6

Royal Institution of Great Britain.

WEEKLY EVENING MEETING,

Friday, May 26, 1865.

SIR HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. President, in the Chair.

HENRY BENCE JONES, M.A. M.D. F.R.S. Hon. Sec. R.I.

On the Chemical Circulation in the Body.

ALL our knowledge usually passes through three stages as it advances to perfection. First, a stage in which we think we know everything; then a stage in which we find we know nothing; and, finally, a stage in which we rapidly obtain those clear and connected ideas in which all sound knowledge consists.

As regards the absorbent system of animals and the mode of action of remedies, we have long been in the first or second stage, and this evening I hope to show you that there is reason for believing that in regard to these subjects we are about to enter on the third stage; for that, in addition to the circulation of the blood, there is the dawn of another or chemical circulation, dependent in part on the mechanical circulation, but carried on mostly by diffusion from the blood into the textures, and from the textures into the absorbents, which thus become necessary agents for performing those actions of oxidation and nutrition on which, in great part, animal life depends.

Mr. Huggins, in his discourse last week, showed us how the spectrum-analysis can determine the chemical composition and the physical constitution even of substances outside those circulating bodies that constitute our solar system. And as the nebulæ and fixed stars are beginning to be analyzed, so in the microcosm of our own bodies substances that are outside the circulating system of the blood can (by the peculiar light they give when burnt) be analyzed with such delicacy that elements can now be therein discovered which all other modes of analysis would entirely overlook.

The human body, in this discourse, may be regarded as consisting of four parts—a funnel, a circle, an envelope, and a drain.

The laws of diffusion modified by pressure determine the passage of all substances from the funnel into the circulation, from the circle into the envelope, and from the envelope or circle to the drains. To Mr. Graham we owe the investigation of the laws of diffusion of gases and liquids; and the division of substances into crystalloids and colloids. One or two experiments, and for them I am indebted ot Mr. Ansell and to Mr. Graham, will make the meaning of these terms more clear to you. Inside and outside this porous cell there is at present atmospheric air. There is no passage of the outer air into the inside of the cell, nor of the inside air to the outside of the cell; but if hydrogen is put outside, being lighter than common air, it rapidly passes into the inside of the cell, whilst the heavier air inside more slowly passes out; and thus pressure is produced inside the cell, and the index shows how much pressure exists. So also with this india-rubber ball. When the gases inside and out differ, the lighter gas will pass rapidly in, and such an alteration of form will occur that a spring will be liberated and this bell will say that light gas has passed through the india-rubber ball. Mr. Ansell has invented this test for the explosive gas in coal mines, that it may ring its own alarm. In these beautiful illustrations of Mr. Anderson's the same excess of diffusion of the lighter over the heavier gas is shown more slowly. Originally over both jars the india rubber was flat. But through this concave india-rubber the hydrogen has more rapidly passed out than the air has passed in; and through the convex rubber the hydrogen has more rapidly passed in than the atmospheric air has passed out.

So with these liquids, for which I am indebted to Mr. Graham. Here is a very diffusible crystalloid substance, acetate of rosaniline, or magenta; and in this other vessel there is a much less diffusible or colloid substance, cochineal. In half an hour the crystalloid will pass through the membrane, whilst the colloid will show no signs of passage.

Here is another semisolid contrast. In the one jar there is bichromate of potash in gelatine above, with pure gelatine below; and in the other cochineal in gelatine above and pure gelatine below: the bichromate diffuses whilst the cochineal is unmoved.

The same laws of diffusion modified by pressure determine in the body the passage of substances from the funnel into the circulation, from the circulation into the tissues or ducts, and from the tissues back through the absorbents to the circulation.

The circulation must not be regarded as the stem of a tree curled round on itself, but rather as a series of circles formed by each terminal branch-twig joining a terminal twig of the root. The enormous number of these terminal circles may be seen in any injected preparation of any part of the body. The whole substance seems to consist of these vessels alone. The walls of these vessels are of the finest membrane, through which diffusion takes place with the greatest rapidity into the tissues beyond the circulation. These tissues constitute the different organs of the body, nerves, muscles, glands, ligaments, bones, &c.

Each particle of each nerve, muscle, or gland, is encompassed by blood-vessels on which its growth and its action depend; but there are some few spots in the body where blood-vessels would be dangerous to the function of the part. These parts may be called the fixed stars of our microcosm, they seem outside the circulating system which binds together the rest of the body.

The most numerous of these fixed stars are the cartilages of the joints; and at a far greater distance may be placed the most remarkable twin stars of our body, the crystalline lenses, which, without any circulation of their own, are separated from all circulation by an aqueous and glassy fluid, which themselves also have no circulation. The lenses then might well be thought to be altogether free from all the multitude of disturbing substances that enter through the funnel into the circulation of man. By this model, perhaps, you will best realize the distance of the lens from the circulation of the blood.

The lenses, the humours of the eye, and the cartilages of the joints, thus constitute the parts of the envelope most distant from the vessels, whilst the proper tissues of the various organs of the body constitute the parts of the envelope most immediately touching the circulation. The absorbent system and the ducts of glands constitute the drains by which substances that have passed out of the circle into the envelope are taken up into the circulation again or pass out of the body.

It has long been known that bile would diffuse into every texture; that madder would diffuse into the bones and into the fœtus, and urate of soda into the joints; carbazotic or picric acid into the skin; mercury into the gums; lead into the gums and muscles, and silver into the skin; and it has long been known that multitudes of substances would run through the funnel into the circulation and out through the envelope into some of the drains. Ether, asparagus, turpentine, and many other such substances require no mention here.

It occurred to me that both in animals and in plants* the spectrum-analysis ought to determine with certainty where diffusing substances go to; how long they are in going out of the circle into the envelope; how long they stay in the envelope, and how quickly they cease to appear in the drain; and with Dr. Dupré's help a long investigation into the rate of passage of crystalloids into and out of the textures of the body was undertaken. The delicacy of the spectrum-analysis may be seen in this table:—

Chlorate of soda . . .	$\frac{1}{195}$ millionth of a grain.
Carbonate of lithia . . .	$\frac{1}{8}$ "
Chloride of strontium . . .	1 "
Chloride of barium . . .	1 "
Chlorate of potass . . .	$\frac{1}{65}$ thousandth of a grain.
Chloride of lithium . . .	$\frac{1}{12}$ millionth of a grain.
Chloride of rubidium . . .	$\frac{1}{16}$ thousandth of a grain.
Chloride of cæsium . . .	$\frac{1}{125}$ "

* Cress sown on paper, when one inch high had the paper moistened wi h water containing a little chloride of lithium, in ten minutes and twelve minutes the lithium was detected in the leaves.

Soda exists everywhere, and in everything we eat and drink, so there was no use in looking for soda in the circulation and envelope, for it was sure to be there.

Lithia exists in many vegetable and animal substances, according to the soil on which they grow or live. Here is a table of substances which we examined for lithia :—

In potatoes—seldom found	In tea—slight traces
apples—sometimes	coffee—slight traces
bread—traces	ale—slight traces
cabbage—distinctly	porter—slight traces
Rhine wines—always	mutton—none
French wines—distinctly	beef—none
Sherry—distinctly	milk—none.
Port—distinctly	

It had already been found—

In sea water
kelp
spring water sometimes
ashes of wood grown in the Odenwald
Russian and other potashes
tobacco
vine leaves and grapes
ashes of the produce of the fields in the Palatinate
milk of animals eating the produce
ash of human blood and muscle
meteoric stones
all the drinking waters of London.

The spectrum of lithium is very characteristic and very perceptible, and some approximation to a quantitative determination may be arrived at by observing the amount of substance that requires to be burnt to obtain the reaction, and by the necessity, in some cases, for the removal of interfering substances previous to the combustion. Thus three degrees may readily be observed. The highest amount of lithia is present when each particle of the substance when introduced into the flame gives the lithia reaction; and a smaller amount of lithia is present when the whole of a lens or of an organ must be extracted with water to remove the lithia previous to the combustion; and the smallest trace is present when the substance has to be incinerated, the ash treated with sulphuric acid, the excess of acid driven off, the dry residue extracted with absolute alcohol, the alcohol evaporated and the dry residue tested. These three quantities may be designated as the slightest trace, a trace, and plenty.

As soon as experiments on man and animals showed that the infinitesimal quantities taken in with the food were rarely to be perceived in the envelope, experiments were made to determine how quickly the lithium diffused from the funnel into the blood circulation, and from the circulation into the envelope, and whether it was to be found in those distant parts of the envelope where no circulation existed, and especially in the lens of the eye.

The following table gives the experiments made when lithia in small quantity was poured into the funnel on the rate of its passage not only into the circulation, but out of the circulation into the envelope of a guinea-pig.

The rate at which chloride of lithium passes into the textures through the stomach:

1½ grain	in 3 days	plenty found everywhere.	
3 "	15 minutes	everywhere except in the lens.	
"	30 "	"	"
"	30 "	"	traces in the lens.
"	30 "	"	outer part of the lens.
"	60 "	"	"
"	60 "	"	except in the lens.
"	in 2½ hours	"	and throughout the lens.
"	4 "	"	"
"	8 "	"	"
"	24 "	"	"
"	26 "	"	"
¼ "	5¼ "	"	except in the lens.

It follows from these experiments that three grains of chloride of lithium given on an empty stomach, may diffuse into the cartilage of the hip-joint and the aqueous humour of the eye in a quarter of an hour. In very young and very small pigs, the same quantity of lithium may in 30 or 32 minutes be found in the lens of the eye, but in an old pig in this time the lithium will have got no farther than the humours of the eye. If the stomach was empty when the chloride of lithium was taken, in one hour the lithium may be very evident in the outer part of the lens and very faintly in the inner part; but if the stomach be full of food the lithium does not in an hour reach the lens. Even in two hours and a half the lithium may be more marked in the outer than in the inner part of the lens. In four hours the lithium will be in every part of the lens, but it will still be more evident in the humours than in the lens. Even in eight hours the centre of the lens may show less than the outer part. The lithium will be found in as great quantity in the centre of the lens as in the outside after twenty-six hours.

When instead of being put in by the funnel, the lithia was injected into the skin: three grains of chloride of lithium in 24 minutes showed the lithium in the lens and in every texture; in 10 minutes slightly in the lens but plenty everywhere else; in 4 minutes no lithium was in the lens but plenty in the aqueous humour of the eye and in the bile; one and a half grain in five minutes showed no lithium in the lens but plenty in the aqueous humour and in the bile.

Having thus shown that lithium will pass everywhere into the textures in between 4 and 15 minutes, when injected into the circulation, and between 15 minutes and 26 hours when taken in by the funnel, some experiments were made to determine after how many days the lithium ceased to be detected in the envelope after it had been taken. Usually three pigs were taken: to one no lithium was given, the second was killed in a few hours after a dose of lithium, and the third was given the same dose and killed after many days.

The following Table shows the rate at which chloride of lithium passes out of the textures :—

2 grs. in 6 hours gave plenty everywhere.	In 6 days gave no trace in the alcoholic extract of the kidneys, livers, or lenses.
,, — ,,	,, ,, ,,
,, — ,,	,, 4 days gave none in the lens.
1 gr. in 5½ hours showed partly in the lens.	,, 3 days gave faint traces in the lens.

It follows from these and other experiments that twice in six days and once in four days two grains of chloride of lithium, which in six hours gave lithium everywhere, in six days ceased to be detectable in the lens, and that even in three days the lithium is most probably diminishing in the lens.

Having thus gained a clear knowledge of the time it takes for a small quantity of lithia to pass in and out of the envelope of an animal, I proceeded, through the kindness of my friends Mr. Bowman and Mr. Critchett, to trace the passage of lithium into that part of the envelope which is most distant from the blood circulation in man. Lithia water is by no means an unpleasant drink, and a few minutes, or a few hours, or a few days before the operation for cataract, twenty grains of carbonate of lithia dissolved in water were taken.

No less than seven cataracts were previously examined with the greatest care, to determine whether lithia was usually absent, and in only one instance was the very faintest trace of lithium detectable.

The following Table shows the rate of passage of carbonate of lithia into and out of cataracts—

20 grains of carbonate of lithia were taken

25 minutes		before the operation	—No trace of lithium was found in the cataract.
2½ hours		,,	—Lithium in the watery extract of the cataract.
3½ ,,		,,	—Lithium in each particle.
4 ,,		,,	,, ,,
4¼ ,,		,,	,, ,,
4½ ,,		,,	,, ,,
5 ,,	(old man)	,,	,, ,,
5 ,,		,,	,, ,,
7 ,,		,,	,, ,,
4 days	{spontaneous soft cataract, 25 to 30}	,,	—Traces in alcoholic extract of ash.
7 ,,		,,	—In alcoholic extract not the slightest trace of lithium.
7 ,,	5 hours	,,	,, ,, ,,
7 ,,		,,	—Slightest trace in the alcoholic extract.

It follows from these experiments, that in the human body twenty grains of carbonate of lithia poured into the funnel in two and a half hours will have partly passed into every particle of the envelope and beyond the blood circulation even into the most distant parts, and in three and a half hours it will be more distinctly present in each particle of the lens.

In four days it will still be distinctly present in each particle of the lens.

In five days it will have begun most clearly to pass out of the lens, and in seven days scarcely the smallest trace will be detectable there. The most striking experiment was in the case of a young girl with two soft cataracts. She took twenty grains of carbonate of lithia, and in seven hours one lens was removed, and the smallest particle of the lens showed the presence of lithium. The other cataract was not removed for seven days after the first operation; then not the slightest trace of lithium could be found in the lens.

A long series of experiments on the passage of lithium out by a drain, after it had been taken in by the funnel, showed nearly the same fact, namely, that after a dose of twenty grains, the lithium was not entirely thrown out of the body under six, seven, or eight days.

Thus, then, both in animals and man the same law obtains. A single dose of lithium in a few minutes passes through the circulation into all the ducts and into every particle of the body, and even into the parts most distant from the blood-circulation.* There it remains for a much longer time than it took to get into the textures, probably for three or four days, varying with the quantity taken; then it diminishes, and finally, in six, seven, or eight days, the whole quantity is thrown out of the body.

In animals it is very difficult accurately to determine the time when a single dose is removed, for a portion passes out in the perspiration and gets into the hair, and the animal thence re-doses itself with the lithium which had already passed through the blood-circulation into the envelope and out by the skin drain, and this re-dosing may be continued over and over again, so that even for thirty or forty days, after a dose of three grains, some lithium may be detected in guinea pigs still passing out of the body.

Having thus traced the lithium in and out of the envelope the question of far greater importance remains—What does the lithium or other alkaline salt do whilst it is in the envelope? In other words, What is the action of alkalies in the system? What is the action of carbonated alkali at a temperature of 38 C. (100 Fahr.) when oxygen at the same time is present, on 1st, organic acids; 2nd, neutral hydrocarbons; 3rd, fatty matter; and 4th, albuminous substances.

The most remarkable instance of the action of alkali when organic acid and oxygen are in contact is in the decomposition of pyrogallic acid. In this vessel I have oxygen and pyrogallic acid in contact, and no action takes place and none would take place if alkali were not added; but immediately on the addition of potass, action begins, the pyrogallic acid is unable to keep its composition, and is burnt by

* When seven grains of carbonate of lithia were given eight hours before delivery, the lithium was detected in each particle of the umbilical cord.

the oxygen aided by the alkali. More stable acids of lower composition are produced, and these combine with the alkali and liberate carbonic acid. If carbonated instead of caustic alkali be used, the action is not nearly so rapid or complete as with caustic alkali.

The best example of the destruction of a neutral hydrocarbon by oxygen aided by alkali is in the reduction of oxide of copper by sugar. The metallic oxide furnishes the oxygen, the alkali assists the formation of acid in the sugar, and draws it out of the sugar destroying the neutral compound.

In fatty matters the alkali splits the fat into fatty acid and glycerine, and forms a soap with the acid. Oil of bitter almonds exposed to common oxygen or ozonized oxygen absorbed in two hours two cubic centimetres of oxygen; with carbonate of soda it absorbed in the same time ·2,75 CC. When mixed with an alcoholic solution of potash, and heated benzoic acid combines with the potash, and the whole contents of the tube solidify; the alkali causes the oxidation of the oil; and by extreme oxidation carbonic acid and water would be the final results.

The action of alkali and oxygen on albuminous substances at low or moderate temperatures, 100 Fahr., has not been yet studied. At high temperatures with alkali the entire decomposition of the substance with the production of carbonic acid and ammonia, and a multitude of less perfect products of oxidation have long been known; the same substances oxidized at a higher temperature without the presence of alkali give rise to fewer intermediate products, and to a greater amount of the ultimate products of oxidation, *viz.* water, carbonic acid and ammonia, out of which the albumen was originally formed.

M. Béchamp stated that by the oxidation of albumen by manganic acid urea was produced, but this proved to be benzoic acid; and probably kreatin, uric acid, urea and other products will not be obtained from albuminous substances until we follow the method of oxidation that occurs in the body, *viz.* a temperature of 38 C. (100 Fahr.) a moderately strong solution of carbonate of soda and basic phosphate of soda, and the action of oxygen possibly in an ozonized state.

Von Gorup Basanez (Liebig's Annalen, vol. cx. p. 86, and cxxv. p. 207) has traced the action of ozone at ordinary temperatures on a multitude of animal and vegetable substances, but of these my time allows me to mention only one or two striking examples.

Cane or grape sugar when in contact with ozone undergoes no change, but where grape sugar is exposed to ozone with potass, soda, or carbonate of soda, it is entirely oxidized, and carbonic and formic acids only result. When no alkali is present no action occurs. Cane sugar oxidizes with alkali and ozone much slower than grape sugar.

Olein is quite inactive when exposed to ozone, but with potass or carbonate of soda the olein is immediately oxidized. The olein is saponified and the glycerine is oxidized into acrolein and ultimately into carbonic, formic, and propionic acids. The oleic acid is much more slowly oxidized into formic and carbonic acid.

Hence the action of alkalies out of the body on the different classes of substances of which we are built up is sufficiently clear. The alkali disturbs the equilibrium of the elements in the organic body by its affinity for acids. Aided by oxygen and heat, more or less complex acids are formed from the neutral substances, and if the action of the alkali is sufficiently continued, carbonic acid water and ammonia alone remain.

The progress of therapeutics probably depends on the application of our knowledge of the action out of the body of different medicines on the different chemical constituents of the body, to the explanation of the action of the same substances on the components of the textures in the body.

I have shown you how alkali out of the body promotes oxidation. The chemist can have no doubt that the same action takes place in each particle of the textures to which the alkali is carried. Thus carbonate of lithia, soda, and potass, lime, magnesia, rubidium, cæsium, are indirectly oxidizing agents, increasing chemical action in the different substances of which the textures are composed, according to the amount of the different alkalies that can diffuse into the textures, according to the different properties of the substances capable of oxidation that happen to be in the textures, and according to the amount and active state of the oxygen present and the amount of heat that assists the action, and according to the facilities for the removal of the products of the combustion.

Chloride of rubidium and cæsium we have proved to follow the same law as chloride of lithium, in that these substances pass into the crystalline lens, and can be detected there ; but the evidence is much less distinct than in the case of lithium, so that the rate of the passage of these substances in and out of the textures cannot so easily be determined. Twenty grains of chloride of rubidium, and the same quantity of chloride of cæsium were necessary to give traces of the spectrum reaction for these substances in the lenses of guinea pigs.

There can be no reasonable doubt that as alkalies pass in, so we shall prove that vegetable acids, if not stopped by the alkaline fluid that is contained in the circulation, will pass into every particle of the textures, and when there these acids must have exactly the reverse action to alkalines. By lessening the alkalescence of the tissues, vegetable acids must tend to stop the oxidizing process.

As starch, sugar, and alcohol may be looked upon as becoming in the body vegetable acids, there is here a vast field for research, for there can be no doubt that the sugar and alcohol of our food pass at least as quickly as alkalies into the vascular and non-vascular textures of our bodies.

How far mineral acids can penetrate into the textures cannot be determined, and it may well be doubted if they reach the textures at all, although, by rendering the blood less alkaline, they must indirectly render the diffusing fluid in the textures less alkaline also.

Alkaloids we hope to detect diffusing into the textures in the same way, if not at the same rate, as alkalies. How they act on the different components of the textures of the body, chemistry at present has not determined. The action of alkaloids on sugars, fatty matters, and albumen at first sight appears altogether unproved. There exists in the brain and nerves a substance discovered by Dr. Oscar Liebreich, and named by him protagon ($\mathrm{C}_{116} \mathrm{H}_{241} \mathrm{N}_{4} \mathrm{O}_{2} \mathrm{P}$). It gives rise to neurin ($\mathrm{C}_{5} \mathrm{H}_{13} \mathrm{N}$), glycerin-phosphoric acid and a fatty acid, when treated with alkali; and this substance, of which $\frac{1}{10000}$th forms a strong jelly with water, may be acted on by the alkaloid, and thus form a nerve substance, having very different physical and chemical properties from the protagon in its unaltered state.

Even the action of ammonia in the different tissues of the body is not yet made out. In the 'Phil. Trans.' part ii., 1851, p. 409, I have shown that in passing through the stomach into the blood, or when in the blood, ammonia is partially oxidized, and that the same oxidation happens when urea is taken, and probably when caffein and the alkaloids pass into the blood, but the action that occurs as soon as ammonia, urea, or alkaloids come into contact with the different substances in the different textures, and the rate at which these alkaloids are ultimately oxidized in the textures, has yet to be determined. The first effect of alkaloids is to increase chemical action; but the resulting chemical combinations that take place, and the alterations in the textures that are produced by ammonia, urea, and alkaloids are at present undetermined. Moreover, the alterations these substances occasion in the products of decomposition of the tissues, whilst being themselves finally decomposed and removed from the body, are still entirely unknown.

Judging from the action of alkalies, there can be little doubt that alkaloids in a few minutes diffuse into every texture, and act according to their powers on the different substances with which they come into contact. If our means of analysis were sufficient, they would be found probably for three or four or more days in the textures, generally much longer than the symptoms, which depend upon contrast, would lead us to expect.

Lastly, we have proved that some salts of the metals diffuse like chloride of lithium into every texture of the body. Three grains of sulphate of thallium we have followed in twenty-two hours into the crystalline lens, and into the cartilages, the nerves, the liver, and the kidneys. It may be doubted, perhaps, whether thallium is a metal; but the same fact we have also determined to be true of sulphate of silver by a very delicate galvanic arrangement.

In twelve days a grain and a quarter of sulphate of silver was given to a guinea pig. The ashes of the liver, kidney, and stomach showed silver fairly. The ash of the bile showed it rather less distinctly. The ash of the lenses showed only very slight traces of silver, but silver was there. The ash of the brain showed no silver.

And here again a vast field for inquiry is opened. What is the action of the metallic salts on the water, salts, hydrocarbons, fats, albuminous substances of which each tissue is built up? How do the metallic salts influence the oxidation and nutrition going on in the textures? The power of the salts of silver, lead, and mercury, &c., to form insoluble or soluble compounds with albumen out of the body seems to indicate the action of these substances on the albuminous matter in the body. A compound with the albumen may be formed which may check the action of the organ, or the metal may be reduced or form a sulphuret, as with silver salts, and may be deposited in the textures and there remain, rendering the organ useless, as with lead salts; or the metallic salt may set up a more active chemical change in the albuminous textures or substances with which it is brought into direct contact, and this chemical action may rise to that degree which is known as inflammation; and the salts of mercury may be taken as examples of substances possessing this action.

From this view of the rapid passage of crystalloid substances into the vascular and non-vascular textures of our bodies, there arises a feeling of surprise that under such constantly varying conditions, the different functions of the different parts can be carried on. There is, however, from these experiments, but little room to doubt that substances like water, alcohol, salt, and sugar, assisted by the mechanical circulation of the blood, can in a few minutes pass by diffusion into each particle of our textures; and if in them these substances must take part in the changes of matter and force that are proceeding there, according to the amount of substance that enters in, according to the chemical properties that the substance possesses, and according to the conditions and times during which the action proceeds.

Thus, this circulation of diffusion rises even to an equal if not to a greater importance than that other more mechanical circulation of the blood, which indeed, in two out of the four grand divisions of animals, is almost absent, and during the early weeks of our own fœtal life is entirely wanting; and in this chemical circulation we recognize a link between the lowest vegetable and the highest animal creation, since this diffusion is a necessary condition on which the chemical actions in both kingdoms of nature depend.

To sum up then, I have tried to show you that there are good grounds for believing that there exists within us, in addition to the mechanical or animal circulation of the blood, another, and a greater and a more strictly chemical circulation, closely resembling, if not identical with, that which obtains in the lower divisions of animals and in vegetables. A circulation in which substances continually pass from the outside of the body into the blood, and through the blood into the textures, and from the textures either into the ducts, by which they again pass back into the blood, or are thrown out of the body; or into the absorbents, by which they are again taken back into the blood, again to pass from it into the textures.

This chemical circulation leads directly to two most important inquiries:—First, whether substances that diffuse into this larger circulation act as they would do out of the body under somewhat similar circumstances upon the different substances with which they come into contact in the different textures; either promoting the formation of new compounds, or giving rise to decompositions in the substances that are present in the tissues.

And, secondly, whether the chemical force, which may have been latent for ages in the mineral and vegetable substances that can enter by our vegetable and mineral food and medicine into this larger circulation, may be so given out in the textures as to increase or diminish those actions of oxidation, motion, sensation, and growth, which almost, although not altogether, constitute that assemblage of correlated actions which we sum up in two words—Animal Life.

[H. B. J.]