CROONIAN LECTURES

ON

MATTER AND FORCE.

Delivered at the Royal College of Physicians.

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LECTURE II.

On the First and Second Stages of our Ideas regarding the Union of Matter and Force in the Biological Sciences.

"And matter, whatever it is, must be held to be so adorned, furnished, and formed, that all virtue, essence, action, and natural motion, may be the consequence and emanation thereof."—LORD BACON.

MR. PRESIDENT,—I ought to repeat the apology which I offered to you in my first lecture, because I shall begin this lecture with some words of wisdom which might not be expected in this theatre, and yet they are the most suitable introduction I can find to what I am about to say. Mr. Faraday was the greatest experimental philosopher, judging from the quantity and quality of his work, that England, or I might say the world, ever produced; and, at the same time, perhaps he was one of the most religious men that ever lived. Among his manuscripts, that have been entrusted to me since his death, I have found this passage: "But, though the natural works of God can never by any possibility come into contradiction with the higher things which belong to our future existence, and must, with everything concerning Him, ever glorify Him, still I do not think it at all necessary to tie the study of the natural sciences and of religion together."

It appears, from what I have said in my first lecture, that a certain fixed direction of development of knowledge is found to obtain in our ideas of the union of matter and force in the sciences from from which the idea of life is excluded. Whether we judge from the general history of science, or from the history of the knowledge of individual minds, the same succession of ideas marks the advance which is gradually being made. First, the ideas of matter and force are considered to be completely separable; secondly, they are held to be incompletely separable; and, lastly, these ideas are found to be completely inseparable the one from the other.

When all idea of life is excluded, the present state of our ideas regarding the union of matter and force may be summed up in the following formulæ. Where matter is, there force must be, showing itself in motion, or tension, or in resistance. Without matter, no kind of motion, nor tension, nor resistance, occurs.

Turning now to the matters and forces in those sciences in which the idea of life is concerned, the question arises, What is the history of the progress of our ideas regarding the union of living matter and living force? As regards the biological sciences in general, or as regards the biological knowledge which each individual acquires, are these three stages here also recognisable? First the complete, and secondly the partial separation of our ideas regarding living matter and living force; and is there a third stage, in which there is a perfect inseparability of the ideas of matter and force? Has our biological knowledge passed, or is it passing, through these three stages? Will the biological sciences follow in the footsteps of all other sciences? Will they share with them in the extent and rate of progress which will result from clearer and more connected ideas regarding matter and force?

Before I proceed, let me state most distinctly, that what I shall say regarding Life will not apply only to man, but will be just as truly applicable to every other class of animals down to the infusoria and protozoa, and, beyond these, to the whole extent of the vegetable creation, in which no reason, no mind, no soul, can by any stretch of the imagination be supposed to exist. In this theatre, at least, there can be no fear of misapprehension, no danger of mistake, from any confusion of our ideas of life with our ideas of the immortal soul. And, however much these ideas may be generally confounded and indistinct, to us at least the question whether, first, a peculiar vital spirit can temporarily lodge in the matter of the body; or whether, secondly, a peculiar imponderable vital fluid can temporarily be diffused through the matter of the body; or whether, thirdly, a peculiar form of motion of the matter of the body is all we can recognise as constituting life,—each and all of these questions, I say, can never be considered by us to have anything whatever in common with any question regarding the existence of the immortal soul.

Let us, then, proceed to the primitive stage of ideas regarding the union of matter and vital force.

In the earliest Jewish record, the same separation may be traced between vegetable and animal matter and life as between carthy and watery matter and light. The separation between matter and force is most distinctly stated in the highest of all organised beings. We read that man was formed of the dust of the ground; and, after he was formed, the breath of life was breathed into his nostrils. This is probably the oldest idea in existence regarding the nature of the vital force. It was a something added to the matter of the full-formed man. The body was without force until the life was given. The idea of the force is distinctly separable from the idea of the body, just as the idea of light was distinctly separable from the idea of the sun. This, then, is the earliest statement of the first stage of ideas regarding the union of matter and force. In it, perfect separation is supposed to be possible between matter and living force. If the Book of Genesis be a revelation of physical science by the Almighty to man, then the existence of vital force separate from the full-formed body is true, and must be believed; but if this book, so far as regards science, represents only the existing state of knowledge at the time when it was written, as is shown by the facts mentioned in it contradicting the revelation which the Almighty has made in his works,* then, whatever may be the interest we feel in the earliest record of scientific knowledge, still it cannot be allowed to possess any scientific authority in determining what is the true relation of matter and living force.

By the early Hindus, the human soul, or life, was thought to be a portion of the Supreme Ruler; as a spark of the fire; as a part of the whole. After transmigration, the spirit was thought to be utterly re-absorbed into the divine essence. The vital powers, and the elements of which the body consists, were both considered to be absorbed absolutely and completely. Both name and form ceased. Immortality without members or parts began.† The Brahman of the old religion and the Buddhist of the reformed religion rejected entirely the idea of the personal immortality of the matter of the body; but they differed completely in the idea of the state in which the separated spirit ultimately existed. In the reformed religion, Narvina, or utter annihilation, was the ultimate aim of the human spirit.

The Egyptians took a different view of matter. "The conservation of the body was essential to the vigour and felicity of the soul; hence embalming, in order that the spirit may have something on which to lean for help. In virtue of the strength afforded to the spirit by this union with the former cause of her vitality, she continued to exist in some analogous condition—disembodied, but still associated with her previous tenement, and still in some mysterious fashion living by its life." (Hardwick, vol. ii, p. 297.) The tombs and pyramids and sphynxes were made to protect the body while the spirit went to Amenhe, to be judged by Osiris, either to be returned to some animal shape on earth, or to pass into a state of permanent felicity in the sun. One chief part of the religion of the Egyptians consisted in the worship of the dead. They prayed to the authors of their bodies. They buried with them food, dress, and implements of war, business, and pleasure. They even made the spirit into a peculiar material substance, and did not consider it as a purely spiritual essence.

Confucius taught the Chinese duty to parents while they lived, and to give sacrifices to them when dead. They worshipped their ancestors, as beings capable of giving aid and counsel to the deserving, and inflicting vengeance on the unworthy. They gave them food, clothes, and even gilt paper-money. Confucius said the body consisted of two principles—the one light, invisible, and ascending; and the other gross, palpable, and descending; and that, on the separation of these two principles, the light or spiritual part ascended into the air, whilst the heavy or corporeal part sank into the earth.

* The contradictions between the first Book of Genesis and the revelation given in God's works, are seen in the statement—1, that day and night and light existed before the sun was made; 2, that darkness was as much an entity as light; 3, that the moon had a light of its own like the sun; 4, that the firmament divided the waters from the waters—in other words, that there was water compared to the sea above the heavens; and 5, in the particulars regarding the order and time of creation of inorganic and organic things. Similar or identical ideas are met with among other nations and tribes before the dawn of natural knowledge. The supposition that an untrue revelation was willingly made by omniscience in consequence of the ignorance of the Jews, is far beyond all possibility of belief.

† "From the doctrine of emanation sprung up the doctrine of transmigration. The human spirit may be united with the lowest species of organic life, may ascend in successive births into the bodies of spiders, snakes, and chameleons, until deemed worthy of inhabiting a human tenement. Then an opportunity is given it of achieving its own liberation; and, according to the present quality of its actions, it will mount directly upwards through the ranks of demigods and gods, or plunge again into the lower region of existence, and commence a fresh series of births. The great object of Brahmical or Buddhist religion, is the discovery of the means of putting a stop to further transmigration; the discontinuance of corporeal being; the liberation of the soul from the body."—Archdeacon Hardwick, vol. ii, p. 295.

The Greeks personified their idea of life, and confused it with motion, matter, and mind. Thales thought that there must be a living soul, a vital principle, in amber and the magnet, because they have a moving force. Anaximenes thought the air was an ensouled and ensouling force, and that it was the life of the body. Heraclitus of Ephesus admitted no distinction between fire, life, and the soul. Man's soul or life was an emanated portion of the universal fire or universal reason which encompasses the heaven and rules all. Democritus maintained that the vital principle and mind were absolutely identical.

If we look at the belief of savages, we find that the Maoris worship departed ancestors, because their spirits could exercise vengeance and inflict injuries (after the fashion of witches). The chief had his bow and arrows buried with him, that he might go forth at night to his old calling. He was made a god, and went to battle for his kinsmen. He was hovering near them in the hours of gloom, of peril and privation. He was spoken to as a familiar friend, and was given offerings of betel and tobacco, and appeared personally in the sacred house to the living chief of the tribe. The extent to which they separated and personified their ideas of force is seen in the fact that they supposed each disease was caused by a different god, who resided in the part affected.

Livingstone says (p. 642) that some of the southern tribes of Africa not only believe in the transmigration of souls, but think that, while persons are still living, they may enter into lions and alligators, and then return again to their own bodies.

Thus, then, in Hindustan, Egypt, and China, and among the wild tribes of New Zealand and Africa, the idea of the separation between body and spirit was distinctly held. The spirit of the deceased ancestor was believed to linger for a certain period near the place of burial, and to be pleased or displeased by the offerings made to it. After a time, it began to pass through the different forms of matter to which it was to be temporarily attached.

At the time of the revival of knowledge, the perfect separation of the ideas of life and body prevailed universally. Thus Van Helmont considered that the body contained a presiding spirit or *archæus*. Paracelsus considered this *archæus* lived in the stomach. Stahl taught that the body, as body, has no power to move itself, but must be always put into motion by an immaterial substance. The cause of all activity, he said, was an immaterial being, which he called the soul. Harvey (ed. 1766, p. 294) has a chapter headed "Ovum non esse opus uteri sed animæ". Looking at the great operations which go on in the egg, he says we must agree with the poet—

"Spiritus intus alit, totamque infusa per artus
Mens agitata molem."

He carries us, in the idea of life, far beyond cells, nuclei, and germinal granular matter, even as far as flatulence, when he says, "Aliquique etiam flatibus vitam quandem atque ortum et interitum inesse arbitrantur." He ends this chapter on the egg thus: "Quibus ritè pensatis propriam illi inesse animam concludimus."

At the present time, the popular idea is, that no distinction exists between the life, the mind, and the soul of man; all are confused together; and all are thought to compose a single immaterial spirit, which comes at birth and goes at death, being perfectly separable from the matter of which we are made.

Thus, in the earliest ideas of all nations, and probably of all individuals, no doubt whatever exists as to the entire separability of the ideas of matter and of vital force; and the first stage of ideas in the biological sciences is identically the same as the first stage in those sciences into which the idea of life does not enter.

As the second stage of ideas in the abiological sciences consisted in the assumption of an imponderable matter, which was considered to be separable from the ponderable matter, and diffusible through it, giving rise to the phenomena of force in every part; so the second stage, or partial separation in the ideas of living force and matter, is marked by the assumption of a living imponderable gas or fluid pervading the ponderable matter. This stage, from the renown of him who gave it the greatest support, may well be called the Hunterian stage. Even Asclepiades and Galen spoke of a subtle humour or spirit existing in the body, which they compared to air. The chemical tendencies of the seventeenth century led to the supposition that it was sulphureous or nitrous acid; and, soon afterwards, it was compared to an æther. Even Newton, in the twenty-third query, says, "Is not vision performed by the vibrations of this medium æther at the bottom of the eye, propagated by the solid capillamenta of the nerves to the place of sensation?" and in the twenty fourth query, "Is not animal motion performed by the vibrations of this medium æther?"

The idea of a vital fluid, a material substance of extreme subtlety, volatility, and energy—in other words, a subtle ætherial fluid diffused through the frame, enabling it to show all the phenomena of life—was

taught by Hofmann. This imponderable fluid was even so far personified or incarnated, that each particle of the vital fluid was believed to have a determined idea of the whole mechanism and organism; and, according to this idea, it formed the body, and preserved it by its motion. As the idea of an electric fluid or fluids became stronger, so the idea of the vital fluid was made more scientific by imagining it to be similar to or even identical with the electric fluid.

John Hunter said "the living principle of the blood is the *materia vite diffusa*, of which every part of an animal has its portion. It is as it were diffused through the whole solids and fluids, making a necessary constituent part of them, and forming with them a perfect whole, giving to both the power of preservation and the susceptibility of impression, and, from their construction, giving them consequent reciprocal action." (Hunter's *Works*, vol. iii, p. 115.) Again, he says, "The blood has as much the *materia vite* as the solids, which keeps up that harmony between them." (P. 115.)

Instead of a single vital fluid capable of being an imponderable of all work, many different vital fluids, each capable of doing its own work and no other, were assumed. The most remarkable of all these was the nervous fluid. Glisson describes the vital fluid residing in the nerves as resembling the spirituous part of white of egg. Whether this was carbonate of ammonia or sulphuretted hydrogen, must be undetermined. Even Cuvier, in the introduction to the *Règne Animal*, p. 30, says: "There is great probability that it is by an imponderable fluid that the nerve acts upon the fibre; and that this nervous fluid is drawn from the blood and secreted by the medullary matter." Johannes Müller taught that the nervous agent differed entirely from electricity or light, but was either an imponderable matter, or the undulations of a fluid capable, like electricity through copper, of travelling at the rate of nearly three hundred thousand miles a second, or, like light through the interplanetary æther, at two hundred thousand miles a second. The researches of Helmholtz show that the rate of passage of that motion through the particles of matter in a nerve which gives rise to sensation or to motion is only between twenty-eight and thirty-three feet in a second. So late as 1866, Professor Bain, in a lecture at the Royal Institution on the Correlation of Force in its Bearing on Mind, speaks of a certain flow of the influence circulating through the nerves.

Another very remarkable vital fluid was considered to be a chemical agent, an elementary principle, or highly attenuated substance, which, among its other singular and remarkable properties, has that of imparting to the constituent matters of the animal frame new chemical affinities between it and the surrounding elements, and thereby protecting the living fibre from dissolution, or giving them other properties which, without this vitalisation, they would not possess.

Out of many other examples, I will take two most interesting chemical discoveries, not yet fully completed, which show in a striking way how many so-called vital actions, as knowledge advances, may be included among ordinary chemical or physical actions.

The first of these discoveries is respecting the coagulation of the blood. Hunter said (vol. iii, p. 113): "As the coagulation of the blood appears to be that process which may be compared with the action of life in the solids, we shall examine this process a little further, and see if this power of coagulation can be destroyed. If it can, we shall next inquire if by the same means life is destroyed in the solids, and if the phenomena are nearly the same in both." "Coagulation," again he says, "I conceive to be an operation of life corresponding to the convulsion of muscles which takes place at the moment of death." "The blood loses the principle of coagulation, and, I suppose, life." (P. 115.)

Alexander Schmidt has found that fibrine is formed by the contact of two albuminous matters. One he calls fibrinoplastic, and the other fibrinogenic. The first is especially plentiful in the red corpuscles, the serum of the blood, the cellular tissue, and the cornea. The second is found in exudations, especially in the pericardium and fluid of hydrocele, in lymph and chyle. When these two substances come into contact in any fluid, they combine quickly or slowly, according to the greater or less quantity of each substance, to form fibrine. The action takes place more quickly at a high temperature, more slowly at a low temperature. You see these two substances here. The paraglobulin or plastic substance has been obtained from serum or blood-corpuscles; the fibrinogenic substance from pericardium-fluid. Apart, they never form fibrine. When mixed together, they form it quickly, as you see.

All idea, then, of a vital action in the coagulation of the blood must be given up, although much more has to be made out of the chemistry of these substances, and especially of the paraglobulin, which is, according to Professor Brücke (*Proceedings of the Imperial Academy of Sciences*, May 23, 1867), a mixture of two substances, one of which acts as the fibrinogenic matter. Those who still think that vital action must be concerned in the coagulation of the blood will probably say that it is

the principle of life that stops the mutual action of these two substances in healthy circulating blood. The chemist will before long solve the problem why these two substances do not always act upon one another, since they can both be got out of the blood. The most probable answer is, that there is some slight difference of composition between these substances in circulating blood and as we obtain them from blood that has been drawn from the body. The fibrinoplastic substance is rapidly acted on by ozone. The fibrinogenic substance also is rapidly changed after it is formed, so that possibly the necessary quantity of these substances is not given the necessary time to act upon one another for the production of coagula.

The second of the unfinished discoveries which I wish to bring before you relates to the subject of digestion. In Dr. Prout's *Bridge-water Treatise* (p. 493), he says: "The stomach must have the power of organising and vitalising the different alimentary substances. It is impossible to imagine that this agency of the stomach can be chemical. This agency is vital, and its nature is completely unknown." In his work on *Stomach and Renal Disease* (5th ed., p. 490), he says: "The third or vitalising function may in some instances be suspended or otherwise deranged. Thus, when more food is taken by healthy individuals than is required for the purposes of the animal economy, there is reason to believe that, however perfectly the superfluous portion of the aliments may, for the sake of enabling them to pass through the system without producing great disorder, be dissolved and converted, the vitalising function is withheld; and that such superfluous matters are finally eliminated either with the bile or in the form of lithate of ammonia in the urine." In short, excess of urates in the urine after a large meal may depend on a want of vital action.

Some late researches of Kühne on the action of the pancreas (Virchow's *Archiv*, vol. xxxix, p. 130) appear to me to promise the solution of the problem why a portion of the albuminous food passes off as urates in the urine, whilst the larger portion remains as albumen in the blood. Kühne shows that albuminous and fibrinous substances when subjected to the continuous action of the pancreatic juice give rise to tyrosine, leucine, and an aniline-like substance in much greater quantity than happens when albumen is fused with potassa, or boiled with sulphuric acid, or allowed to decompose. Here is tyrosine thus prepared by the action of the pancreatic juice. It seems in the highest degree probable that, when an excess of albuminous food is taken, then, in consequence of the slower absorption, a portion of it remains long exposed to the action of the pancreatic fluid, and this continued action of the pancreatic fluid on albumen produces substances which are able, more or less immediately, to form uric acid.

The relation of some of these substances is seen in the following table:—

Tyrosine	=	C ⁹	H ¹¹	N	O ³
Creatine	=	C ⁸	H ⁷	N ³	O ⁴
Leucine	=	C ⁶	H ¹³	N	O ²
Uric acid	=	C ⁵	H ²	N ⁴	O
Urea	=	C	H ⁴	N ²	O

Measured by the carbon it contains, tyrosine is a higher product of albumen than leucine, uric acid, or urea. Whether it, or some other product from albumen in the blood or in the kidney, gives rise to uric acid, has to be determined. Certain it is that our chemical knowledge now entirely does away with all idea of any want of vital action, causing excess of urates in the urine, and a very slight advance will probably enable us to prepare uric acid in the laboratory from the albuminous substances.

The progress of animal chemistry proves more and more clearly that the matter in the body has no special chemical properties peculiar to life; but that matter within possesses the same chemical energy which it possesses out of the body. Life has no power to create or to destroy any chemical force in the matter of living things; but the very slightest difference in the circumstances under which any chemical action occurs, produces a variation in the effects that are produced. Ultimately, when all the circumstances under which vital chemical actions occur are fully made out, there will be found to be no difference between these actions and those which can be made to take place where no influence of life can be supposed to exist.

Another vital fluid, or principle, has been assumed to account for the phenomena displayed at the beginning of life in animal and vegetable bodies. Dr. Prichard says: "This vital principle assumes the character of a plastic or formative power. It presides over, and sets in action, the different processes by which growth and organisation are effected; and gives form and modification to the components parts of the animal and vegetable body, and contributes afterwards by a preserving influence to the maintenance of its existence for a definite portion of time. This doctrine ascribes to a thing which is supposed to be merely

a species of matter highly attenuated, properties and agencies which belong to the highest power and the highest intelligence." It appears, then, that, in the biological as in the abiological sciences, ideas of the union of matter and force have gone, or are going, through two identical phases. As in the abiological sciences the earliest ideas of matter were quite separate from the ideas of force, so vital force, in the first stage of our ideas, was originally pure spirit, void of all materiality, perfectly separable from matter.

In the second or transition stage in the abiological sciences, force was imperfectly separable from matter. Force was itself a highly attenuated volatile substance, an imponderable elementary principle; or the force was inseparably united with an imponderable fluid, gas, or æther, which gave to ponderable matter its energies whilst the union lasted. In the second, or transition, or Hunterian stage in the biological sciences, the vital force is either itself an imponderable solid, fluid, gas, spirit (*geist*), or ghost, or it is inseparably attached to an imponderable matter which can temporarily be diffused through ponderable matter.

In my next lecture I shall show you that the abiological sciences are far in advance of the biological sciences in the extent to which the third stage of ideas of the perfect union of matter and force is held to obtain. I shall try, also, by some examples in physiology, pathology, and therapeutics, to show you that in this third stage of perfect inseparability of matter and force, and in the principle of the conservation of energy, "we have," in the words of Mr. Faraday, "a new stimulus to investigation and a pilot which will lead to discoveries far beyond the region to which our present biological knowledge extends."

A CASE OF SYPHILITIC ULCERATION OF THE THROAT TREATED WITH SULPHUROUS ACID.

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WE are indebted to Dr. Dewar of Kircaldy, and Mr. Pairman of Biggar, for bringing more prominently under the notice of the profession, the various uses of sulphurous acid as a therapeutic agent; and several cases have been recorded in the medical journals in which this remedy has effected speedy cures. The following case, I think, testifies to its value.

Mr. Robert W., aged 30 years, consulted me on August 17th, 1867, for a hard chancre of a few days' duration, situated at the corona glandis, which I touched with strong nitric acid, and prescribed "black-wash" as a local application, with the green iodide of mercury internally. Under this treatment, he was apparently cured, and I lost sight of him till the following November. I may mention, he told me that about four years previously he contracted a chancre, and which was quickly followed by a bubo. The medical man he then consulted prescribed "Plummer's pill," and which occasioned profuse salivation. I again saw him in November, and found that he was labouring under a syphilitic affection of the throat, both tonsils and part of the pharynx being covered with an ash-coloured slough; he experienced great difficulty in swallowing, appetite bad, passed sleepless nights, and was extremely anxious about his present state of health; no cutaneous eruption visible. For upwards of eight weeks various remedies were tried, viz.: iodide of potassium, in ten grain doses three times a day, the bichloride and biniodide of mercury, gargles of chlorate of potash and alum, and solution of the nitrate of silver, twenty grains to the ounce, with opium at night to procure sleep. This treatment only checked the spread of the disease, which remained in *statu quo* till the middle of January, when I happened to see recorded in the *Lancet*, for October, 1867, a case, in which a patient of the London Hospital was treated for syphilitic ulceration of the throat by the application of sulphurous acid spray. I thought Mr. W.'s case likely to benefit by the same treatment, and commenced using the spray to the affected part three times daily on January 25th inst. At first I applied it for a short time only, but, finding that it gave no pain, the end of the instrument was brought nearly in contact with the part affected, and the application of the spray continued for several minutes each time. On Saturday, February 15th, the throat was perfectly well, and there has not been any return of the disease since.

I have at the present time under treatment a gentleman suffering from a syphilitic affection of the tongue, in which I am applying the sulphurous acid spray with the best results.