves to their special terminations, where they produce the symptoms peculiar to each individual poison. For example, the peculiar paralysis known to follow the impregnation of the system with some of the salts of lead—I say some of the salts of lead, for their number, as enumerated by chemists, already amounts to nearly a hundred and fifty—may be ascribed to this poison advancing through the nerves rather than through the capillary vessels, to the muscles affected. This paralysis takes place for instance not only in the involuntary muscles which give action to the intestinal tube, to the colon more especially—the seat of the painters' colic, but also in the voluntary mus-

cles of the fore-arms. These effects may be ascribed to the affection of the capillary vessels, which supply the structures just adverted to; but when we consider the wasting of the limbs and muscles, the numbness, and the general languor, which follow the introduction of this poison into the system, we must refer them to an affection of the nervous fluid and of the nerves in which it is contained. The same mode of reasoning will apply to many other poisons, and will also derive additional corroboration from the extraordinary influence of certain gases on the imagination, the senses, and the limbs, as detailed by Sir Humphrey Davy; I allude more especially to the nitrous oxide gas, or the laughing gas, as it is frequently called. And as these effects may serve to familiarize the mind with the view which I am endeavouring to establish of the continuous circulation of blood from the arterial capillaries, dipping down in immense profusion, and supplying the vesicular or cortical structure of the brain, I would on this point quote the evidence of my esteemed friend, Dr. Roget. For though these effects are very generally known, his description of them, published not very long

after Sir Humphrey Davy's experiments were made, has the greater interest on that account.

Dr. Roget states as follows:—"The effect of the first inspirations of the nitrous oxide, was that of making me vertiginous, and producing a tingling sensation in my hands and feet; as these feelings increased, I seemed to lose the sense of my own weight, and imagined I was sinking into the ground. I then felt a drowsiness gradually steal upon me, and a disinclination to motion; even the actions of inspiring and expiring were not performed without effort. I felt myself totally incapable of speaking, and for some time lost all consciousness of where I was, or who was near me. My whole frame felt as if violently agitated; I thought I panted violently; my heart seemed to palpitate, and every artery to throb with violence. I felt a singing in my ears; all the vital motions seemed to be irresistibly hurried on, as if their equilibrium had been destroyed, and every thing was running headlong into confusion. My ideas succeeded one another with extreme rapidity; thoughts rushed like a torrent through my mind, as if their velocity had been suddenly accelerated by the bursting of a

barrier which had before retained them in their natural and equable course. Every unnatural sensation gradually subsided, and in about a quarter of an hour after I had ceased to breathe the gas, I was nearly in the same state in which I had been at the commencement of the experiment." *

If then we admit the adulteration of the blood and of the nervous fluid which is continued from it through the vesicular cortex of the brain, the mode by which the bodily organs are influenced in the manner described, is satisfactorily explained; for, as the brain is the seat of sensation, it may be more or less directly influenced by the noxious fluid affecting it, and proceeding from it to the terminal points of the nerves. In this way it affects certain sets of muscles, or certain glands, ducts, and pores, or the intestinal canal, or the heart and arteries, or the respiratory apparatus. These several effects, then, arising either from an unnatural condition of the blood and nervous fluid, or from actual lesion of the cere-

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* See *Researches Chemical and Philosophical, chiefly concerning Nitrous Oxide.* By Sir H. Davy. London, 1800.

bral mass, are so many proofs of the universality of the influence of the brain upon the rest of the body. These effects indicate, moreover, a distribution—nay, a circulation—of the nervous fluid, which, like the red blood, is subjected to many affections and accidents; and not only so, but they also indicate the remarkable fluidity of the blood, as well as the existence of that other property which we shall have to consider at some length, namely, its vitality: for this property admits of infinite varieties in its manifestation, which are induced upon it by the deteriorating and vitiating influences to which I have just referred. Hence it is that mental disturbances arise, which occasion the loss of memory, or the privation of thought and judgment, or the perversion of ideas and sensations, or the want of power over the limbs. All the forms of intoxication also proceed from affections of the blood and of the nervous fluid, produced by the excessive ingestion of intoxicating fluids.

The diversities of these influences again claim our attention, not only in their nature, but also in their position and degree. Some, for instance, affect the brain specially, others the spinal marrow, some again the thalami nervorum opticorum,

others the medulla spinalis. These organs therefore, are severally affected, to a greater or less extent, by the condition of the blood; and, according to the nature and extent of these affections, will the provinces of the body also be affected. In this way, we may perceive that in proportion as disorders, however induced, spring from a higher or deeper source, they fall with greater certainty upon the lower or dependent structures, and thus spread more widely. Hence if they proceed from the brain proper, which holds the highest place, or from the spinal marrow, which holds the next place under the brain; or from the nerves, by which the brain is continued, according as they are more or less distant from their origins or terminations; instantly the subjacent region is affected with the disorder which influences that on which it is itself dependent. By considerations of this nature indeed, not only anatomical but physiological and pathological science may be illustrated and promoted.

But further, this view of the direct influence of the blood upon the brain and nerves, by a continuous circulation from the arteries of the pia mater into its vesicular cortex, &c., enables us to understand the modus operandi of medicines.

For, from extreme disorderly influences and effects we may derive instruction respecting the more moderate and manageable, and in this way turn our experience of the noxious and prejudicial to advantage in the restoration of health. This is the method already pursued, to a great extent, by the most intelligent of our professional brethren. Thus strychnine, which, given in a large dose, would produce violent convulsions, opisthotonus, and death, is not unfrequently administered as a medicine to overcome muscular paralysis and debility. Here the remedy must first act through the medium of the blood, then through that of the nervous fluid, for the paralysis for which it is administered mostly has its origin in the spinal marrow. In amaurosis again it is administered for nervous obstruction, and as a stimulant to nervous action. So that Materia Medica and medical science can supply proof without end of the transmission of a fluid along the nerves. But it would be tedious, as well as unnecessary, to adduce more instances to the same purpose.

Having, however, mentioned one very active agent in our Materia Medica, it brings to my mind various others which are administered, in

infinitesimal doses, by a class of men who draw largely upon the credulity of their patients. I cannot, therefore, forego this opportunity to record my deliberate protest against the doctrine of homœopathy; for to my mind it is founded upon an entirely false position, and the support which it derives from its alleged success is also grounded upon a wholly baseless inference. For if cure be the exclusive criterion of the soundness of a theory, then may the most palpably absurd notions be received and pass current as truth. Medicines, we know, have been administered in vast doses in our own day, and the practice was lauded on the ground of its success. In like manner, most extraordinary routines of diet and starvation, water drinking and abstinence from liquids, have been prescribed with alleged marvellous results, to sanction the practice. Even charms, amulets, and galvanic rings have worked their wonders upon the same curative shewing. But some of these modes of treatment are either extensions of legitimate practice beyond legitimate grounds, or they are distortions of order, monstrous births from the fruitful womb of art, or intrusions upon the privileged ground of the experienced physician, who may consistently and conscientiously

avail himself of the confidence of his patient, and turn even his imaginative faith to a good account. They are in fact spurious offshoots from an unauthorized stock; and empiricism, in its worst signification, is the only appellation they deserve. Small doses of subtle poisons is no new practice; nor is abstinence. They are ancient prescriptions; and though many strange remedies have been often in vogue, yet they were honestly introduced, and the sincere hope of a beneficial result from them gave them admission into the Pharmacopœias of the day. But for myself, I would be liberal even to homœopathy, as I would to every other pretension to a healing power; and I would be so, not because of any wide-spread adoption it might attain, for this would be pandering to the weakness of a generation, but because it tends to confirm the influence of medicine as operating more especially through the medium of the nerves, and thus reaching, in their deepest seats, those disorders which strong and drenching purgatives will not serve to remove. For it proves what nature does and can do in the work of healing; in fact, it is in the nature of the animal economy itself to repair and to heal what is amiss. It is for art, experience, and judgment combined,

to assist nature, and so to expedite the cure. Art is but nature's auxiliary, and if rightly exercised removes the obstructions that oppose and frustrate nature; for if obstruction is once removed, nature instantly returns to its pristine order. That which nature requires then in homœopathic practice, is time—protracted to weeks and months, and, it may be, years. But, in medical practice founded upon true principles, the cure should be attained, wherever it is possible, with much greater expedition and certainty. If such is not the case, then either our art is defective, or our principles are wrong, and our pretensions unfounded. To one or other of these alternatives I am reluctant to ascribe the present prevalence of every sort of nostrum for the cure of disease. But if we ourselves have no uniform, consistent, and incontrovertible rule of practice, I fear our profession must continue to be deprived of its due support, by the parasitic growths which beset it on every side.

And as I am speaking in general terms of the vitiation of the blood and nervous fluid, as a fruitful source of cerebral diseases and bodily maladies, several points suggest themselves to

me which merit some share of our attention. How frequently for instance do we see alarming disorders ushered in by shivering, chills, rigors, and severe head-ache. Soon afterwards a reaction begins; the cold is succeeded by intense heat of skin, by a flushed face, injected eyes, intolerance of light, spasmodic twitchings of the limbs, with pain, severe back-ache, and a closing of every duct and pore. The pulse is now hard and throbbing; the arteries seem filled to their utmost stretch; and the respiration is short and hurried. In this period of general excitement, hæmorrhages sometimes take place, more especially from the nose, relieving the head-ache; sometimes vomitings succeed, discharging large quantities of bile; a commotion, in fact, is set up, which subsides only in fever, bilious, or gastric, or irritative, or cerebral, or nervous, as the case may be, or as it may be denominated by the view which the medical attendant takes of it. Now let us refer all these phenomena to states and conditions of the blood. Let us reflect upon the kind of remedies that are prescribed to meet the exigencies of the case. Let us enquire with

what views they were adopted. For we must perceive, that the blood claims this consideration, and sanctions this reference. Why then should we dwell so much on the "irritation of the mucous membrane of the stomach and bowels," and regard it as the source of the febrile disturbance? The stomach is irritated by the presence of foul secretions from divers sources; it heaves and retches to eject the nauseous vapour, the acrid fluids, and the tainted solid matter that may be in it—a perfect mixture of abominations. Our forefathers administered emetics for this state of things, and frequently with good effect; but when "irritable mucous membrane" became the prevalent doctrine, emetics were discarded, and many an instance of low and protracted fever kept physician and nurse long at their anxious post of duty. Under both modes of treatment the patient might possibly recover, but nature, or the powers of the system, would take a large share in the recovery. In the management of such a case as this, every symptom and every organ should be duly considered. Instead of referring the phenomena to an irritable mucous membrane or to a congested liver exclusively, the remedies should be of more general application. Not a

symptom nor an organ ought to be disregarded. The complexity of the case will best be met by a rational combination of remedies in our prescriptions, such indeed as signalized our excellent President at an early period of his distinguished career, of which his Pharmacologia is an enduring proof. The distressed stomach, however, must first be quieted, in order to prepare the way for the introduction of medicines which operate on organs at a distance from it; and, to speak from my own experience, I have never been disappointed in the administration of copious draughts of bicarbonate of soda dissolved in warm water. This neutralizes the acridities met with in the stomach, and, should it be ejected in the first instance by vomiting, the act is easy, and will seldom be repeated. It is taken into the system, there to work a benefit in various ways; or it passes on to the duodenum, lessening the acrimony of the bile, which it will be sure to meet with coming from the liver and gall bladder. This remedy may be followed by others, which promote the action of the bowels, or calm the fretted points of the villi lining the alimentary canal; the combination of calomel with opium mostly serving both these

purposes. The full and aching head must be relieved by leeches, or cold applications; the abdominal region must be tranquillized by fomentations, which help to derive blood from the head, and to induce free perspiration, with even an abundant secretion from the kidneys, as well as from the liver. Cooling drinks and saline draughts will likewise assist in the reduction of the febrile heat. These beneficial results will, however, be less likely to be realized, unless the head is relieved quickly of its distress; for the brain, as we have had occasion to shew, is the grand ruler in all the secretory and excretory processes of the glandular system. I have taken a commonplace case in illustration of method in medical practice, in order to shew the application of Materia Medica to one case, in which heat, and cold, and moisture, an alkali, and an acid, a purgative, and an opiate, with leeches, and hot and dry applications to the feet, may be simultaneously and most judiciously exhibited. Or, were I to take a more chronic and deep seated disease as an example of practice, I should meet the case by one remedy simply, by a form of mercury in minute doses,

or by arsenic, or by antimony; and I should probably witness the complaint yielding to the remedy in a most satisfactory manner.

All these results, be it remarked, are to be attributed to the nervous system which regulates and governs all secretions, excretions, and absorptions. Brain, and its nervous appendages, work out the entire combination of processes for the re-establishment of health; for, without them, glands will neither secrete nor excrete, and consequently, they cannot eject impurities from the vitiated blood; without them again the skin will not perspire, nor the stomach and intestines move; the heart and arteries cannot pulsate, or strive for regularity and uniformity of rhythm; nor will respiration pant and sigh and even cough to help on the sluggish blood, or relieve the labouring brain. For, as we have already shewn, the lungs aid the brain in every action and influence; so that every membrane that envelopes every part; every capillary vessel also that compounds every organ; every moving fibre that makes up every muscle—these are all respectively influenced by respiration. For respiration is in the body the vice-

gerent of the brain, acting both co-ordinately, co-incidentally, and yet subordinately to it, the atmospheric pressure performing faithful service from without. All these considerations imply respectively a free and sound condition of brain and lungs. But let there be congestion or inflammation of the lungs, as is frequently the case in fevers, and then what debility do we behold! The patient, who a few hours before could have felled an ox to the earth, is now weak and helpless as the infant. If the lungs again are suffused or choked with phlegm almost to suffocation, then we witness delirium and muttering, picking fingers and the hectic flush, the livid lip and the parched tongue—all portending approaching death. Again, if we contemplate cerebral structure deranged, or cerebral functions disturbed, without any visible breach of organization, what a temple of discord do we behold!

If then there is a nervous fluid, we may naturally conclude that it must be subject to various derangements, which would, in a corresponding degree, affect the brain. And surely these derangements ought to be regarded as capable of cure upon still more philosophic

and enlarged principles of treatment than have been yet adopted; upon such, for instance, as would make chemistry minister to the production of gaseous remedies, more likely than either solid or liquid matter to reach the very root of the maladies in question.

LECTURE VI.

In my former Lectures I discussed the important question of the relation existing between the fluids and solids of the animal body, more especially that existing between the blood and the bodily organs formed from it.

In this discussion I adopted the analytic method as closely as possible, advancing from a general to a particular view of the subject, or from the body to its parts, and, more especially from the blood in its aggregate or entire volume, to its unities, or smallest volumes as red blood. I then traced it onwards to the reduction of these to the condition of a nervous fluid by the instrumentality of the cineritious or vesicular substance of the brain.

I offered to your consideration, in my last Lecture, a general sketch of the wonderful properties of this fluid, ascribing to it every thing which, by common consent, pertains to the nerves; so that the nerves are relatively to the fluid circu-

lating in them, what the arteries are relatively to the blood—each being respectively formed in exact adaptation to the laws and motions of their fluids. Undulation and circulation I considered as being predicable of the motion of the blood in the arteries, whilst modification and animation are predicable of the circulation of the fluid in the nerves.

Contemplating, therefore, the animal body, we look for the order which reigns universally in it; and, as the order of subordination abstractedly considered, is the most perfect, so we find it confirmed and realized to our very senses, as the established rule of the animal economy.

Now, if we pursue the process of the formation of animal being, we first observe a fluid; we have next the manifest initiaments, so to speak, of a nervous system; then the beginnings of a vascular system, which follows the composition of a colourless fluid, and precedes the composition of the red blood. Hence we plainly perceive an order of instrumental subordination distinguishing the very primordia of animal existence. This order, moreover, I consider as continued throughout all the subsequent stages of formation up to the very completion of the

animal being, the direction, end, and power of the formative force being all clearly and distinctly embodied in the organized product. Naturally, therefore, does the analytic method lead us upwards and inwards, from compound organs to their initiatory, capillary, and nervous elements, and to those fluids which they severally contain and circulate. This method also enables us to perceive clearly how the capillary system comprehends all vascular structure, whilst the nervous system, extending to the organization of the vascular, embraces all cerebral structure. It further assists us in understanding the mode in which the nervous system so wonderfully influences and controls the vascular. Anatomy, physics, and philosophy demonstrate the truths brought out by the analysis, whilst physiology and pathology abundantly illustrate and confirm them.

Hitherto I have been speaking at some length of the blood and its several properties, more especially of its chemical relations, its colour, warmth, and fluidity, and I have slightly touched upon its vitality; but this latter and interior property, will be better elucidated by an examination of the first visible product of the red

blood, namely, the heart, the undoubted instrument of its circulation.

Now the progressive stages in the development of this most astonishing specimen of mechanism, demonstrate most convincingly to my mind the wonderful foresight and power of the formative force; for in this process of formation, whether of the embryo in the womb or of the chick in the egg, every thing advances in the most distinct and orderly manner. The several parts and members are successively produced, so that in the least member there is no entire effigy. There is in the germ no type of the future body; that is to say, there is no type which, according to an erroneous notion, is the result of simple fœtal expansion. Nay, all that is thus successively produced is formed in anticipation of, and according to, the use it has afterwards to perform. Thus, every thing is a medium to some ulterior use and end; and, therefore, as such, it contains within itself the law of those things that come after it, and refers itself to those which were before it. For on these it depends, and for the sake of these it exists in its own distinctive manner.

And not only so, but whatever is contingently

necessary, is also prepared and provided for the purpose of completing the work of formation; for in the womb and in the egg, such provision and preparation are most obvious. In each the living product grows successively, passing through certain remarkable changes and diversities of state; the first of which consists in the delineation and development of the brain and the spinal marrow; the second, in the weaving together, so to speak, of the fibres of the heart; the third, in the growth of the lungs; and the fourth, in the expansion of the lungs, by inspiration of the air at birth. But these changes take place with a difference according to the perfection or imperfection of the animals in which they occur, and according as they are formed in the womb, or in the egg. To trace the whole series of changes however, which occur in their orderly and successive progression, would occupy a life-time. I can only allude to them in the most general manner, for the sake of shewing how distinctive nature must be in the first rudiments of formation; or, what is the same thing, how exact, but at the same time, how distinct, in each individual animal, is the operation of that formative force in which nature

dwells, and of that fluid in which this agency commences.

If indeed the form intended at the outset were, in the earlier part of its course, to be interfered with in the smallest degree, the product would be immensely different from its prototype; just as an arrow would be wide of the mark, were the point of it to make the slightest deviation as the archer relaxed the string of his bow. To speak philosophically, the cause must exist before the effect, the prior before the posterior, and the universal before the particular; and therefore, before anything is co-ordinated, it must be subordinated. Hence it is, that when the mind traces out causes analytically from their effects, it discovers them existing according to the laws of subordination and co-ordination; and, in conformity with these laws, there can be no possible instance of a cause depending upon its effects. But the formative force not only begins the work of formation, it also proceeds with it, even to the termination of life, and it is moreover identical with that power which repairs the wear and tear of the body, and which, in case of accidents, renovates the system; for all things that follow from it are subordinate

to it, and each of these again is subordinate to that which in the order of succession preceded it.

But as the animal fabric presents an instance of structure which, to all appearance, contradicts this view of the universality of this law of subordination, I cannot relinquish my present office, or take leave of my most indulgent audience, without referring to the seeming anomaly. If then I can shew that this instance in fact verifies my view, I trust you will admit that at least a new and most interesting field of investigation here invites, or rather demands, the serious attention of the whole profession. It supports at the same time, in the most satisfactory manner, the view that the blood is primary and essential in all the actions, as well as in all the uses, of the bodily organs. I here allude more especially to the manner in which the blood is distributed to the muscular parietes of the heart, which, I am satisfied, after the most deliberate reflection on the subject for upwards of thirty years, is very different from what is generally believed at this day. But in making this remark on the anatomy of the heart, and on the physiology of muscular action

in general, I do not desire to invite your attention merely to any conclusions of my own, but rather to the facts from which those conclusions are drawn, and to some of the reasons which compelled me to question the correctness of the opinion commonly received.

Now it does not require much discernment to perceive the relation which subsists between the heart and the other organs of the body, for it is evidently the relation of constant dependence. It therefore becomes an interesting point of enquiry to ascertain what the circumstances are which enable the heart to act as the primum mobile in relation to the body; for, like every other muscle, it requires a supply of blood by its arteries on the one hand, and of nervous influence on the other, to support its action. And further, if the action of the heart is necessary to inject blood into the arteries, by what power are the so called coronary arteries injected? Or, again, if muscular fibre cannot act without blood, from what source is the fibre of the heart supplied with it?

According to the generally received opinion, as well as according to the appearance, the parietes of the heart are supplied with blood

from the coronary arteries which first arise from the aorta. But if the fact is so, and the inference from it is correct, then the heart, for its supply of blood, is dependent upon the arteries, and the arteries again are dependent upon the heart. Which then, let me ask, is the primum mobile—the coronary arteries, or the heart? Muscular fibre cannot act without blood, and the artery which supplies the blood, cannot possibly receive that blood, without the action of the heart. This position is, I conceive, indisputable. In the case then of the coronary arteries, whence do they receive their blood, when the heart cannot act, unless its fibres first receive blood from them?

We have, however, an abundance of arguments from anatomy itself to weaken the common opinion respecting the coronary vessels; and some of them will be adduced presently. But I must observe, that, to make the heart depend upon a precarious supply of blood to its own fibres, when it is the grand organ of such supply to the entire body, is to maintain that it holds its life by tenure from its own artery! whereas, no organ demands more imperatively than the heart both an abundant and a constant supply of blood, which is, in

fact, its own inalienable property. If the motive fibre of the heart should become idle, in consequence the blood, by any chance, failing the left ventricle, it would no longer have the power of erecting or arousing itself; for it could no longer demand of the aorta what the aorta had not to give; its motion would, therefore, soon cease irrecoverably, and the whole frame be consigned to certain death.

There is then an evident anomaly here; but is it to be supposed that nature is the source of this anomaly? or do we not rather draw erroneous conclusions from the mere semblance of facts? Is it a fact that these coronary vessels are arteries, like other arteries in the body? To this question I can unhesitatingly reply in the negative; for, in the first place, their internal surface is not smooth and polished like that of other arteries, but rugous or puckered; in the second place, if traced to the points where they dip into the muscular substance of the heart, they present a distinctly valvular or sphincter-like structure; in the third place, their openings into the aorta are, for the most part, situated close to its semilunar valves, and close enough indeed for these valves, in many instances, to overlap

them, during the contraction of the heart. The force of the blood would thus naturally drive these floating valves against the orifices of the coronary vessels; so that these floating valves would, from the innumerable strokes of the blood against them, become stretched, and assume the form of a pouch. When, indeed these orifices present this appearance behind the semilunar valves, many anatomists have conceded that an obstruction to the passage of the blood from the aorta into the coronary arteries is by this means produced.

To remove this difficulty, which militates against the idea that the heart obtains blood in this way, during the time of its own contraction, physiologists have not unfrequently taught, that a portion of the blood is regurgitated by the aorta, and finds its way into the coronary arteries, to supply the fibres of the heart. But this view, it is evident, must be wrong, for this reason, that the blood does not move in the arteries in opposite directions, that is to say, forward and backward, at the same time; but rather, that it hastens on in an accelerating ratio, even during the re-action of the aorta, towards the capillary region of the body.

This view moreover of the regurgitation of blood by the aorta, acting in this manner, claims for this artery a new action, differing altogether from that which it performs on the ramifications of its system; in other words, this view claims for the aorta, after it has discharged its especial function, a stronger, inverted and retrograde action upon the heart—an organ the most muscular of any in the body.

Again, the peculiar rugous surface which marks the interior of the coronary arteries, as well as the sphincter-like apparatus which is found at the points where they dip into the muscular substance of the heart, militates most strongly against the notion that they perform the ordinary functions of arteries. The direction, moreover, which these vessels take around the base of the heart before they ramify upon its surface, and afterwards penetrate its muscular substance, is so obviously contrary to what obtains in other muscles of the body, more especially in such as exhibit strong and vigorous action, that some other use for these vessels must suggest itself. The origin, again of the nerves which are distributed to these vessels is different from that which supplies the fibres of

the heart. Nor can I omit the circumstance of there being an utter want of proof of any communication whatever between the coronary arteries and the coronary veins. In fact, they do not communicate at all, for no injection of coloured liquid into the arteries ever colours the veins, nor does any injection into the veins ever colour the arteries; and if the veins are empty, they continue empty even after the arteries are injected. In this respect the former have not the condition or character of arteries, nor the latter of veins. This circumstance, therefore, would indicate that both classes of vessels are similar in kind, and that they arise from the interior of the heart—not from the aorta.

Considering indeed the extraordinary actions and relations of the heart, and the numberless disturbing causes which beset it on every side, we may naturally expect to find it, even as to structure, very differently circumstanced from any other muscle in the body. Consequently, in the absence of anything like a satisfactory proof that the coronary arteries, and the coronary veins, communicate with each other in the manner generally believed; and further, with a failure in every effort to establish by injection

such a communication, I am, I conceive, warranted in concluding that these vessels stand in a very different relation to each other from that of arteries and veins.

The physiology of muscular action in general also admits of careful review, for the alternations of state, under the contraction and relaxation of the muscles, necessarily affect the circulation of the blood from the arteries to the veins. Thus, when a muscle is contracted, the circulation must be different from what it is when the muscle is relaxed; and, if the circulation is different, the channels of communication themselves must be different also to admit of it. And this reasoning applies to the heart more especially, since it is a four-fold muscle, so to speak, having two of its terms in contraction, while the other two are in relaxation. Hence, there is doubtless a necessity, as well as a reason, for the want of communication between the coronary arteries and veins. The reason which I have to offer is founded upon the consequences which would result from their communication on the one hand, and from their respective terminations and beginnings, on the other. And these consequences would be precisely the same as would

arise were there no septum between the two ventricles. However, it is not possible to enlarge upon these points in a single lecture.

Many experiments have been made by injecting different sorts of fluid into the coronary arteries and veins, and the results have been most extraordinary. These injections, when forced into the coronary arteries, have found their way into the cavities of the heart, through the lacunæ and ductus Thebesii, which are to be found here and there in the sides of those cavities, and especially on the septum of the right ventricle; and when quicksilver has been injected, it has found its way to a number of vessels on the interior surface of the right ventricle, producing a beautiful appearance there, whilst another portion of the quicksilver has made its way into the several cavities of the heart.

Injecting the coronary veins, again, has resulted in charging a considerable portion of the apex with the injected fluid, as if the coronary arteries had little to do with this part of the heart. The larger coronary veins moreover are devoid of valves, except in those situations where they rise out of the muscular substance, and in this respect they resemble the coronary arteries.

But the lacunæ and the ductus Thebesii deserve more especial attention. They have been explored, to some extent, by several anatomists, though with no satisfactory result as to their use and functions. For myself, I have succeeded in some degree in injecting them, and tracing their course to the internal layers of the muscular substance of the heart. In one instance I met with a somewhat larger orifice, or mouth of a duct, in the left ventricle, which I injected with colored water, and the result was, that the fluid passed across in a full stream to the right auricle.

A great many more facts of a similar kind might be adduced from various authors, and I cannot but express my surprise, as well as regret, that so few modern investigators have turned their attention to this subject. They seem to leave the matter as a quæstio vexata, incapable of solution. Beyond my own testimony, what I have been advancing is from authors of an earlier date, as from Lancisi, Lower, Boerhaave, Winslow, Ruysch, Morgagni, Verheyen, and Vieussens, the last of whom made numerous experiments with regard to the coronary vessels, all of them demonstrating most clearly the communication of both the coronary arteries and the coronary veins, with the cavities of the heart.

Verheyen, referring to Vieussens, says, "he made injections of a mixture of saffron into the left coronary artery; the injection soon passed into the entire substance of the left auricle, which he thinks is destitute of veins. He injected both the left and the right coronary arteries, when he saw the liquid pass respectively into the right or left ventricle. He afterwards found in the cavities of the heart, when macerated in water, a great number of particular passages terminating on the inside of the same cavities, which passages, he calls fleshy ducts, and adds, they are continuous with the arteries. He concludes that the coronary veins with their branches are entirely superficial to the heart, and that these veins do not communicate immediately with the superficial arteries of the heart, as do the veins in the liver, spleen, and some other parts; since the communication in the heart is effected by the intervention of the fleshy ducts, which proceed from the sides and extremities of the superficial arteries of the heart, and reach to the sides of the veins."* Such were the experiments of Vieussens, as given by Verheyen, who

* *Corp. Hum. Anat.* Lib. I., cap. viii.

himself also injected a large trunk of the coronary veins, and took precautions against the fluid making its escape into the right auricle, when it readily found its way to the cavity of the right ventricle. At another time the injected fluid passed so largely from the orifices on the inside of the ventricle, that there was no seeing the places from which it came. He then inserted into the vein a small tube, and air blown through it came out with the water in the form of bubbles, shewing the places admirably. The orifices from which the air escaped were very numerous; some of them were overlaid with the internal membrane of the heart, which thus acted as a valve; others, instead of this valvular provision, were inserted obliquely. On dissecting some of the larger orifices from which the water issued, he saw at the sides of them a number of minute foramina, which were all, beyond doubt, orifices of vessels discharging their contents into the ventricle.

I need not adduce more proof that there is a number of orifices opening into the cavities of the heart, and more especially into the right ventricle. Their situation is such that they receive the force produced by the contraction of

the heart, tending necessarily to drive the blood towards them. Hence it would seem to be a natural inference that the blood makes its way into the ductus Thebesii, and thence into the entire muscular compages of the heart, stimulating every fibre and urging it to assume the state of diastole, and so enabling it to perform its systole. The communication between these ducts and the superficial vessels of the heart is in fact unquestionable, whether it be between the coronary arteries and the heart-cavities, on the one hand, or between these cavities and the coronary veins, on the other. With this ready and permanent communication, then, there can be no difficulty in conceiving how well suited the so called coronary arteries are to perform a mixed simultaneous function of artery and vein, and to stand in the relation of veins to the ductus Thebesii, which, as arteries, rise from the ventricles by many mouths rather than by one.

Nor is this the only example of anomalous actions in the body. For, where a sort of double office is assigned to one set of vessels, we have an artery conveying venous blood—the pulmonary artery, for instance; we have also veins carrying arterial blood—the pulmonary veins,

for instance; and not only so, but we have in fact veins distributing their blood precisely like arteries, as in the case of the vena portæ.

If then, the coronary arteries, in these respects, perform the function of veins, I may be asked, how is it that they can at the same time perform the function of arteries? My answer is, that, as they are of a dilatable structure, with numerous folds or rugæ on their internal surface, they can adapt themselves to the fluctuations in quantity to which the blood in the heart is subject. Hence it is that, under every state of the heart, they can act as it were, like safety valves to that extraordinary mechanism of which they form a most important part, receiving more blood at some times than at others from the cavities of the heart, and returning a quantity adequate, in case of need, to ensure a due provision for its muscular fibres. According to this view, we can discern with what care nature secures the presence of the blood at all times, and under all circumstances, to these fibres, and with it the means of maintaining the life of the body at every moment. For in this way, indeed, the heart, as the primum mobile in the organization,

is unceasingly supplied with blood as the primum movens; and thus the cause instrumental conjointly with its cause principal, produces the intended effect. The peculiar structure moreover of these vessels plainly declares their use; and it would be difficult to conceive any other use which so well applies to the constantly recurring exigencies of the case.

Of all the organs of the body, the heart must be regarded as the most astonishing. For, if we reflect on the great and rapid changes to which it is liable even in the space of a few moments, both as to its condition as depending on its nerves, and as to the frequency and force of its pulsations; if we consider how all the mental emotions concentrate with resistless influence upon it; or if we attend to the sudden alternations from muscular repose to muscular action to which it is subject, and remember that the certain effect is a torrent of blood rushing from innumerable points to one centre, we clearly perceive that all these circumstances are so wonderfully compensated, that in the healthy subject the equilibrium of the organ is scarcely disturbed. This astonishing compensation strikes us again, if we call to mind the amazing differ-

ences both in the quality and the quantity of the blood transmitted to the heart, from all the provinces of the body, at every moment of even a long life, and that for such contingencies, ample provision is made in the healthy heart, so that, instead of trembling and palpitating beneath the chaotic load, it vigorously transmits this heterogeneous compound to the dependent members, as if with a certainty that order will spring out of the confusion. Many more considerations, indeed, of this nature, might be submitted to you in order to shew how necessary it is for this noble organ to preside over the affairs of its kingdom with absolute independence; and whilst ruling its own destinies, to render those of its members subservient to itself. For this purpose, the heart necessarily appropriates the first fruits of its kingdom, and by the force of their invigorating qualities is recruited for the due performance of its incessant service. Independent in position, as well as in function, the heart can not be dependent upon that which—whether artery or blood—has proceeded from it, but, after appropriating from its own resources the means of support, it dispenses the rest to every dependent member alike. How natural then is

it that the heart should be the first organ that lives, and the last that dies!

From what has been stated, it may now be concluded that the coronary vessels, which all belong to the same family, are the proper veins of the heart, springing from its lacunæ and fleshy ducts. They also traverse the surface, without communicating with each other; they increase from the smaller twigs to the larger, the blood flowing simultaneously into them all; their expansion and contraction respectively commence and terminate together; they possess no membrane in common with the arteries, but are rugous internally and full of folds; hence they cannot propel the sanguineous stream from one point to another with any pulsatory and undulating motion. They meet together from innumerable sources, and thus undergo impletion; they are all passive, and hence sent out to the surface; and therefore they are veins.

And the fleshy ducts that lead from the crypts of the auricles and ventricles into the muscular substance of the heart, are the arteries of these veins; they are in fact so many little arteries, furnished with their little ventricles, and septa, and sometimes valves, arising immediately from

the general cavity of the heart, and with it observing the same systole, while their texture is altogether different from that of the vessels which occupy the surface. They also gradually decrease in size, till at length they become extremely minute vessels, which communicate with the motive fibres, like the arteries in every other muscle of the body. Hence these ducts may be regarded as the proper arteries of the heart, occupying its interior recesses, and penetrating every portion of its muscular substance; for the heart is in all respects a muscle, and, subserviently to the blood, forms the strength and life of the body.

The view which I have here taken of the distribution of the blood through the parietes of the heart is, you will observe, widely different from that which is generally received. I have adopted it, after much reflexion, on philosophical, anatomical, and physiological grounds; and in reconsidering it, as I have done again and again, I can discover no cause of apprehension either as to its soundness or its ultimate triumph. On the contrary, I am more and more convinced, that it is tenable on every side, and this because all its bearings rest upon the order of subordination

which, as I stated at the outset, rule universally in the animal economy. The appearances presented by the action of the heart seem, at first sight, to militate against me; for they apparently sanction the notion that there is an inherent principle, or an occult quality, in the animal fabric, and especially in the muscular system, which is expressed by the term "irritability;" and such a principle is conceived to exist even independently of all nerve, or vessel, or circulating fluid. And as the involuntary muscles, more especially the heart, manifest a susceptibility of influence even from the slightest stimuli, and when separated from the body, this property is erroneously ascribed to a self-produced and self-existent irritability, and these muscles are adduced as proofs and examples of its real existence. But after all, the existence of this irritability as a principle, is entirely destitute of foundation; inasmuch as muscle cannot possibly act under ordinary circumstances, without arterial influence on the one hand, and nervous influence on the other; and hence we must conclude that a condition so essentially dependent is quite incompatible with the very idea and nature of a principle. For a principle must not only itself be

independent of conditions, but impart them also to all things that are dependent upon it. Muscle, therefore, as an organ of motion, cannot be a principle, nor usurp the place of one; it requires blood in its blood-vessels, and nervous fluid in its nerves, before it can be acted upon by any stimulus whatever, either from within or from without; and deprived of the presence of these, as it may be by disease or by accident, it is incapable of all power and motion.

The stability and welfare of the body, are thus secured upon an infinitely better footing than upon such a supposed principle of irritability, an organic, not an accidental, provision being made in the heart, the instrument by which the circulation of the blood is effected, and hence the first to receive from the blood its own ability to act. And in this respect the subordinate condition of the heart is very manifest, and, therefore, instead of being self-acting, it is, as a muscle, subordinate to the blood, and affected also by its adverse influences, from which proceed the palpitations and distresses, the irregularities and differences in its motion, indicative of unhealthy conditions in this vital fluid. In like manner, the heart is subordi-

nate to its nerves, and therefore, subject to their multifarious influences, which affect the strength of its pulsations, as well as the tone and regularity of its action. All these considerations must surely banish irritability, regarded as a principle, from all philosophical views of muscular action. The skill of the physician may, therefore, be exercised to greater advantage in applying the measures at his command to calm the troubles of this all-sympathizing organ, which are communicated to it through the omnipresent medium of the nervous system. If he discovers it to be beating with more frequency than suits the equilibrium of nature, he seeks the cause of the disturbance throughout the provinces of its little kingdom, and his experienced eye quickly detects the seat and nature of it; but, if he perceives that derangement in the structure itself is the cause of the increased or diminished action, he will find his judgment and skill taxed to the utmost to prevent—or it may be, only to postpone—the fatal result.

Having thus briefly noticed the pathology of the heart, I would avail myself of this opportunity to state a strong argument in support of my view of the circulation of the blood

through the coronary vessels. The so-called coronary arteries, then, are liable to earthy and calcareous deposits, to a very considerable extent. When these deposits take place in the arteries of the limbs, mortification of the parts supplied by those arteries is a very frequent consequence; but, in the case of the heart, I never heard of or met with a single instance of this kind. And yet, if this result creates no surprise in the case of a limb, how is it that a similar result is not looked for from a similar disorder in the so-called coronary arteries? The fact is, that these vessels are not the sole channels of supply to the fibres of the heart; upon them nothing, in a primary sense, can be said to depend, as they are merely passive vessels or canals, and hence admit of being ossified even to the extent of total obstruction. Of this the annals of Medical Science supply us with a striking instance;* a case being given in which the so-called coronary arteries were not only ossified, but their cavities completely closed for an inch in length from their origins. The heart

* See the Case at length in "*The Dublin Hospital Reports for* 1827—1828."

was found to be flabby and large, and of a yellow colour from fatty deposition, and all its cavities were distended with fluid blood. The semi-lunar valves were completely ossified also, the ossification extending to the coronary arteries, which were so completely turned into bone as to be perfectly solid, having no perceptible canal, except, as I have said, at the distance of an inch from their origins; beyond this, these vessels were at intervals completely interrupted by small bony specks.

The symptoms during life were, cessation of arterial pulsation for seven weeks, dyspnœa, the motion of the heart imperceptible, erect posture the most easy, digestion impaired, gradual loss of strength, the patient becoming gradually delirious, then falling into stupor; his upper lip swelled suddenly, and upon it a large livid spot appeared. The want of pulsation in the arteries was ascribed to paralysis of the heart from defective supply of blood by the obliteration of the proper nutrient vessels, whence arose the incompetency of its efforts to excite the slightest movement in the arteries.

In this very remarkable case it is most manifest that the heart received no blood from the

aorta; it must consequently have been supplied from another source. What, then, could this source have been but the ductus Thebesii, which, receiving the blood from the heart's own cavities, conveyed it to the muscular fibre, and thence to the coronary vessels?

I may, in conclusion, I trust, be permitted to record my deep conviction that the order of subordination which I have endeavoured to elucidate, as the order which reigns universally throughout the animal economy, merits the serious attention of every member of our profession. I am satisfied that there is—that there can be—no exception whatever to its rule; and that, wherever the semblance of an exception is observable, it is the province of true science carefully to examine and explain it. A tenacious adherence to what may be rightly called the appearance of truth, has led, in the lapse of time, to repeated collision and controversy; but truth has hitherto won, and, we may rest assured, will ever win, sooner or later, her own way. It was forcibly said centuries ago, by one who knew well the prejudices which she has to encounter, "Magna est veritas, et prævalebit." Let us hope that an enlightened zeal for truth,

rather than a wrangling spirit of controversy, is strengthening amongst us, and that we are becoming less and less attached to mere opinion and precedent as the true basis of authority. For my own part, I am most reluctant to rest in mere theories, and as disinclined to dispute about them. The certainty resulting from truth is a far better possession; for it imparts to the mind a tranquillity of its own, and, shewing us how much remains to be discovered, how much we have all yet to learn, it should silence ignorance, and forbid presumption.

THE END.

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