Physiological fragments : to which are added supplementary observations to shew that vital and chemical energies are of the same nature, and both derived from solar light / by John Bywater.

PHYSIOLOGICAL

FRAGMENTS:

TO WHICH ARE ADDED,

SUPPLEMENTARY OBSERVATIONS,

TO SHEW

THAT VITAL AND CHEMICAL ENERGIES ARE OF THE SAME NATURE, AND BOTH DERIVED FROM SOLAR LIGHT.

BY JOHN BYWATER.

LONDON:
PUBLISHED BY R. HUNTER, ST. PAUL'S CHURCH YARD.

1824.

ADVERTISEMENT.

The supplementary remarks are chiefly intended to carry forward the hint thrown out at page 117, *that vital and chemical energies may be of the same nature; and by taking up the subject in this novel point of view, it has brought together an assemblage of facts and opinions which were never before associated and published.*

Although the inquiry was first instituted for the purpose of examining what are called the animalcules of vegetable infusions, yet it has so far extended itself as to embrace a sketch of magnetism, combustion, and the organization of plants and animals, and new views are offered on these subjects at the close of the essay.

That many of our popular theories are greatly embarrassed by various experimental results, must be obvious to the slightest examination; but whether we are arrived at a period sufficiently favourable for any great theoretic change is still doubtful; yet, new opinions can have no bad effect on science in general, if they are not prematurely converted into dogmatical theories.

As I have not compared the supplement with the former part of the essay, several expressions may have the appearance of repetition, and even give rather different views of the same subject; nevertheless, I have published them together, being convinced that such an amplification will shew more clearly how the inquiry has led to the speculative opinions contained in the additional observations.

ERRATA.—Page 21, line six, for *Burzelius* read *Berzelius*.

—— 61, seventh line from the bottom, for *visible* read *irritable*.

INTRODUCTION.

AT the present enlightened period, when new views and doctrines in physiology are received by the public with a liberal indulgence, perhaps it will not be necessary to offer any apology for publishing the new opinions contained in this Essay; but as they are of a very peculiar character, it may not be improper to state the circumstances which led to the experimental results on which they are founded.

Having been long impressed with an idea that the real character of what are termed *animalcula infusoria*, was not understood equal to what we might reasonably expect, from the great number of facts already pub-

lished, I commenced an inquiry in the summer of 1816, under a strong persuasion, that if the subject was carefully examined, a more favourable and satisfactory view of their nature and character might be obtained.

After having made a great number of experiments and observations, it became evident, that the little beings which had been considered as distinct animalcules, were congeries of still smaller animalcules or animated portions, and that it was to this peculiar principle of animation that all their strange phenomena ought to be referred. This conclusion, when connected with various other facts, gave rise to new views, and pointed out the probability, that this species of congregating energy might extend itself to the vegetable kingdom, and was the probable source of what is termed vegetable life; and by still extending the investigation, it appeared equally probable that a similar energy

is intimately connected with several processes belonging to the animal economy. Hence the subject became so extensively interesting, that I was induced, by its apparent importance, to pursue the inquiry, and, from a minute examination of a variety of facts, through some of their most extensive bearings, it appears extremely evident, that the small particles of bodies in general, when placed under certain circumstances, become, though probably in various degrees, possessed of an irritable or vital energy; and to the influence of these vitalized particles, perhaps, we ought to refer most, if not all, the physical changes which come within the reach of our inspection.

That the vitality of atoms has been a popular opinion in various countries and at different periods, is evident from the works of many able writers; but, as the conclusions of these early physiologists were chiefly

drawn from plausible conjectures, instead of experimental demonstration, they were subject to continual fluctuation. According to the learned Dr. Cudworth and others, this system has been generally called the Pure Atomical Philosophy, and is supposed to have originated about the time of Moses; it is believed, also, that neither he nor his immediate successors were strangers to its peculiar doctrines. This system, which some have ascribed to this learned lawgiver, supposes, that the particles of which bodies are composed, are not merely inert matter, but have received from the Deity certain qualities, which render them actively instrumental in promoting the physical economy of the world. "Democritus and Lucippus afterwards destroyed this rational simplicity, and mixed it with many extravagant notions." It also underwent various other changes, by Epicurus and his followers, all of whom, as well as Democritus and Lucippus, abandoned

it to the most fatal consequences. That an agency of this atomical nature pervades the visible creation seems so obviously probable, that even the followers of Mahomet have been roused into contemplation by its probability; and if we may credit the doctrines ascribed to some of their scholastic divines, they are peculiarly interesting, as these writers have supposed, that every atom belonging to a living sensitive body is alive, and endowed with sense and understanding. Nor have these opinions respecting the vitality of these extremely small portions of matter been confined to the ancients. It has been supposed, by the learned Leibnitz, that even the very smallest or ultimate particles of matter are endowed with a kind of active principle, and that each particle forms an individual centre of perception, from which it can perceive the beauty and fitness of the universe. The celebrated M. Buffon afterwards varied this supposed active energy of

matter, by asserting, that only a portion of the particles of matter were endowed with a principle of activity to which he ascribes every physical phenomena, and adds, that no change of circumstance can destroy the energy of these active particles. He also contends that their active influence is derived from a peculiar organic structure they individually possess, but supposes that other particles of matter, which he terms *brute* or *dead* matter, do not possess this organic structure, consequently are not endowed with these active energies. These views chiefly refer to what has been called the Atomical Philosophy; but the celebrated Mr. John Hunter has taken a view of the subject which seems better supported by experimental facts than any previous opinions. This physiologist contends, that every portion of vegetable or animal matter, which resists the common forces of chemical decomposition, is actually alive, or at least possesses a living

principle. To establish this opinion, he has brought forward a great number of curious facts and ingenious arguments; but as he was particularly anxious to prove that the blood possessed this living principle in an eminent degree, his chief attention has been directed to that object. One of his most powerful arguments in favour of this very *ancient doctrine*, is drawn from the coagulation of the blood, and the coagulating varieties it exhibits under different circumstances, as they correspond to many varieties which living bodies exhibit under similar circumstances, yet he seems well aware that it is a difficult thing for the mind to reconcile itself to the idea of a living fluid; and perhaps this very difficulty has been the reason why some physiologists have thought Mr. Hunter's theory obscure and visionary.

The idea that a vital principle pervades the vegetable and animal creation, is an

opinion which has been admitted in every age and country; but with respect to its source and nature, a great variety of notions have been promulgated at different periods. Some writers have supposed, that fire, and this principle, are derived from the same source, and are of a similar nature: others have supposed it to be derived from the sun. The principle of vitality has also been supposed to be a humid vapour, and that humidity was the active principle of all things. Other writers have imagined this vital energy to be the same as the soul, and derived from the air. Several modern physiologists have considered the nervous fluid as the source whence it is derived; and some have identified it with the electric and galvanic fluids; while other writers have ventured to conclude that life itself is nothing more than the mere organization or modification of matter. Respecting the real nature of this energy we term vital, very little is known at present;

and perhaps it is a question as far beyond the clear comprehension of finite beings, as the nature of that almighty Cause whence it is derived; yet there are many imposing facts to support the conclusion, that its mode of operation, when connected with tangible matter, is not of such an incomprehensible nature.

That a vital energy is concerned in almost every organic change, is an inference resting on such a train of experimental results, that we can scarcely doubt its correctness; and it will be the chief object of this Essay to point out some of the hitherto unobserved laws by which it brings about so many important changes in the material world. After having connected these views with several vegetable and animal processes, the phenomena of the atmosphere very naturally become a subject of consideration; and by pursuing this branch of the inquiry, we are gradually led to enter-

tain new views respecting the nature and character of light, which, if closely examined, may prove highly interesting to those who are disposed to give this part of the subject a further investigation.

Several original observations on the probable nature of caloric, and attraction in general, are also added, which may not prove unworthy the attention of experimentalists, who are commencing an inquiry into these very difficult subjects.

REMARKS

ON MATTER IN GENERAL.

THE term Matter, in its most extensive acceptation, is generally applied to those bodies which have length, breadth, and thickness, and which impart to us an idea of tangibility.

These are well known properties, which most bodies possess that are cognizable to our senses; but in taking a more particular view of some branches of physiology, we shall have to consider matter or agencies which have none of these tangible qualities, and can only be analogically detected by the nicest experiments and observations.

The tendency which all masses of matter have to approach each other we ascribe to the general principle of gravitation, and the tendency which the small particles of bodies have to come in contact with each other we refer to the principle of attractive cohesion.

That the principle of gravity extends through every part of the earth, is clearly shewn by the well known effect of falling bodies, and the spherical surface of the globe on which we live; while in the globular appearance of a small drop of mercury we have a beautiful display of what is termed the principle of cohesive attraction.

From this general view of the subject may we not conclude, that the whole of the planetary worlds are composed of matter somewhat like the world we inhabit, for they are evidently, from their spherical figures, subject to the influence of similar principles.

The attractions of gravitation and cohesion seem to be widely diffused powers; but if we turn our attention to the attractions of magnetism, we shall find they have very distinct characters, though there is a strong probability that they depend on the same energy which produces the more general attractions we have already mentioned. That the agency which produces magnetic attraction, is so subtile and active that we cannot actually detect it by our senses, is a fact well known, yet there are several results attending its different influences, which furnish us with such strong manifestations of its general character and mode of action as may, if nicely attended to, not only throw fresh light on its principles, but on the principle of attraction in general. After having paid considerable attention to an experimental investigation of this subject, I obtained one result in particular, which seems so closely connected with the general remarks already made, that

a detail of the experiment may not be thought altogether uninteresting. It has long been known as a physiological fact, that iron, when red-hot, is not attracted by a magnet; and various reasons have been assigned for this apparent deviation from a general rule. The most general opinion seems to be, that the heat of the iron "destroys the magnetic virtue;" but as experimental deductions are ever superior to mere speculative conclusions, I made a number of experiments, and found the above opinion was contradicted by the clearest evidence. To obtain the particular results to which we have just alluded, let two thin plates, four or five inches in diameter, of copper, brass, or any substance except iron, be placed in a horizontal direction, leaving a space of about a quarter of an inch between them, taking care that the under side of the lower plate shall be so situated, that the two poles of a compound horse-shoe magnet, capable of lifting

twenty or thirty pounds, can be brought in contact with its centre; and when steel filings are laid on the upper plate, and the magnet moved in various directions on the surface of the under plate, the filings on the upper plate will also be moved in various directions.

This effect will take place even when a plate of any substance, except iron, is introduced to fill up the space between the two parallel plates; but when a piece of sheet iron is introduced between the two plates, these magnetical effects do not take place among the filings, although they are not perceptibly interrupted by the introduction of any other body.

These results present us with a favourable opportunity of trying whether the magnetic virtue is destroyed by the action or influence of red-hot iron. In pursuing this experiment, we shall find that the cold sheet iron forms an impassable barrier between the steel filings

and the magnet; but if placed between the two plates, while red-hot, it will not interrupt the magnetic influence any more than other substance, yet the magnetic influence will be stopped, in proportion as the iron loses its high degree of temperature, and when it becomes of the same temperature as that of the atmosphere, then all communication between the filings and the magnet will again be interrupted. Hence we may conclude, that the magnetic virtue is not destroyed by the heat of red-hot iron, but that the pores of the iron are so far extended by this high temperature, that the magnetic fluid, or energy, can pass through while the iron is red-hot, which cannot take place when the pores of the iron become contracted by the cooling influence of the atmosphere. In order to support this conclusion by analogy, let us attentively inquire what are the most evident differences which obtain between the hot and cold iron, and we shall find that the pores of the hot

iron are expanded, and the cohesion of its particles considerably lessened, by this high temperature; and we may also learn, from a number of other facts, that the particles of cold iron are more firmly united by the force of attractive cohesion, than the particles of any other known substance; consequently, point out, in a satisfactory manner, why the magnetic fluid cannot pass through the cold iron.

From these circumstances, we are led to this important conclusion, that the effects of magnetism do not depend on a mere quality inherent in magnetic bodies, as some writers have supposed; but are the result of an active agent, whose free operation is impeded by the strong adhesive union which obtains among the particles of ferruginous bodies, and that it is by the general pressure of this widely diffused agent, which acts upon the impenetrable masses of ferruginous bodies,

that magnetic effects are produced; therefore, if this be the principle on which magnetic effects depend, may we not venture to conclude, from these obvious facts, that the more general attractions depend on a similar principle; for the small particles of bodies in general may be as impenetrable to the action of this fluid agent, as the larger portions of ferruginous matter.

Before we close our remarks on the different attractive phenomena, let us turn our attention to what are called electrical attractions, as they evidently depend on a different agency from the one we have just been contemplating. The various results attending electrical attractions are so numerous, that a particular account of all their varieties would lead us too far into the science of electricity; therefore such facts only will be mentioned, as seem to have a reference to the general view we are taking of these subjects.

If we examine the science of electricity, we shall perceive that its attractions and repulsions, as well as other phenomena, depend on the operation of agencies, which we can confine in certain vessels, and remove from one place to another. This tangibility of character, in all probability, is derived from the constituent parts of the atmosphere; for we have several strong analogical facts in favour of the idea, that the atmosphere is decomposed at the point of excitation, and that its constituent parts become united to a still greater portion of caloric or some other active agent, and constitute two electric fluids. In favour of this conclusion it may be remarked, that electricity cannot be excited in a complete vacuum; also, if the prime conductor, and rubber of a common machine, be insulated, and a pointed wire be affixed to each, a stream of electricity will flow from each point; and the more perfect the insulation of the conductor and rubber is

made, the greater will be these two streams; evidently shewing they are produced or generated at the point of excitation, by the friction there is between the cylinder and the rubber.

The chief object of these remarks is to shew the probability that these electrical agents are not, as some writers have supposed, permanent and widely diffused agents, but only occasional forces, produced by an accidental combination of circumstances; and that all the electric phenomena we behold arise from the efforts these newly formed agents make to restore that equilibrium which art or nature has destroyed: therefore, in our further inquiries, it will not be necessary to consider these as permanent energies, although they may, by their continual formation, perform an important part in many physical changes. The attractive energies we have mentioned may be recognised among

tangible portions of matter; but among the particles of bodies too minute to be individually observed, other attractive results take place, which have been ascribed to what are called *elective attractions*, or *chemical affinities*. Professor Burzelius has endeavoured to establish the opinion, that bodies which chemically act upon each other, are in contrary states of electricity, and derive their chemical activity from this difference: but there have been instances pointed out, in which bodies, possessing similar electricities, enter into chemical union, consequently, throw some doubt on the learned Professor's hypothesis.

The energies we have been considering may clearly be recognised in operations of what is termed *unorganized matter;* but, as we proceed, other forces, or agents, will present themselves, whose influence is more evidently connected with organized bodies,

and form a more interesting subject for our consideration.

Thus, when the seed of a plant is placed in a favourable soil, and supplied with a proper quantity of heat, light, and water, it will gradually unfold itself, until it becomes similar to the parent plant, in size and character. Now this increase and unfolding of its vegetable character, are results completely independent of any direct parental succour; nor can we comprehend the nature of these changes by referring them to the general properties of unorganized matter; therefore we must seek for a solution among other principles than those which belong to matter in general. It is true, we can form a tolerable idea from the well known principles of aggregation, how many changes take place among unorganized bodies; but by what principle a carnation seed, when placed in the earth, produces a group of beautiful flowers, or how

a simple acorn unfolds itself, and becomes a stately oak, are questions which have never been answered in a satisfactory manner.

That the vegetable process depends on the agency of a vital principle, is generally admitted by most physiologists of the present day; therefore, to ascertain by what law this vital energy operates in the vegetable kingdom, so as to produce the various results it evidently does, will occupy this part of the investigation.

In pursuing this difficult subject, we shall have to refer to facts which, at first view, may seem little connected with the inquiry; but the analogies to be obtained from these facts will appear more important as the process of vegetation becomes better understood. Had this inquiry been left to the aid of unassisted vision, its bounds would have been extremely limited, and we must have

stopped short of that satisfaction we in all probability shall obtain from experimental demonstration.

Happily, the invention of the microscope has opened to our view a new world of existences, and among this race of beings, we may find a solution to many results which, before their discovery, were generally classed among the impenetrable secrets of nature. Soon after the microscope was introduced to public notice, a class of living beings were brought to light, whose character and habits were perfectly distinct from what had been previously known, either in the vegetable or animal kingdom; and if we attentively consider their nature and character, it seems probable we shall obtain a more intimate knowledge of the vegetable and animal economy.

The race of beings just alluded to were discovered by the indefatigable researches of

Mr. Trembley; and so astonishing were the changes he observed in these little creatures, that he was at a loss, for some time, whether to consider them as plants or animals. Mr. Trembley, in January 1741, wrote to M. Bonnet respecting the kind of polype shewn at fig. 1, and observes, "I have studied it ever since June last, and have found in it striking characteristics of both plant and animal. It is a little aquatic being; at first sight, every one imagines it to be a plant; but, if it be a plant, it is sensitive and ambulent: if it be an animal, it may be propagated by slips, or cuttings, like many plants." The publication of these facts soon roused a general spirit of inquiry, for they were quickly corroborated by the experimental researches of different physiologists in various parts of Europe.

Mr. Adams informs us, in his Essay on the Microscope, that "in March, 1742, Mr.

Folkes gave an account of them to the Royal Society, from observations made on several polypes which had been sent to him from Holland by Mr. Trembley. The insects now began to be known, and were soon found in England; and the experiments that had been made on them abroad were published by Mr. Folkes, my father, (Mr. Adams) and Mr. Baker. Conviction now became too strong for argument, and metaphysical objections gave way to facts."

A letter from Cambridge was also read to the Royal Society, in which the author endeavours to lessen, by reason, the prejudices which combated the belief of these facts. "Some of our friends, (says the author) who are firmly attached to the general metaphysical notions they have formerly learned, reason strongly against the possibility of such a fact; but I have myself owned, on other occasions, my distrust of the truth,

or certainty at least, of some of those principles; and I shall make no scruple of acknowledging, that I have already seen so many strange things in nature, that I am become very diffident of all general assertions, and very cautious in affirming what may or may not possibly be.

"The most common operations both of the animal and vegetable world, are all in themselves astonishing, and nothing but daily experience and constant observation, can make us see without amazement, an animal bring forth another of the same kind, or a tree blossom and bear leaves and fruit. The same observation and experience make it also familiar to us, that besides the first way of propagating vegetables from their respective fruit and seed, they are also propagated from cuttings, and every one knows that a twig of a willow, particularly, cut off and only stuck into the ground, does presently take root and

grow, and become as real and perfect a tree as the original one from which it was taken. Here then we find in the vegetable kingdom, quite common, the very thing of which we have an example before us in the animal kingdom, in this newly discovered insect. The best philosophers have long observed strong analogies between these two classes of beings, and the more they have penetrated into nature, the more they have extended this analogy. Now, in such a scale, who is the man that will be bold to say, Just here animal life entirely ends, and here vegetable life begins; or, Just so far and no further, one sort of operation goes, and just here another sort, quite different, takes its place; or again, who will venture to say, Life in every animal is a thing absolutely different from that which we dignify by the same name in every vegetable?" Several remarks of this judicious writer evidently shew, there was a great degree of opposition to the opinion, that these

little objects were possessed of animal life; and when we take a general view of the results which attend this race of beings, it is no wonder that a general opposition should have been raised to the extraordinary doctrine, that animals could be propagated by slips and cuttings, like plants, as it is an assertion at variance with every species of animal life that comes within the common observation of mankind.

But this state of surprise and doubt was succeeded by the general assent of naturalists to rank these newly discovered objects in the animal kingdom. After they had been admitted to this rank in the scale of organised bodies, their various phenomena were carefully watched, and published in conformity with their supposed animal character and capabilities. Hence Mr. Adams has remarked, in his Essay on the Microscope, that "so strange is the nature of this creature's life,

some time; the two individuals are at last united, and grafted into each other; and the polype, which was at first double, is converted into one, with a great number of arms, and performs all its functions like another."

"The hydra fusca furnishes us with another prodigy to which we know nothing that is similar either in the animal or vegetable kingdom. They may be turned inside out, like a glove, and notwithstanding the apparent improbability of the circumstance, they live and act as before. The lining or coating of the stomach now forms the epidermis, and the former epidermis now constitutes the coating of the stomach. A polype thus turned, may often have young ones attached to its sides. If this be the case after the operation, they are of course enclosed in the stomach. Those which have acquired a certain size, extend themselves towards the mouth, that they may get out when separated from

the body; those which are but little grown, turn themselves inside out, and by this means place themselves again on the outside of the parent polype." To this class of beings we may add the animalcula infusoria, which take their name from being found in all kinds of vegetable and animal infusions. In their forms there is a prodigious variety: "some perfectly resemble the bell polype; others are round or oblong, without any, at least apparent, members; some resemble a bulb, with a long taper tail; some are nearly spherical; the greater part are vesicular and transparent."

"The birth and propagation of these microscopic beings are as regular as those of the largest animals of our globe; for though their extreme minuteness prevents us, in most cases, from seeing the germ from which they spring, yet, we are well assured, from numerous observations, that the manner in which

they multiply is regulated by constant and invariable laws. It has been shewn, that different species of the hydra multiply and increase by natural divisions and subdivisions of the parent's body: this manner of propagation is very common among the animalcula in infusions, though with many remarkable varieties. Some multiply by a transverse division; a contraction takes place in the middle, forming a kind of neck, that becomes smaller every instant, till they are enabled, by a slight degree of motion, to separate from each other. Another species, when it is on the point of multiplying, fixes itself to the bottom of the infusion; it then forms an oblong figure, afterwards becomes round, and begins to turn rapidly, as if upon an internal centre, continually changing the direction of its rotatory motion; after some time we may perceive two lines on the spherule, forming a kind of cross; soon after which the animalculum divides into four distinct

beings, which grow, and are again subdivided. Some multiply by a longitudinal division, which in one kind begins in the forepart, and in others in the hindpart; from another kind a small fragment is seen to detatch itself, which very soon acquires the form of the parent animalculum. Lastly, some propagate in the same manner as those we deem more perfect animals."

By this assemblage of facts, we see there is a race of beings which can scarcely be ranked either in the animal or vegetable kingdom, yet evidently partaking of the nature of both. Nor can there scarcely remain a doubt, after perusing these results, that they are produced by an agency whose energetic ramifications must extend still further into the two kingdoms; consequently it becomes an object worthy of research to ascertain whether this active agency does not influence processes connected with more perfect organizations. Numerous

other results, besides what have been already mentioned, were published by highly respectable authorities, and brought forward in the most imposing manner, to favour the generally received opinion, that these little objects are complete animals. Yet in opposition to this evidence, Messrs. Buffon, Needham, and several other writers contended, that these little objects are only organized particles, from which animals are formed, and are not possessed of vitality. But as we proceed in the inquiry, we shall see there is strong evidence in favour of a middle path between these very opposite opinions, and perhaps we may with more safety conclude, they are congeries of certain living portions of matter which have not attained a complete animal organization, consequently are not entitled to be ranked in the animal kingdom, although they are evidently possessed of vitality. Many analogies are to be found in the vegetable and animal kingdoms, which favour this conclu-

sion; but, if the compound microscope is used in a particular manner, we shall obtain more direct evidence respecting this interesting question, than by any other means. It has been remarked by Mr. Adams, that "the brightness of an object depends on the quantity of light, the distinctness of vision, in regulating the quantity to the object; for some animalcules will be lost in a certain quantity of light, which is scarcely sufficient to render others visible. This is more particularly the case with animalcula infusoria, whose thin transparent forms blend with the water in which they swim, therefore the degree of light should be suited to the character of the objects; if they are dark, the light should be strong, but if very transparent, they should be examined in a fainter light." It has also been remarked by the same author, that "there is an oblique position of the mirror, and consequently of the light, which is easily acquired by practice,

but for which no general rule can be given, that will exhibit an object more beautifully and more distinctly than any other situation, shewing the surface as well as those other parts through which the light is transmitted." Now this is partly a description of the method in which I have used the microscope; and as the new results which will be detailed in this inquiry, in a great measure depend on this peculiar mode of applying the light, it will be proper to give a particular description of the method, before we proceed further in the investigation.

The construction of the compound microscope I have generally used, is known by the name of Culpepper's Microscope, and I am of opinion it is the best kind that can be used for repeating the experiments; but whether this superiority arises from the peculiar situation of the stage, or any other accidental circumstance, experiment and obser-

vation will best determine. When the microscope is used for inspecting vegetable infusions, the sun must be clear, and the light thrown upon the stage so obliquely from the mirror as to shew the infusion of a dark blue colour, and then it will be evident that these animalcules are congeries of still smaller dark linear bodies, as shewn at fig. 2, which individually exert a writhing motion every time the congeries move from one position to another. That this oblique manner of applying the light will shew smaller particles which happen to be in the infusion, than any other mode of using a strong light, is very obviously pointed out by that method we intuitively adopt when we wish to inspect whether a glass of liquid is fine and clear; for if we examine it by candle light, we instantly throw the light obliquely through the liquid; or if we inspect it by the direct rays of the sun, we let the rays pass through the liquid in the same oblique manner. The reason of

this is obvious, for if the stream of light, which illuminates the small objects floating in the liquid, were to enter the eye in a direct manner, these small particles would be lost in the light; but by this means the small objects become illuminated, and reflect a small degree of light to the eye, while the stream of light by which they are illuminated passes off in another direction, consequently enables us to observe their illuminated surface more distinctly: and it is on this principle that the bright rays of the sun have been applied in my experiments. To place the subject in a clearer point of view, let the following experiment be made, as it will scarcely leave a doubt respecting the aggregating nature of these animalcules, and at the same time lead us on to the investigation of more interesting subjects.

In making the experiment in question, a small portion of flour must be placed on a

slip of glass, and mixed with a drop of water, then instantly applied to the microscope, and if stirred and viewed by a bright sun, as already described, it will appear evidently filled with innumerable small linear bodies, like those imbedded in the larger animalcules, and shewn at fig. 2, writhing and twisting about with extreme activity.

I know it will be reluctantly admitted by many, that this result is a proof that the particles of the flour have become vitalized, or possessed of an irritable energy; and I am equally aware that it will be ascribed generally to some supposed chemical action which is taking place between the constituent parts of the flour and water; but if we attend to the following results, they will shew pretty clearly that there is some other energy concerned in producing this effect besides the *present received* principles of chemical action.

If the weather be warm, let a wine glass half filled with pure water be mixed with about a tea spoonful of flour, and then we shall find, by inspecting a small portion on a slip of glass, that the mixture is filled with these linear bodies, which may be so far excited as to manifest a quick writhing action when touched, or stirred with an external body; but in a short time, if the weather continues warm, these linear bodies will have acquired such a degree of vital energy as to shew that the mixture is full of them, writhing about in every direction, without being excited to action by external agents. It was by viewing an infusion of the pollen of flowers, with one of Wilson's highest magnifiers, that I first observed these linear bodies, though I afterwards found, that by using the compound microscope, and applying the light as already described, a more perfect view of their nature and character might be obtained. That these linear objects are real bodies is

evident from their becoming magnified like other bodies, in proportion to the magnifying power used. Perhaps it is also worthy of remark, that Mr. Ellis seems to be the only experimentalist who ever mentions having seen these linear objects in any infusion, and as his description of these little bodies is so exact, I shall subjoin an extract from his communication to the Royal Society on the subject.

"On the 25th of May, 1768, Fahrenheit's thermometer 70°, Mr. Ellis boiled a potato in the New River water till it was reduced to a mealy consistency. He put part of it, with an equal proportion of the boiling liquor, into a cylindrical glass vessel, that held something less than half a wine pint, and covered it close immediately with a glass cover. At the same time he sliced an unboiled potato, and, as near as he could judge, put the same quantity into a glass

vessel of the same kind, with the same proportion of New River water not boiled, and covering it with a glass cover, placed both vessels close to each other. On the 26th of May, twenty-four hours afterwards, he examined a small drop of each by the first magnifier of Wilson's microscope, whose focal distance is reckoned at one-fiftieth part of an inch, and, to his amazement, they were both full of animalcules of a linear shape, very distinguishable, moving to and fro with great celerity, so that there appeared to be more particles of animal than vegetable life in each drop. This experiment he repeatedly tried, and always found it to succeed in proportion to the heat of the circumambient air, so that even in winter, if the liquor be kept properly warm, at least in two or three days, the experiment will succeed. The animalcula are infinitely smaller than spermatic animals, and of a very different shape, of the truth of which every accurate observer will soon be

convinced, whose curiosity may lead him to compare them, and he is persuaded he will find they are no way akin.*"

It seems very evident from this communication, that Mr. Ellis had a correct idea of the general appearance and character of these small linear bodies, or vital portions; yet it does not appear that he paid much attention to the subject; and, in all probability, this want of attention might arise from not being able to see them by the compound microscope; for although he could see them by the highest magnifier of Wilson's, still he could not see their various changes and operations in a satisfactory manner by that instrument. By returning to the subject of the infused flour, and supposing that it has been infused several days, we shall find by inspection, that a great number of these small linear bodies, which may be congeries of still

* See Adams on the Microscope.

vessel of the same kind, with the same proportion of New River water not boiled, and covering it with a glass cover, placed both vessels close to each other. On the 26th of May, twenty-four hours afterwards, he examined a small drop of each by the first magnifier of Wilson's microscope, whose focal distance is reckoned at one-fiftieth part of an inch, and, to his amazement, they were both full of animalcules of a linear shape, very distinguishable, moving to and fro with great celerity, so that there appeared to be more particles of animal than vegetable life in each drop. This experiment he repeatedly tried, and always found it to succeed in proportion to the heat of the circumambient air, so that even in winter, if the liquor be kept properly warm, at least in two or three days, the experiment will succeed. The animalcula are infinitely smaller than spermatic animals, and of a very different shape, of the truth of which every accurate observer will soon be

convinced, whose curiosity may lead him to compare them, and he is persuaded he will find they are no way akin.*"

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* See Adams on the Microscope.

smaller ones, have assumed a new character, which enables them to pervade the infusion in every direction with comparative ease and facility. This change of character seems to depend on a small globule of gelatinous matter which surrounds them, and which, in all probability, they have instinctively secreted for the purpose of moving about in various directions with more facility. In a very few days after these globules have begun to make their appearance, the whole of the infusion will be comparatively filled with them, as shewn at fig. 3, and it is a curious fact, that the outline of these globules may be faintly distinguished in the compound microscope, by a common light, although the linear agents which move them are not distinguishable by this light. These little objects, in all probability, are the small animalcules which naturalists have classed under the term Monas, and of which Mr. Adams gives the following description.

"Among the various animalcula which are discovered by the microscope, this is the most minute, and the most simple; a small jelly-like point, eluding the powers of the compound microscope, and being but imperfectly seen by the single; these and some others of the mona kind, are so delicate and slender, that it is no wonder they often escape the sight of many who have examined infusions with attention; in a full light they totally disappear, their thin and transparent forms blending, as it were, with the water in which they swim. Small drops of infused water are often so full of these, that it is not easy to discover the least empty space, so that the water itself appears changed into another substance less transparent, but consisting of innumerable globular points thick sown together, which, though full of life, seem only a kind of inflated bladders. In this, a motion may be perceived, something similar to that which is observed when the

sun's rays shine on the water, the animalcula being violently agitated, or in a commotion like unto a hive of bees. They are very common in ditch water, and in almost all infusions both of animal and vegetable substances." In a short time after these small globular points have become general in the infusion, various other tribes, of a larger kind, may be seen, some of which are represented at fig. 4. Now there are two points to be taken into the account respecting the formation of these larger tribes: the first is, the gradual disappearance of the small globules, as shewn at fig. 3; secondly, that all these larger animalcules are evidently, when inspected by a suitable oblique light that illuminates their upper surface, aggregations of similar looking globules to those which have disappeared, therefore readily point out the inference, that they have become united by their secretive capabilities so as to form these congeries.

The operative results which attend the efforts of these little portions of irritable matter, very much resemble the effects which M. Buffon has ascribed to his organic particles, though it is evident, from his own observations, he had not a clear idea of the nature or existence of these small linear bodies we have described in this inquiry.

The reasoning of this celebrated naturalist chiefly rests on the experiments of Mr. Needham, who classes paste eels, polypes, and all the larger animalcula infusoria, under the character of organic particles, though it has been clearly shewn, during this investigation, that these animalcules are extensive congeries of the vitalized particles we have just mentioned. In some papers I have published on the subject, and in the early part of this inquiry, these active particles of matter have been considered as extremely small animalcules; but as we proceed in the inquiry we

shall see many reasons for considering them in no higher character than small portions of irritable matter, or the tangible means by which a widely diffused principle of vatality connects itself with organized life.

Having shewn the probability that a vital energy is intimately connected with the changes which vegetable matter undergoes when subject to infusion, it naturally leads us to consider our former remarks respecting the probability that this vital or irritable energy extends its influence into the vegetable kingdom; and by supposing that it performs the chief part in the vegetable process, we enter a most extensive field for further investigation. In order to shew by experiment, that an agency of a very similar nature is actually engaged in the vegetable process, let us examine small portions of leaves, and the delicate parts of plants, and we shall find linear bodies, exactly in appearance like

those we have detected in vegetable infusions, imbedded in every part of a leaf and flower; clearly shewing whence those linear bodies have proceeded in vegetable infusions: and to shew that they possess a degree of irritable vitality, let a little juice be pressed out of an herbaceous plant, and examined in the manner already pointed out, and it will be found full of these linear bodies, writhing about in a very active manner. By this result we see the above supposition is not entirely void of probability, for the experimental facts already mentioned are very strong in favour of that opinion, and may readily be supported by a great number of corresponding analogies. It has long been a perplexing question in vegetable physiology, how the evident secretive processes of vegetables are carried on; for in the animal economy there are certain parts which seem exclusively adapted to carry forward their particular secretions, but the secretions of a

plant are chiefly produced by the action of the leaves, though they do not seem adapted for such a process.

Sir James Smith, when speaking of the secretive energy of plants, has remarked, in his Introduction to Botany, that "when we attempt to consider how the particular secretions of different species and tribes of plants are formed; how the same soil, the same atmosphere, should, in a leaf of the vine or sorrel, produce a wholesome acid, and in that of a spurge or manchineel a most virulent poison; how sweet and nutritious herbage should grow among the acrid crowfoot and aconite; we find ourselves totally unable to comprehend the existence of such wonderful powers in so small, and seemingly simple, an organ as the leaf of a plant. The agency of the vital principle alone can account for these wonders, though it cannot to our understandings explain them."

Now, in all probability, the vital principle here alluded to, is of a similar nature to that energetic force we have seen operating in vegetable infusions, and the facts already mentioned give us fresh views respecting its mode of operation when connected with living vegetable matter. By some of the experiments which have been noticed, we may see very clearly, that the small linear bodies obtained from infused vegetables, form, through their secretive capability, the larger animalcules of aggregation, many of which, in their general outline, represent the most delicate vegetables; therefore we may venture to refer the different secretive processes which are carried on in vegetables, to this kind of vital energy, when we find the very parts in which these secretions take place, completely filled with the above secreting agents. In favour of this reasoning, several collateral arguments might be adduced; for instance, the coralines are many of them such

beautiful vegetable imitations, that they were at one period classed by naturalists in the vegetable kingdom; but since, it has been clearly demonstrated that they are the secretive productions of a race of little animalcules which are imbedded in their apparent leaves and branches. Nor is it merely by a few analogies that this kind of reasoning is supported: the whole of the vegetable phenomena evidently point to a principle of this nature; yet it is only by an experimental investigation that we can reasonably expect to understand its mode of operation in a satisfactory manner.

That the whole of the growing, or what is termed living, vegetable matter, is influenced by a vital energy, appears very evident; and as we are well aware that the fresh matter which is added to the growing plant chiefly passes through the medium of the soil in which the plant grows, it becomes a question

whether the soil may not also partake, to a certain degree, of this peculiar vitality. To put this to the test of experiment, let a little soil be mixed with a drop of water on a slip of glass, and then quickly examined by the microscope, and it will be found filled with very active linear bodies, similar to those we obtained from vegetables and vegetable infusions. This result we might almost have anticipated, from our former experiments; but as we proceed in our researches, some very unexpected facts will present themselves for consideration.

Having seen that the soil which covers the surface of the earth becomes, under certain circumstances, evidently connected with this vital principle, we are readily induced to ask, whether this active principle may not extend its influence below the earth's surface; and to put this surmise to the test of experiment, a portion of sand-stone, which had just been

obtained several yards below the surface of the ground, was examined, and gave the same results as the soil: a small piece of coal, just drawn from a pit, was then subjected to a similar test, and it also gave similar results.

At this period the subject assumed rather an unexpected character, and on recollecting that the linear bodies described by Mr. Ellis had undergone the process of boiling the day before he detected them, as well as several other results of a similar nature obtained by my own experiments, I was induced to try what degree of heat these little agents could endure before they gave up their evident vitality. The first experiment to ascertain the point in question was made by heating a portion of the sand-stone red hot, and when cooled to the temperature of the atmosphere, subjecting a small part to the same process as the soil; even then linear bodies were obtained, displaying the same activity as

those obtained from the soil or vegetable matter. To put this question to a still further test, the white ashes of coal, which had undergone a more complete combustion, were then examined, and the vital effects were very similar to what were obtained when flour or the other bodies were infused in water. Hence the inquiry arrived at a difficult crisis; but, after due consideration, these results gave a turn to the investigation that led to the most satisfactory conclusions. The vitalizing results obtained by vegetable infusions, and the intimate connection there evidently is between unorganized matter and this vital energy, do not appear very unnatural; but the idea that living bodies, rendered visible by the microscope, can retain their vitality after they have been subject to the process of combustion, is not easily reconciled to our general notions on the subject of life. The statement showing, that the particles of the ashes possessed a vital energy after they had

passed through the ordeal of combustion, would be readily given up, on account of its extreme improbability; but if we give up this point, the whole of that well connected train of vital results, obtained by the infusion of vegetable matter, must be also given up, for they both rest on a similar experimental demonstration. Before, however, we come to the conclusion, that the particles of the stone and ashes cannot possess a degree of irritability, let us take into the account the particular circumstances under which the particles of these bodies were placed by infusion, and then, perhaps, we shall obtain more satisfactory views of the subject.

It is well known to physiologists, that while the particles of matter which compose rocks and mountains are excluded from air and water, they undergo little or no change of character, but the instant they are exposed to the varieties of the atmosphere, or

the action of the water, they acquire energies which completely change their character; therefore may we not infer, that the particles of the stone and ashes, which were examined by the microscope, did not possess any vital energy until they came in contact with the water: an inference that will do away the difficulty of supposing that these irritable portions passed through the ordeal of combustion without having lost their irritability.

That these little active linear bodies, obtained by infusion, derive their vital or irritable power, and perhaps a part of their tangible nature, from the water, is extremely probable, although it may be difficult to prove the truth of the conclusion in a direct manner; yet, if we take a general view of various changes which take place in the vegetable and animal kingdoms, we may obtain strong analogies in its favour. If we closely examine the economy of perfectly organized

bodies, we shall find that air and water, or at least the presence of oxygen, is absolutely necessary for the continuance of their vital energies; therefore, if complete animal and vegetable life are dependant on the vitalizing force they derive from air and water, why may we not suppose the less perfect vitality, which is thus manifested by the particles of unorganized matter, derive their irritable power from the same source? In the vegetable kingdom we have many direct proofs that vegetables derive their vital or energetic forces from air and water; for without the presence of oxygen, one of the constituents of these two bodies, the germination of seeds will not take place, nor will the vegetable process go on after it has commenced, if this stimulating agent be not present. Having shewn that when the particles of unorganized bodies are placed under circumstances, with respect to air and water, similar to what living vegetables require, they derive a de-

gree of irritability from these circumstances, it presents us with some plain and simple views respecting the nature of the vegetable process.

Let us suppose we have just passed a severe winter, which has stripped the vegetable world of all its beauty, and that we are again visited with the genial showers of spring; then, according to the principles we have endeavoured to establish, the surface of the earth will become vitalized by the genial showers, and prepared to aid the general process of vegetation. The particles of unorganized matter which are thus rendered visible by the return of spring, will be all ready to rush into vegetable life, and, when under the organic influence of previously formed plants or seeds, their active energies will be rendered subservient to all the changes of the vegetable process. We have already supposed, that the quickened particles of

unorganized matter possess a secretive power, consequently we may form some idea of the vegetating principle by which a carnation seed, when placed in the vitalized soil of spring, unfolds itself into a beautiful group of flowers, and how a majestic oak becomes annually clothed with its innumerable leaves. What can be more natural than to suppose, that these little secreting agents, which become quickened by showers and a due portion of light and heat, should ascend with the sap, and pass through the branches to the buds of trees, and there assist in unfolding the leaves, and carrying on the vegetable process; and that as the summer retires, and they have performed their appointed duty, they should drop, with their airy habitation, to their mother Earth, and again become vegetable mould, and there lie dormant till the reviving breath of another spring shall quicken them for all the purposes of future vegetation?

In these remarks we have only mentioned two cases of vegetable life, yet, if we take a more extended view of the subject, we shall find this principle equally applicable to every other change that is comprehended in the vegetable process; for whether we contemplate the enameled beauty of a meadow, or the vegetable grandeur of a stately forest, we shall perceive evident marks of the same active energy in every part of the vegetable kingdom. Although it is evident that the unorganized particles of the earth acquire a degree of vitality when placed under circumstances favourable to vegetation, yet it does not appear that they ever had the sole power of forming perfect vegetables; for if they once had this exclusive capability, they would, in all probability, have still retained that power; but as no such power or capability is manifested, we may venture to conclude that they never possessed such a power; consequently, we are compelled to adopt the scrip-

tural idea of a special creation of perfect vegetables, to aid and direct the energies of these irritable portions in forming new vegetable organizations, except we adopt the bold and daring conclusion, that the present order of things has existed from eternity. Nor are the effects of this vitalizing power confined to the vegetable race alone; it seems to extend its influence to the animal kingdom, and there brings about results which, at first view, appear to be the effect of principles entirely beyond our comprehension; but if examined more closely, cannot fail of impressing us with the idea that they in a great measure depend on a similar agency.

In our former remarks on the vegetable phenomena we commenced with the results of vegetable infusions, as they furnish a better connected train of simple facts than any other results whatsoever; and if we subject animal matter to the same process, we

shall meet with a series of changes which scarcely differ from those obtained from vegetable infusions. When a small portion of animal matter is infused in a wine glass of water, the water in a little time will be filled with little linear bodies, similar to fig. 2,* and these in a few days will change into the kind shewn at fig. 3, and afterwards these disappear, and a variety of a larger kind make their appearance, some of which resemble those at fig. 4. It has also been shewn in our former remarks, that this energy, which so strikingly displays itself in the process of infusion, may be plainly recognised in the living parts of the vegetable kingdom; and if we attentively examine the larger animalcules of infusion, and compare them with some of the lower links in the animal kingdom, we shall see that they strongly approximate each other in their general character.

* The linear bodies which are obtained from the pollen of some flowers and animal matter, are larger and more active than what are procured from matter in general.

The particular part of the animal creation here alluded to, is the larva of small flies. These little lumps of animation have a very peculiar structure; for if a puncture is made in their external coating, nearly the whole of their internal parts will quit them in a liquid form, and if this fluid matter is instantly examined by the microscope, it will be found filled with small active linear bodies, similar to those we obtain by infusion. Nor is this peculiar vitality confined to this part of the animal world, for we shall meet with similar results if we subject the mites of cheese and small flies to the same inspection. These observations have been restricted to the lowest links in the chain of animal life; but if we ascend to higher links in the scale, and even refer to man, we shall meet with many reasons for supposing, that several changes which take place in the human frame are influenced by a similar principle: for, however great and distinguished may be the

powers of the human mind, yet the physical powers of the body do not seem exempt from the laws and principles which obtain in less perfect organizations.

In support of this assertion, let a small portion of blood from the human frame be examined, and we shall find it to be attended with the same vital appearances we have obtained from the inferior class of animated beings; a result which involves in it questions of the highest interest: therefore it will be proper to describe the mode of making the experiment as accurately as possible. To ensure success in this experiment upon the blood, the sun must be bright, and the microscope adjusted to the slip of glass on which the object is to be placed, then a small drop of blood must be obtained from the finger, by the point of a needle or lancet, and placed on the slip of glass, and immediately illuminated by the rays of the sun and

inspected by the microscope, when it will appear full of animation, or little linear writhing agents, like those at fig. 2. These active little bodies will retain their activity for some time, and may be again excited to action by the influence of any small-pointed body, for a considerable time afterwards. This result very strongly corroborates the opinions of the celebrated John Hunter on the vitality of the blood, which have generally been represented as a new theory, whilst his own writings indicate that he had not so clear and satisfactory a view of the subject as to entitle them to this decisive character, though from the manner in which he has treated the question of vitality, it is probable that his mind was impressed with analogical inferences of a more specific nature than what have been expressed in his writings.

It also appears very probable, that the facts which have been brought to light by

this inquiry respecting the vitality of the blood, are in unison with the general views of Mr. Hunter, for he observes, "I had long suspected that the principle of life was not wholly confined to animals, or animal substances endowed with visible organization and spontaneous motion; I conceived that the same principle existed in animal substances devoid of apparent organization and motion, where there existed simply the powers of preservation." Although these deductions were drawn from many accurate experiments and observations which he had made on the animal economy, yet it does not appear that he ever obtained the result in question, as he supposes the blood to be a living fluid, and not a fluid filled with, or composed of, living particles. The simple fact that the blood is filled with small linear bodies, which possess an individual energy, is sufficiently curious to render it worthy of notice; but when we take into the account the probability that they in-

dividually possess a secretive energy, and are capable of being excited to action by the influence of exterior agents, we are unavoidably led to the consideration of other highly interesting, yet difficult, questions.

Several changes take place in the animal frame which cannot be satisfactorily referred to either mechanical or the generally received principles of chemical action, and perhaps none can be referred with less satisfaction than what are termed animal secretions. Dr. Murray, when speaking of these secretions, remarks, in his valuable treatise on chemistry, that "various hypotheses have been given of the nature of this process. At one time it was regarded as mechanical, as a species of filtration; but the mere fact, that the products are different from any existing in the blood, affords a sufficient refutation of the opinion, while it proves it to be strictly chemical. A fluid is received into certain vessels;

in these its composition is changed, not merely from the abstraction of principles previously existing in it, but from new combinations of its elements. From the description of this process, therefore, it is evident that it consists of a series of chemical actions; but if we endeavour to investigate how these are effected, or inquire by what powers these new chemical powers are formed, we find ourselves engaged in a task of the most difficult kind. In the structure of the glands we perceive nothing but a series of convoluted vessels, through which the blood circulates, and we are unable to discover how the action of these vessels can operate so as to form one new product, far less how different glands can, from the same fluid, form substances entirely different in their chemical composition and properties. It might be supposed, as one mode of solving these difficulties, on chemical principles, that the matter of which the glands consist, exerts an

attraction to one or other of the elements of the blood, by which the order of attractions being broken, new products may be formed. But the obvious objection to this opinion is, that the glandular matter must undergo a proportional change, a change utterly incompatible with the office it is designed to perform, or even with its existence as an organized part." It has also been remarked by some other able writers respecting animal secretions, that "the whole business is carried on in the minute, and, as we may call them, elementary parts of the viscera and glands, the structure of which eludes the research of our senses, and can still less be developed by reasoning or reflection. Observation cannot follow the work throughout, nor does it admit of illustration by experiment, like some other subjects which have been explained by artificial imitation of the proceedings of nature. Unwilling to confess their ignorance, and leave their sytem im-

perfect, physiologists have attempted to raise an hypothesis on that structure for which anatomy afforded no foundation. These notions, resting merely on probabilities and loose analogies, have flourished and fallen in succession; and we shall find that the list of truths and ascertained facts is much shorter than that of opinions and errors. We cannot doubt, indeed, that the whole essentially depends on a vital power of which chemistry can neither detect the nature, nor appreciate the force." This latter conclusion appears so consonant with what in all probability will prove to be matter of fact, that it ought not to be overlooked in any inquiry respecting the various secretions which take place in the animal frame.

The facts and reasoning adduced by these highly respectable authorities, shew very clearly that they were well aware of the difficulties that attend the subject; and they

very properly inferred, on the testimony of strong evidence, that a vital energy must be concerned in these processes, though they have scarcely made an attempt to point out the manner or principle by which this force brings about the results in question. With respect to the exact nature of this vital power we know but little; yet, if we take a general retrospect of what has been said in this inquiry, we shall see many reasons for referring the results in question to the secreting energy of the small agents we have detected, even in complete animal organizations. Nor would it be inconsistent with the view we have taken of the subject, to consider the delicate organic structure of the living body as resulting from this kind of agency; for it is extremely probable that digestion, the first step in the process of animalization, is brought about by a quickening energy similar to that we have witnessed in the first stage of vegetable and animal infusions.

It is well known, that the nature of animal secretions has long been a subject of profound inquiry among physiologists: and it is equally well known, that the phenomena attending muscular actions have also engaged and perplexed physiological writers, and are still enveloped in great obscurity. So interesting was the subject of muscular action thought at one period, that annual lectures were established in London for the express purpose of completely investigating this branch of anatomy.

The contractions produced by muscular energies are extremely evident, but in what manner these effects are produced, or how the mind influences the muscles, so as to render them subservient to its various determinations, are questions which have never been answered in a satisfactory manner, though numerous opinions have been published on the subject. Borelli and other anatomists

have supposed, that the muscles consist of strings of small bladders, which the mind has the power suddenly to inflate with blood and spirits, and that this sudden change is the cause of muscular action. According to Dr. Haller, there is a power he calls *vis insita*, which resides in the muscles, and is the chief cause of all those involuntary muscular motions, over which the mind has little or no control; but he also admits there is another force, which he calls *vis nervea*, and supposes it to be the directing power by which voluntary action is induced. This latter force is supposed to be a power not residing in the muscles, but an energy that particularly belongs to the nerves, and is under the immediate control of the mind. He contends, that when the mind has determined upon the necessity of any particular muscular contraction, this force, through the medium of the nerves, stimulates such muscles to action as shall produce effects agreeable to its deter-

minations; and that when this force becomes exhausted by too great an application, muscular energies, dependent on the will, become proportionably languid, until this exhaustion is restored.

Dr. Brown, in his System of Medicine, has ascribed muscular action, as well as several other phenomena attending the animal economy, to a property which he terms excitability, and the action of certain stimulants on this excitable quality, but he has not even offered a conjecture respecting its nature, or mode of operation, and has therefore left the principle of muscular motion as obscure as his predecessors.

That there is a force residing in the muscles, which can produce contractions in the animal frame, independent of the mind, is evident from a variety of facts. The muscles of a calf's head will sometimes contract,

when pricked with a pointed body, the day after it has been separated from the carcass; and the head of a turtle will snap at a straw, when put into its mouth, twenty-four hours after decapitation; yet other and more obvious contractions take place in the living animal frame, which are evidently regulated by the will or mind of the animal, though the power of contraction is probably derived from the same source as the former. That there is a strong degree of evidence to be brought in favour of the *vis insita* and *vis nervea* of Dr. Haller, as well as the muscular excitability of Dr. Brown, cannot in the least be doubted; but even admitting their conclusions to be perfectly correct, it is little more than saying, that the muscles contract because they possess the capability of contraction; for their opinions or doctrines do not in the least explain or shew by what principle these physical changes in the animal frame take place.

In Dr. Hartley's curious Theory of the Mind, we meet with the following observations, which probably give as correct a description of the changes which take place in the muscles, at the time of contraction, as any that have been offered to the public, though it does not appear that he had a clear idea respecting the kind of force by which these singular results are produced :— When speaking on muscular motion he observes, " If we suppose the small ultimate fibres of the muscle to bend alternately to the right and left, as an eel does, at exceedingly short intervals, agreeably to Dr. Lower, this may somewhat assist us to conceive in what manner a muscle may be shortened, and yet so increased in breadth and thickness as to remain of nearly the same dimensions. For, if these flexures be increased by the increase of the attraction of the parts, the whole muscle will become shorter and thicker, as it is found to be in contraction ; and con-

versely when the flexures are drawn out, the muscle will be longer and thinner, that is, in a state of relaxation." The physical change which the Doctor has supposed to take place in the muscular fibre at the time of contraction, is simple and very natural, and is exactly that kind of change which might be inferred from a retrospect of this inquiry. By the experiments which were made on vegetable and animal infusions, it was shewn pretty clearly, that the very small linear bodies which compose those aggregations termed animalcules, possess a force which exactly corresponds with the shortening and lengthening power of a muscle, and that when they are united in the congeries just mentioned, they can unite this force in a more effectual manner. Also, this force bears the strongest analogy to the *vis insita* of Dr. Haller, or inherent contractive force observed in the muscles of all living animals. It has been likewise shewn, that the whole of the

animal frame is filled with these linear bodies, each possessing a distinct contracting energy, which is capable of being excited to action by an external agent; therefore, what can be more plain and simple, than to suppose that the whole of the muscular contractions arise from the contracting energy of these individual portions? That the muscular changes called *involuntary contractions*, are brought about by the functional economy of the animal frame exciting these little contracting bodies to a suitable action, is a very natural inference; but in those muscular energies called *voluntary contractions*, it is equally probable that these irritable portions of matter are induced to action by some agent like the nervous fluid. That it is by a fluid agency of this kind that the mind, through the medium of the nerves, brings about those specific changes called voluntary actions, is rendered still more probable by the results obtained when Galvanism is ap-

plied to recently killed animals. This latter agency will excite as strong a contraction of the voluntary muscles as if the animal were actually alive, and consequently would lead us, by a fair analogy to infer, that when voluntary muscles, or the living portions we have just mentioned, are stimulated to action agreeably to the determinations of the will, it is by the agency of some subtile medium not very unlike the galvanic, or supposed nervous fluid. In taking this view of muscular phenomena, we avoid that incomprehensible influence which some writers have supposed the energies of the mind exercise over the mere matter of the body, when muscular contractions are produced, by shewing, that the muscles possess a living energy within themselves, capable of producing the physical changes in question, and that this energy is ever ready, on the slightest intimation, to aid every purpose the superior powers of the mind shall bring within its determina-

tions. By pursuing this view of the subject, we verge on another very interesting question, namely, whether the intellectual powers of man are derived from the same source, and in their nature bear any analogy to this vital energy, which displays itself among the organized particles of the body? and from several facts already noticed, and the arguments of some modern physiologists, it might be inferred, that they are derived from the same source, and are of a similar nature, and that the mental capabilities which flow from this energy are gradually formed, with the curious organic structure of the body, and are dependant on its organization. It might also be argued, from a variety of other circumstances, that mind is something added to organized vitality, and is of a superior nature to the energy just mentioned, and is derived from a more exalted source; but these are points which our present scientific knowledge will not enable us to decide: nor has Reve-

lation removed the difficulty, though she has clearly revealed the far more important fact, that, after the temporary sleep of death, our organic capabilities will again be restored, and that we shall exist for ever in a progressive state of mental improvement. The idea that a living principle, inferior to the mind, or what has been termed the rational soul, exists in the animal frame, is not a new opinion, though it has undergone a variety of changes; but as it is now generally considered under the term excitability, or irritability, it may not be amiss to notice what several modern writers have said respecting the nature and source of this widely diffused energy.

Mr. Johnson, in his History of Animal Chemistry, has remarked, under the term *irritability*, that "Whatever motion there is in the animal body, it is all brought about by the muscular fibre; and since the connec-

tion of this fibre with oxygene is necessary, in order that it shall preserve its irritability, or contracting power, physiologists have endeavoured to investigate what may be the nature and origin of irritability itself. Glisson is said to have been the first discoverer of the irritable principle in the solid fibre; and this was afterwards enlarged upon by Haller, who found, by a variety of experiments, that the irritability of the muscles remains a long time after their connection with the brain is destroyed, and gave it the name of *vis insita*. Fothergill, in his Hints on Animation, published in 1783, considers oxygene as the proximate cause of irritability; and Girtanner looks upon himself to be the discoverer of the same principle in the fluids of the body; and to this celebrated physiologist and Humboldt, we are indebted for many curious observations on this principle. According to Girtanner, who has made a number of experiments on the subject, irri-

tability is the principle of life in organized nature, and oxygene is the principle of irritability. His opinion is, that the irritable fibre, improperly called the muscular fibre, is universally expanded throughout all organized nature. It is on this that organic motion, sensation, and even life, depend. He affirms that this irritable fibre is the same in all parts, and subject to the same laws; that the fluids of animals are endued with irritability as well as the solids; their irritability consisting in their coagulability, which is subject to the same laws as that of the fibre; that the degree of irritability of the solids and fluids is continually changing, and is different according to the age and regimen of the same animal, according to the sex, organization, and size of the individual; that the state of health, or the tone of the fibre, consists in a certain quantity of the irritable principle necessary to its health and preservation.

"To maintain this state, it is necessary that the action of the stimulus be sufficiently strong to deprive the fibre of the surplus of the irritable principle which the lungs and the circulation of the fluids continually furnish. When the irritability is totally destroyed, the fibre is in a state of gangrene; it changes its colour, becomes livid or black, and is then subject to the laws of unorganized matter. That 'the irritable fibre, from the first moment of its existence to that of its dissolution, being constantly surrounded by bodies that act on it by stimulating it, and upon which it reacts by its contraction, it follows, that during life the irritable fibre is in a continual action; that life consists in action, and is not a passive state, as some authors have advanced.' He then attempts to prove, that it is to the oxygene distributed to all parts of the system, by means of the circulation of the blood, that the irritability and the life of organized bodies are

owing. The proofs of which are, 'the irritability of organized bodies is always in a direct ratio to the quantity of oxygene they contain: —every thing that augments the quantity of oxygene, in organized bodies, augments at the same time their irritability:—every thing that diminishes the quantity of oxygene, diminishes likewise their irritability.'

"Humboldt, who has written an ingenious treatise on the nature and properties of the galvanic fluid, looks upon irritability to be the common foundation of all vital action, and that it depends upon the property of the elementary parts of the muscular fibre to change their relative situation, on the approach of a stronger or weaker stimulus, whilst in the sensible fibre of the nerve a fluid is accumulated, called the *galvanic fluid;* and he likewise asserts, that by means of this galvanic fluid "the state of the irritable capacity of a nerve or muscle may

be ascertained, for which experiment a metallic stimulus, composed of zinc and silver, is necessary."

In these notions of irritability there is nothing contrary to the conclusions which have been already drawn from the results obtained by this inquiry, for in every instance where the particles of bodies have become quickened or vitalized, we find that it has only taken place when they have had access to oxygene; therefore, it cannot be very extravagant to conclude, that this vital power, whatever it may be, is intimately connected with that elastic body.

Having extended our remarks thus far respecting the vitality of organized bodies, it may not be improper to turn our attention to some of the varieties which obtain in the mineral kingdom, as we shall meet with strong proofs that this vital energy even ex-

tends its influence into this branch of natural history.

Sir H. Davy has remarked, when speaking of chemical changes, that "in the bosom of our rocks and mountains, where air and water are incapable of penetrating, all is permanent and still, without change or motion; wherever water and air are capable of acting, decomposition slowly goes on; and these agents gradually change the nature of the surface, render the soil fertile, and decompose and degrade the exterior of strata." Here then we see that no chemical change takes place among these masses of matter without the presence of oxygene, or bodies which contain it; therefore, when connected with the fact, that the particles of unorganized bodies in general become vitalized when subject to infusion, it would lead us to infer, that chemical changes may partly depend on this vital energy. If this be ad-

mitted, the subject of mineralogy becomes very simple, as we may conclude, that every crystal has originally been vitalized matter, and that it chiefly owes its present character to the secreting energy which its particles possessed when in a fluid and quickened state, an inference which is strongly supported by the results we obtain when a solution of neutral salts is examined by the microscope.

If a small portion of salt is examined at the time of solution, a part of it will be evidently quickened, like the linear bodies at fig. 2; consequently, when we see what these vitalised portions of matter can perform in the vegetable and animal kingdoms, we have strong reason for referring the formation of crystals, as well as all the other results attending elective attractions, to the influence of this vital capability. Thus, in every physical change, we may recognise marks of

this active energy: it pervades the cavities of the earth, and there works its secret wonders; it envelopes the exterior of the globe, and covers its everchanging surface with an endless beauty and variety. And if we extend our inquiries to the regions of the clouds, we shall there find it displays the same active character.

Many results which take place in the atmospheric regions are attended with circumstances that favour this opinion; but, perhaps, we shall recognise this principle more clearly in the configurations which obtain among the flakes of snow than any other, as they are changes evidently governed by the laws of crystallization. If we examine figs. 5, 6, and 7, which represent flakes of snow, we shall perceive how strikingly they correspond to the crystallizations of different salts; therefore if it be admitted, that the crystallization of salts is governed by this vital energy, we

shall almost be compelled to refer this crystallizing effect among the flakes of snow to the same influence.

By taking a retrospect of what has been advanced during this inquiry, we shall perceive that a vital energy has been recognised in the mineral, vegetable, and animal kingdoms, operating by certain peculiar laws which have hitherto escaped experimental detection. It will also appear evident, from a review of the various facts already mentioned, that the operations of this vitalizing power are only experimentally detected among the extremely small particles of matter when they are in a state of infusion, or so far liquified as to be capable of moving about freely amongst themselves.* In the mineral

* These small particles, or linear bodies, have been termed animalcules by Mr. Ellis, but had he been aware of the fact, that boiling an infusion will kill all those animalcules which seem to be congeries of these linear bodies, without injuring the latter, it is probable he would not have called these linear particles animalcules.

kingdom, we may recognize this vitalizing influence acting in its humblest character; and from what has been advanced we may, by the aid of analogy, infer, that the particles of each crystal have been quickened while in a state of fluidity, and that the propensity this vital energy has to promote every organical process, has imparted to them their crystallizing character; and it may be also inferred, that this vital energy quits these particles, or their vitality ends the instant they enter into the solid embrace of crystallization. I am well aware that the manifestations of this vital energy in the mineral world appear weak and feeble when compared with the vital changes which take place in the vegetable kingdom, yet if we minutely attend to what has been said respecting the varieties of each, we shall see that both are essentially dependant on a similar principle. From a review of numerous results, it appears probable that a crystalline

body proceeds from a quickened fluid matter; and it is equally probable that the very matter which is added to a growing vegetable assumes this character before it can ascend into vegetable life. It ought, however, to be remarked, that when this quickened matter conforms itself to the law of crystallization, it does not appear to be influenced by any parent organization; but when quickened particles of matter become associated to the vegetable world, they are under the influence of previously organized structures, through which they display an endless beauty and variety, until they become joined or assimilated to the vegetable organization under which they operate, and then their active irritability seems to end, and they become fixed vegetable matter. Another result attends the vegetable process, to which we find nothing analogous in the mineral kingdom, namely, the capability of vegetables to provide a seed or seeds containing

the embryos of other distinct organized structures, and which, like the parent plants, will become unfolded into complete vegetables, by the vegetating principles we have pointed out, if they are placed under suitable circumstances.

This latter result partakes so much of design, that it seems to form a union with the lowest link in the chain of animal life, and very properly directs our attention to a retrospect of what has been said on this highly interesting branch of physiology. Among the lower links of the animal world we shall find a number of animals such as the oyster, the muscle, &c. whose functional capabilities are little superior to some of the vegetable race; for some of the sensitive plants may be as readily excited to action as these very beings we admit to be animals.* From the

* The Dionæa muscipula exhibits some of the most striking instances of vegetable irritability. This effect has been ascribed to an electrical prin-

facts already advanced we shall see no reason to be surprised at this similarity, for the organization of animal matter seems to depend on exactly the same energy as that from which vegetable organizations proceed: therefore it is probable, that superior functional capabilities result from the directing influence which previously organized structures exercise over this operating energy.

In this retrospect we may perceive the gradual ascent of this vital power from the mineral to the vegetable, from the vegetable to the animal world; and from the lowest links in the animal world we may trace a gradual improvement in organized structures till we arrive at man, whose exquisite formation and functional powers seem capable of developing, or becoming associated to, that still more incomprehensible energy we call Mind.

ciple; but the contraction of the leaves will take place when touched with a glass rod, as well as with any other substance, which proves the inference incorrect. Many excellent specimens of this plant may be seen in the Botanic Garden at Liverpool.

The experiments and observations which have been made, through the whole of this investigation, have been chiefly directed to operations and results connected with organized bodies; and from our being able to detect, experimentally, the operating agents by which many of these results are produced, the inquiry has proved highly satisfactory; but when we attempt to investigate the law by which, in all probability, this vital energy produces so many changes among particles of matter that are too minute for observation, and inconceivably smaller than the linear bodies we have just noticed, the investigation becomes far more speculative, though perhaps equally entitled to notice, and not unworthy our attentive consideration.

OBSERVATIONS

ON THE

Nature of Atmospheric Electricity, Combustion, Light, and Attraction in general.

In pursuing this extremely speculative part of the inquiry, we cannot reasonably expect to obtain such direct evidence in favour of our conclusions as we did in the former part of the investigation; yet the discovery, that this widely diffused vital energy operates by quickening extremely small particles of matter, may enable us to apply this principle of vitalization in a more satisfactory manner to account for the phenomena in question, than any other principles which have been previously adopted.

Some ancient physiologists held the doctrine, that fire was this universal agent, or

subtile medium, by which every change is brought about in the physical world. Theophrastus has remarked, that "fire is neither generated nor destroyed; is every where and always present, while its effects in different times and places shew themselves more or less, and very various: soft and cherishing; or violent and destructive; terrible or agreeable; converging good and evil, growth and decay, life and death, throughout the mundane system." The effects which this ancient writer has ascribed to the energies of an invisible subtile agent he terms fire, have also been ascribed by various other writers to the substance of light, ether, &c It has been observed by Bishop Berkely, that "there is a mind that governs and actuates this mundane system, and that the inferior instrumental cause is pure ether, fire, or the substance of light, which is applied and determined by an infinite Mind in the macrocosm or universe: that there is no effect

in nature, great, marvellous, or terrible, but proceeds from fire, that diffused and active principle, which, at the same time that it shakes the earth and heavens, will enter, divide, and dissolve the smallest, closest, and most compact bodies. In remote cavities of the earth it remains quiet, till, perhaps, an accidental spark, from collision of one stone against another, kindles an exhalation that gives birth to an earthquake or tempest which splits mountains or overturns cities." These general notions have not been confined to any particular period, for physiologists in modern times have supposed that some widely diffused subtile medium gives birth to the phenomena in question. Some writers have considered electricity as a universally diffused agency, and to its activity almost every physical change has been ascribed: but to elucidate effects of this nature by such a general application of any widely diffused agency is too vague

to prove in the least satisfactory. That every physical change originates from the active influence of some very extensive agency seems to be a conclusion so rational and so consistent with the most extended view of every natural phenomenon, that we can have little or no doubt of its correctness: but, however plausible such general inferences may seem, they give us no precise idea how this energy operates when it becomes connected with tangible matter, or by what principle it produces the physical results under consideration. If we attentively examine many electric phenomena which take place in the atmosphere, we shall perceive how admirably a vital energy seems adapted to produce the results to which we have just alluded. Let us contemplate the rapidity of motion, and the energetic force which is often displayed by an electrical explosion in the atmosphere, and we shall see how imperfectly these tremendous results are

explained when referred to the common laws of matter: nor are the curious and fanciful effects produced by an electrical machine more reconcilable to these laws; they seem more like the results of some quickened matter not under any organic control than the effects of any other known principle. Having thus alluded to certain atmospheric effects which are evidently connected with a combustible process, let us turn our attention a few moments to the process of combustion in general, as it may tend to impart new views respecting this branch of meteorology. In pursuing this subject, we shall meet with many analogous facts in favour of the idea that this active and energetic principle, which we have recognised in various branches of physiology, performs a part in the curious process of combustion. So strongly has the analogy been proved, by a variety of results obtained by animal respiration and combustion, that several physiologists have con-

tended that animal respiration is a slow combustion. This opinion is not mentioned with any particular view as to its physiological correctness or incorrectness; but when such accurate observers as Lavoisier and De la Place advance and advocate the opinion, it shews there must be strong evidence in favour of its probability.

The idea, that a vital principle is concerned in the process of combustion, is supported by the fact, that the two processes of respiration and combustion require to be placed under very similar circumstances with respect to atmospheric air. To put this to the test of experiment, let the air in a small vessel be exposed, exclusively, to the respiring process of a small animal, until it die for want of fresh air. Let another vessel be similarly exposed to the combustible process of a burning candle, till the candle go out; and then introduce a small

animal into the air thus deteriorated by the process of the candle, and it will immediately die; and let a lighted candle be introduced into the air deteriorated by the animal, and it will instantly go out. Therefore it is no wonder, that physiologists, like Lavoisier and De la Place, who were in the habit of making inductions from clear analogies, should have concluded, that the process of animal respiration was a species of slow combustion: and if their reasoning be allowed, surely we may reverse the inference and conclude from the same data, that combustion is not very dissimilar in its nature to the vitalizing process of animal respiration. We shall also find by inspection, that both the vegetable and animal world present us with many examples of processes and changes that set at defiance all reference to the common laws of matter, and that, by a general consent, these results have been referred to a vital principle: therefore may

we not with equal fairness refer the unaccountable effects of combustion to a similar principle, particularly when analogies are so strong in its favour, and the common supposed laws of matter will not account for its various phenomena? Several very curious results attend the simple process of a burning candle. The quantity of light which is thrown off by this process, in every direction, seems beyond all calculation, and the velocity with which it is projected from the candle is equally extraordinary.

It has been observed, that a candle throws off more particles of light in one minute than there would be grains in a globe of sand as large as the earth, and that these particles move with a velocity little less than two hundred thousand miles in a second of time. Light, according to Dr. Thompson, acquires this velocity in a moment, "and it seems to acquire it too in all cases, whatever the body

be, from which it separates." Now these results admit of no satisfactory solution by what are considered the general laws of matter, nor do the generally received opinions on this subject afford the least idea of any principle to which these results can be referred; but if we imagine the flame of a candle to be a body of highly vitalized matter, in a rapid state of decomposition, we shall be furnished with another principle besides the commonly received principles of matter to account for these very extraordinary results. The decomposing energy which the flame of a candle possesses, is too well known to require any description, and from a number of circumstances we may infer, that this decomposing energy separates this tangible body, or flame, into its ultimate particles; therefore may not some of these extremely minute particles still retain a portion of their vital energy, and constitute that active agent we term Light?

This view of the question very naturally turns our attention to the subject of light in general, but particularly to that which emanates from the sun; and, I trust, it will form a sufficient apology for the following remarks on this interesting branch of physiology.

Various opinions have been formed respecting the nature and phenomena of light; but two hypotheses have particularly claimed the attention of physiologists. The celebrated Huygens and several eminent writers have contended, that light is nothing else but the quick vibrations of an extremely elastic and highly attenuated fluid, and that these vibrations affect the organs of sight somewhat in a similar manner to what those vibrations of the air called sound affect the sense of hearing; while Sir Isaac Newton and many other able philosophers have contended, that light consists of small particles

of matter, thrown off from the surface of luminous bodies, at the prodigious rate of two hundred thousand miles per second, by a principle of repulsion, or some other mysterious law; though it has not been clearly proved by experiment, that the light, which flows from bodies we subject to the process of combustion, obtains this extreme velocity.

To both these opinions several strong objections have been raised: but the first hypothesis appears the simplest, and equally consistent with the well known laws of matter; although it has been contended, that if this opinion were correct, we ought to have perpetual day. This, at first view, seems to be an insurmountable objection to the doctrine of Huygens; but if we attempt to explain, agreeably to the second hypothesis, how these particles of matter, which it supposes to constitute light, are projected from the gravitating body of the sun, with

such force as to travel ninety-eight millions of miles in eight minutes and a half, we shall find it a task attended with equal, if not greater, difficulties. It has been argued, in favour of this projecting hypothesis, that light is projected from the sun by a law, or principle, peculiar to his surface or atmosphere: but, in the combustion of a candle, we have a display of an extreme projecting force, though we have no evidence whatever that the mass of matter, which forms the candle, is under the influence of any other law than what belongs to the particles of unorganized matter in general.

After these general remarks on the two popular theories of light, let us turn our attention to the new views we have taken of the various results which attend a burning candle, as they seem to promise a better solution to these difficulties than any other opinions which have yet been pub-

lished. It has already been observed, that when the particles of matter become vitalized, they are so situated as to move freely among themselves; and this state is generally obtained either by heat or infusion. Now, in the decomposing process of the candle, which in all probability is an *excess of vitality* incompatible with organization, we have supposed that a portion of its ultimate particles are perfectly liberated, and so far vitalized as to constitute that active agent we call light; therefore may we not venture to infer, that solar light consists of extremely small particles of matter which are vitalized in the sun's atmosphere, and then wing their way through the upper regions by the vital energy they have thus obtained?

Although this view of the subject is agreeable to what has been said respecting the illuminating effects of a burning candle, yet it will not absolutely require us to embrace

the vulgar and improbable notion that the surface of the sun is in a state of rapid combustion, as several phenomena attending our own atmosphere shew, that a great quantity of light is generated in the atmospheric regions while the surface of the earth immediately beneath is covered with ice and snow, instead of being in a state of combustion.

The phenomena here alluded to attend the *aurora borealis*, and by a strict examination of the circumstances under which these appearances take place, we may see a tolerable developement of the principles we have been endeavouring to establish respecting the nature of solar light. The auroras are the most prevalent in high northern latitudes, during winter; for at this season of the year, when the northern part of the globe is covered with snow or ice, they are so brilliant as to illuminate the heavens equal to, if not more than, our common twilight. This lu-

minous effect has been referred to electrical energies; but it has also been attributed, and perhaps with more propriety, to a slow combustion which takes place among the different gaseous bodies that escape into the upper regions. Now the circumstances under which this light is generated, strengthen the view we have taken respecting the generation of light in the atmosphere of the sun; for if we conceive it probable, that innumerable small particles of matter rise from his surface, may we not from the above statement suppose, they may be quickened in his atmosphere by appropriate causes, and fly off in all directions in the character of light?

That this active agent we recognise under the term *solar light*, should lose its extreme velocity when it comes in contact with the earth, is a very probable circumstance; but it is equally probable, that its particles, after this loss of momentum, may still retain

a part of that active energy which gave birth to their extreme velocity, as light; and that these very particles, under some slight circumstantial difference, besides the loss of this rapid momentum, may constitute that widely diffused agent we term *caloric*. It appears extremely probable, from a number of facts advanced during this inquiry, that the particles of light, when they have assumed the character of caloric, or some other very active agent, are strongly disposed to vitalize the surface of the earth, and ascend in the scale of organized life; and to this strong vitalizing propensity, perhaps we ought to ascribe several other extensive effects and operations. It has long been a disputed point among physiologists, whether to ascribe the attraction of gravitation to an inherent property of matter, or to the external pressure of some highly attenuated and active agent pressing on its particles; and from the manifest difficulties which attend both views

of the subject, Sir Isaac Newton seemed in doubt whether to adopt the former or latter opinion, though perhaps far less merit, or presuming ignorance, would have dogmatized where his transcendant genius doubted.

To suppose that the tangible particles of matter which compose this earth, are possessed of an inherent force, which makes them gravitate towards its centre, is a conclusion unsupported by any clear and satisfactory evidence; and if we refer this general effect to the mere pressure of some external fluid, we shall be obliged to adopt a fluid machinery, like Des Cartes, or fill the universe with an extremely elastic medium for this gravitating purpose; a notion quite incompatible with the velocity of solar light, and that simplicity of design every where displayed in the works of creation. Let us, however, for the sake of illustration, suppose, that the particles of light which come

in contact with the earth, and have lost their rapid momentum, do constitute that widely diffused agent termed caloric, and that they are intimately connected with that quickening or vital energy which is continually making an effort to vitalize the surface of the earth, and ascend in the scale of organized life: then let us imagine that this energetic matter, which is ever pouring from the sun, surrounds the earth to an extent of several thousand miles; and that each individual particle of this active matter is making an effort, from its own internal energy, to come in contact with the tangible matter of the earth and ascend in the scale of organization, and we shall readily perceive, how such an effort would produce an effect like that ascribed to gravitation. If it would not appear too much like following the fanciful conjectures pointed out by an hypothesis, many other phenomena might be referred to the active energy we have been considering.

This widely extended vitality might be applied to many curious varieties belonging to what are termed elective and magnetic attractions; but the many particulars such an application would embrace, are too numerous for a small work like the present Essay.

SUPPLEMENTARY OBSERVATIONS.

This inquiry was pursued thus far as early as the year 1819, since then I have occasionally turned my attention to the subjects alluded to in the preceding page, particularly to what are called chemical attractions, as they furnish a series of interesting phenomena, which are very imperfectly accounted for by our present popular theories.

That there are many difficulties attending the action of what are termed chemical affinities, is well known to all who are conversant with chemical science; nor is it likely those difficulties will be removed so long as we strictly adhere to the present popular opinions; therefore, they furnish an apology for differing from great authorities on this

subject. Having mentioned in a former part of this essay the extreme probability, that vital and chemical energies are of the same nature, we shall now inquire how far such a supposition is supported by the evidence of facts.

In an inquiry that embraces such an important question as this, there will be many difficulties to encounter, before we can obtain views that will prove completely satisfactory; as it is a question that not only bears a simple relation to this subject, but, in all probability, is more or less connected with the general phenomena of nature; consequently ought to be considered in such a manner, as will have a due reference to other physical operations. Perhaps there is no branch of science that will furnish more decisive arguments respecting the object of our research, than vegetable processes, and more especially when they are connected with the different

opinions which have been published on the subject. The processes particularly here alluded to, are vegetable secretions, which are evidently the most interesting part of the vegetable economy.

By consulting the works of many able writers on vegetable physiology, we shall find two opinions have been offered to account for vegetable processes; some referring them to the influence of a living principle, while others entirely refer them to chemical affinities, or the laws of inorganic matter.

After having viewed the various phenomena of the vegetable kingdom with a scrutinizing eye, the great Linnæus felt such a strong conviction that vegetable processes were influenced by a living principle, that he even bestowed much labour to prove that the functional parts of plants bore the strongest analogy to the organized structure of the

animal frame, and that they were stimulated to action by a similar principle. Chaptal, when treating on vegetable substances, remarks, "In the mineral kingdom, we are justified in referring all the phenomena to the action of external bodies; and forces purely physical; or the simple laws of affinity, afford deductions sufficient to account for all its metamorphoses. In the vegetable kingdom, on the contrary, we are compelled to acknowledge an internal force which performs every thing, governs all the processes, and subjects to its designs those agents which have an absolute empire over the mineral kingdom." Sir James Smith observes, in his Introduction to Botany, after expatiating on the secretions of plants, that, "The agency of the vital principle alone can account for these wonders, though it cannot to our understanding explain them." These opinions are further corroborated by the writings of Sprengel; for this able physiologist contends, that,

"Plants live, not merely in the common sense of the word, which includes activity of every kind, but in that stricter sense, by which a higher and self-dependant activity is expressed." And then affirms that three operations, "the assimulation and maintenance of the sap; activity arising from internal impulse; and the production of new individuals, are the characteristics of the life of plants." Having noticed these opinions in favour of the vitality of plants, let us turn our attention to some of those writers, who think that most vegetable processes are of a chemical nature, and depend on the action of chemical affinities. Sir H. Davy thinks there is no power in vegetables similar to that which produces life in animals, and that in calling forth the vegetable functions, common physical agents alone seem to operate, and that irritability ought to be excluded from the vegetable economy.*

* Elements of Agricultural Chemistry, page 217.

Dr. Thompson, after expatiating on those vegetable processes which convert the sap of plants into what he calls the "peculiar juices of plants, or the true sap," observes, "The true sap is conveyed into every part of the plant, and all the substances which we find in plants, and even the organs themselves by which they perform their functions, are formed from it;" and adds, "All these operations indeed are evidently chemical decompositions and combinations; but we neither know what these decompositions and combinations are, nor the instruments in which they take place, nor the agents by which they are regulated."

Dr. Murray not only considers the secretive process of vegetables to be of a chemical nature, but even concludes that animal secretions are chemical processes; though he contends, in the most unqualified manner, that vegetables are living systems, endowed with a principle of irritability, which is

excited to action by the application of external agents.

This short sketch of opinions, so highly respectable, is important to this inquiry, as it shews the extreme probability, that vital and chemical energies are of a very similar nature; or the same effects could not have been ascribed by one set of writers to a chemical influence, and by the other to a principle of vitality.

It is also a fact worthy of notice, that most writers on the physiology of plants, furnish arguments and results which support the idea, that vegetable processes are of a vital nature; while at the same time other arguments and effects may be obtained from the same authors, which seem favourable to the opinion that they entirely result from a chemical influence. Besides these difficulties and theoretic contradictions, which seem highly

favourable to the idea, that vital and chemical energies are of the same nature, many other experimental results may be obtained, which are equally favourable to the same opinion.

In Egypt it has long been a practice to put a number of eggs into an oven, when by raising its temperature to a given point, the chickens are hatched; they are then fed and placed under artificial mothers, until they are fit to provide for themselves. In our manufactories for white lead, it was a practice some years ago, and perhaps is now, to put a little acetic acid into small pots, and suspend a coil of thin sheet lead over the acid, at the same time covering up the pots, and then imbedding the whole of them in a large quantity of vegetable matter, in order that the heat generated by this collection of vegetable matter might gently increase the chemical action of the acid, and convert the two substances into white lead.

In these two cases we see that radiating caloric has been the chief means employed to bring about both vital and chemical changes, a circumstance we ought to bear in mind through the whole of the investigation.

That the Deity brings about all the purposes of his providence by the agency of a few simple secondary causes, is a position in union with the most enlightened philosophy; and being impressed with the correctness of this inference, and directed by an assemblage of strong analogies, all tending to establish the important conclusion, that chemical and vital energies are of the same nature, I was desirous, if possible, to obtain more direct evidence on the subject. Having witnessed, in a variety of instances, the peculiar living character which vegetable matter manifests when subject to the process of infusion, I was induced to try whether, in one of the most powerful instances of chemical change,

any effect could be discovered which bore any resemblance to this living or vital principle so readily discovered in vegetable infusions; and in this expectation I was not disappointed. To obtain this favourable result, let a small strip of polished zinc be laid upon the stage of a single microscope, and a small drop of diluted sulphuric acid be placed on the zinc, and examined by a strong convex lens, when the sun is shining on the plate, and we shall observe a similar action among the particles of its surface to what takes place in vegetable infusions, which are evidently influenced by a living principle. I am perfectly aware it may be said, that this effect is only the play of chemical affinities, or it may arise from the inflection, or refraction of light, or the changing shadows of the particles of the zinc, induced by the powerful action of the acid; but, whatever view we take of the effect, still it must result from a quick motion among the particles of the zinc;

and, whether we contend for the inflection or refraction of light, or the play of shadows, or any supposed chemical energy, still the particles of matter, which give rise to this effect, are in violent motion; and it is the cause of this motion which is the object of our consideration. To appreciate the importance of this result, let us attend to other effects, which may be obtained from the same process, and we shall find, if it be carried to a greater extent, that other evidence will be obtained, favourable to the view we are taking of the subject. In this class of experiments, we have the developement of another distinct force, which far exceeds every energy we can rationally ascribe to the influence of inert matter, and strongly resembles many of those results, which we know to arise from the action of a vital principle. The energy here alluded to, is that of Galvanic Electricity: but to point out the particulars of this resemblance, will not be necessary now, as

its theoretic importance will be more obvious as we proceed in the inquiry. To carry this process still further, let a small bit of zinc be put into a little diluted sulphuric acid, and in a short time, if the acid be gently heated, the zinc will disappear, and a white crystalized subtance will be the product of this change, possessing very different properties to either the acid, or the zinc; and if copper is used instead of zinc, beautiful blue crystals will be the result. Now, as there is no process in nature that bears the least resemblance to this chemical transformation of matter, but the secretions of living systems, it seems highly probable, that there is a force or energy concerned in these changes, which has not been brought forward in any of our present theoretic illucidations of chemical affinities. Although these results manifest a strong approximation to the secretive action of living systems, yet we can only attribute this approximation to

an elementary vitality : while in living systems, the same principle acts under the influence of organized structures, consequently, in many instances, will produce very different results; though in both cases, the energy may be exactly of the same nature. Nor is it in these instances only, that experimental results are favourable to the views we are taking of chemical and vital energies ; for scarcely a physical change takes place which does not support the same conclusions.

That the operations of nature result from very simple causes can scarcely be doubted, consequently hold out a hope that some agent may be discovered that will diminish the number of secondary causes, and render our theoretic conclusions more conformable to this simplicity. This desideratum, however, is not likely to be obtained by the guidance of our present popular opinions, as they are too confused and obscure to lend

us much aid in the accomplishment of such an object.

After having taken a general view of a great number of natural phenomena, and bearing in mind many collateral facts, which seem to be connected with these phenomena, I feel a strong conviction, that solar light is the source whence both vital and chemical energies are derived. The probability that the light which emanates from the heavenly bodies, particularly the sun, conveys to this earth a living principle, did not escape the first attentive observer of natural appearances.

Aristotle was so impressed with its influence in physical changes, that he ascribed to it a divine power; and many other opinions have since been suggested, to account for the various phenomena it evidently produces; but two, in particular, have claimed the greatest share of public attention,

and are supported by numerous advocates at the present time; viz. what are termed the Cartesian and Newtonian systems, or theories of light. These two systems have been powerfully assailed by their different partisans, as each being incompatible with experimental facts, and the harmony of many physical operations.

Solar light is one of the most wonderful agents in creation; but whether we contemplate its nature and effects, under the hypothesis of Des Cartes and Hugens, or that of Newton, still the subject is embarrassed by difficulties that cannot be completely removed by any dexterity of reasoning. If, however, we suppose that each particle of light possesses within itself an individual energy, that is not dependent on the mere laws of matter, but is derived from a vital influence, communicated to it for special purposes, we shall find that it will supply us with a solution to many difficulties.

Had the great Lavoisier lived to have applied his sublime inquiries to organized bodies, which he intended, it is probable he would have arrived at the same conclusions, though by a different routine of observations and experiments; for when speaking about this agent in his system of chemistry, he observes, "organization, sensation, spontaneous motion, and all the operations of life, only exist at the surface of the earth, and in places exposed to the influence of light. Without it, nature itself would be lifeless and inanimate. By means of light the benevolence of the Deity hath filled the surface of the earth with organization, sensation, and intelligence. The fable of Prometheus might, perhaps, be considered as giving a hint of this philosophical truth, which had even presented itself to the knowledge of the ancients."

Sir H. Davy, near the close of his chapter

on the motions or affections of radiant matter, remarks, "the later investigations on light teach us that there is still much to learn, with respect to the affections and motions of radiant matter; and this subject, when fully understood, promises to connect chemical and mechanical science, and to offer new and more comprehensive views of the corpuscular arrangements of matter."

These observations have been made by authorities which are certainly entitled to an attentive consideration; and if it can be shewn, that these opinions respecting light are consonant to an assemblage of facts which support the conclusion, that vital and chemical energies are of a similar nature, they become still more important to this inquiry, and claim a greater share of our attention.

That the particles of light possess an

energy which does not belong to the particles of matter in general, is rendered evident by their extreme momentum ; and if we admit it is a living energy, it will naturally direct us to the adoption of more satisfactory views, respecting the physiological and chemical influence of light.

When we witness all nature drooping as the sun retires from this hemisphere, and see her again bursting into life and beauty at his return, we cannot conclude that this glorious change results from any energy that belongs to mere matter ; it must be some force of a more specific and powerful nature than the undefined energies of matter, and none seem so probable as that of a living or vital principle.

That the divine influence in the works of creation is extremely various, must be evident to the slightest degree of reflection.

Let us look at man, possessed of a bodily structure that depends on the same physical laws that pervade every other link in the animal kingdom, and we shall find him endowed with a special ray of heavenly light, that enables him to enter into the most sublime conceptions of his nature, and the purpose of his being; and then pass along the descending scale of intelligence, until we arrive at the last link in this vast chain of perception, and we shall perceive a difference so great, as scarcely to admit of a comparison, though we have the strongest assurances that they are all derived from the same infinite source of divine power and intelligence. Although we cannot compare the energies of light, even with the lowest part of intelligent nature, yet its particles may possess the capability of being excited to action by external objects, and answer all the purposes we have ascribed to their agency. That the particles of light may, by their combined

energies, give rise to chemical affinities, and produce new combinations of matter, or even supply the particles of organized bodies with a principle of irritability, does not seem improbable; but it does not appear so obvious, how organization results from this influence; yet, as we proceed in the inquiry, we shall meet with a beautiful adaptation of this supposed irritable power of light to the formation of organized structures.

Admitting that the similarity, which is to be found in many chemical and vital processes, arises from the influence of the same secondary cause, which we have supposed to be solar light, we may also infer that its active particles will be influential in producing many other phenomena. This being granted, may we not conclude from its extreme momentum, and its trong propensity to unite with terrestrial matter, that it does become united, though in various degrees, to

the particles of some highly attenuated matter; and that it pervades the earth and atmosphere, though under a less active character than that of light? And if we carefully inquire, whether there are any phenomena that furnish evidence of an energy such as we are anticipating, we shall find that the effects ascribed to the magnetic fluid are just such as we might anticipate from the energies of light, when deprived of its extreme momentum, and united to a small portion of highly attenuated terrestrial matter.

In support of this conclusion, let it be remembered that the magnetic fluid and light will pass through many dense bodies with little interruption; and, also, that the very class of bodies which most impede the passage of the magnetic fluid, are the very bodies which most impede the progressive momentum of light. This inference is also countenanced by a great variety of

magnetic results, and promises a more satisfactory solution to them than any other opinion which has yet been published. The idea of a distinct magnetic fluid, or agent, specially created for the purpose of producing a few magnetic effects, is incompatible with the apparent simplicity and economy of secondary causes. That the most striking magnetic effects result from a partial interruption of some very general agent which pervades the earth and atmosphere for more important purposes, is extremely probable; and none so likely as solar light, when deprived of its extreme momentum, and united to a small portion of highly attenuated terrestrial matter; which we may justly term insensible caloric, as well as the magnetic fluid. If we follow up this mode of reasoning, founded on analogies and the simplicity of secondary causes, we shall also perceive that the particles of light may become united to a still denser portion of terrestrial matter, by

which union, and consequent loss of activity, they will not be so well prepared to pass through dense bodies, as they were before that union, but that they will be better calculated to produce more powerful effects in the material world; and here sensible caloric, or the radiant matter of heat, offers itself to our notice. Sensible, or what is termed radiating, caloric, we know cannot pass through bodies with the same facility that light, or the magnetic fluid does, which we have supposed to be insensible caloric; consequently, it is of a more dense nature, and well calculated by this density to produce more powerful effects.

To support the similarity of light and caloric it may be remarked, that light will develope a bird from an egg, also unfold a plant from a seed, and give increased activity to chemical processes; and just the same effects will result from a proper application of terrestrial heat, or sensible caloric. Light, also, if its

application is very powerful, will destroy the organized structure of an egg and vegetable seed, but increase chemical energies: heat, or sensible caloric, will do exactly the same, if powerfully applied; therefore goes far towards proving that light, and sensible or radiating caloric, are of the same nature.

By still pursuing the same analogical mode of reasoning, we may discover, that this disposition of light to unite with the particles of terrestial matter will give rise to other combinations besides the magnetic fluid and sensible caloric. This inference leads us to the electricity of the atmosphere, which, by passing from one place to another, displays energies which bear the strongest resemblance to the momentum of light: nor is the rapidity of lightning more irreconcilable to the mere energies of matter, than those of artificial electricity; for our electrical results furnish phenomena that are incompa-

tible with every notion we can form respecting common matter.

Artificial electricity, which is very dense when compared to light, or even sensible caloric, has been known to pass through a circuit of four miles without taking up any sensible portion of time; and when viewed in the dark, it seems to be a luminous body of matter, that flies by its own energy, with inconceivable velocity, from one place to another; and just such an agent as we might conceive an highly attenuated portion of the atmosphere to be, when united to a large portion of insensible caloric, if we suppose its particles possess the activity we have ascribed to them.*

* In a small electrical essay of mine, published in 1810, by Messrs. J. Johnson and Co., I laid down a few theoretic positions, which I then thought to be more consistent with electric phenomena, than any other opinions I had seen, and as they so completely coincide with the general views of this essay, I shall republish them.

"POSITIONS.

"1st. There are two electric fluids, which are composed of caloric and the

Having shewn that both vital and chemical changes are promoted by the influence of radiating or sensible heat, it will not be improper to examine a little more minutely into the nature and action of insensible caloric, as it will direct our attention to that peculiar process, called combustion, which is one of the chief sources of radiating caloric.

Respecting the magnetic fluid, or insensible caloric, no direct evidence has yet been obtained to demonstrate its existence; but, admitting that there is an active fluid, which produces magnetic effects, we may infer from the polar action of the needle, that it pervades

constituent parts of the atmosphere. In the excitation of electricity by the electrical machine, the air is decomposed, its two gases are more closely united to caloric, or matter of heat, by the attrition of the cylinder and rubber, and constitute two distinct electric fluids.

"2nd. These fluids can pass through the best electric bodies, but cannot pervade the interior of good conducting substances, though they can pass along the surface of the latter with inconceivable ease and velocity.

"3rd. When an electric body is charged, for example, a pane of glass, or a Leyden phial, a small portion of the electric fluid is retained on one side of the charged electric; which, in the act of discharging, excites a considerable portion of fresh electricity, and gives birth to the most singular part of the Leyden phenomena."

every part of the earth and atmosphere; and is that active agent which instigates all those new combinations which attend both vital and chemical changes.

When flint and steel are violently struck together, a portion of their particles, particularly those of the steel, become so violently agitated at the point of contact, and their cohesion so far destroyed, as to allow them to enter into rapid union with the oxygen of the atmosphere; but still there must be something more concerned in the process of combustion than the simple union of oxygen and the particles of the combustible body. To render this more evident, let the detached particles of the steel, which are entering into a rapid union with the oxygen, be allowed to come in contact with a proper combustible body, and we shall find that their energetic influence will operate upon the particles of that body, as the mechanical force did on the

particles of the steel, by destroying their cohesion and preparing them for entering into union with fresh portions of oxygen; and thus the process of combustion may be carried on to an unlimited extent, if proper materials are supplied.

Another combustible effect may be produced with fulminating silver, which far exceeds the power of gunpowder. In this instance, we have the particles of a metallic substance so prepared, that if the slightest motion is communicated to them by a mechanical force at the common temperature of the air, they rush into union with the oxygen of the atmosphere, and produce the most terrific effects. It is evident from these, and a variety of similar cases, that oxygen is a very active agent in the process of combustion: nevertheless, we want some other agent of a more active nature than oxygen and the combustible body, before we can form a clear

and satisfactory idea of the principles by which this process is carried forward.

Having supposed that solar light pervades the earth and atmosphere under the character we have ascribed to insensible caloric, and is the active source of vital and chemical energies, may we not in the present instance again refer to its effects for an illustrative principle? It is well known that the rays of light communicate no intense degree of sensible heat, when passing in straight lines or their natural direction; but if they are converged by a large convex lens, and brought to a focus on the surface of a combustible body, they instantly produce the most rapid combustion. This is a very illustrative result; for it shews that the particles of light possess within themselves the power of producing the very effect we have ascribed to a mechanical force, and the action of insensible caloric in other cases of combustion.

By referring these effects of light to an energetic force its particles possess, we ascribe to it a power that surpasses the most active mechanical force in nature; yet, it should be remembered, that it is not like referring them to our popular notions of chemical affinities, and a supposed principle of repulsion, or the still more undefined energies of matter; for we refer them to vitalized matter, which has been demonstrated to proceed at the rate of two hundred thousand miles in a second of time; consequently furnishes us with a principle of activity that is not to be equalled in any other part of the visible creation.

In every combustible process that does not originate from the direct action of light, two things seem necessary; viz. a mechanical force, to first move the particles of the bodies concerned in the process, and then the influence of something like caloric, to carry forward this process; and though some chemical

cases may appear like an exception to this general rule, yet, if examined more closely, we shall be able to trace that the influence of light, or this common principle of combustion, has been the cause of their particles being placed under circumstances favourable to the combustion produced by the action of what are called chemical affinities.

By pointing out that solar light possesses within itself the true source of combustion, and having already supposed that light, when united to a small portion of highly attenuated terrestrial matter, perhaps oxygen, constitutes insensible caloric, which pervades the earth, and promotes the general process of combustion, when aided by a mechanical force, we shall still see that the chief energy of every combustible process is derived from the energies of solar light; and if we proceed on this principle, to investigate combustion in general, we shall find a tolera-

ble solution to several results attending the process, which are at present involved in complete theoretic obscurity.

Many are the facts which shew that light has a strong propensity to enter into union with terrestrial matter; and if we suppose its slightest degree of union is with that portion which constitutes the magnetic fluid, or insensible caloric, and that this force is the active source of all combustible processes which have not been induced by the direct influence of solar light, we shall readily discover that the combinations which take place with this agent and terrestrial matter, in the process of combustion, must be various. Thus we find radiating caloric, and electricity* developed by this progressive, but rapid, change of matter, both of which are much denser than insensible caloric; nor is the extrication of light incompatible with this

* See the Rev. Mr. Bennet's Essay on Electricity.

idea of combustion, for in such a powerful conflict, it is natural to expect that some of its particles will become liberated from their slender union with terrestrial matter, and resume all their former activity of light.

From this view of the subject, we may be led to ask, what is the essence and nature of this active energy; or how is it united to the particles of matter which form the basis of light; and why are the particles of light so strongly disposed to unite with the particles of other matter, particularly oxygen; or how do they promote the organization of living structures, to which we have before alluded? To these queries it may be remarked, there are many natural phenomena, which lie beyond our present powers of comprehension; for we know not the essence and nature of the human mind, we only know its powers when united to a living organized structure; nor is it likely we shall be able to disco-

ver the exact essence, or nature of that power, which gives to the particles of light their extreme momentum; yet, we can clearly prove this extreme velocity to be matter of fact, which is of the highest importance to our inquiry, as it supplies us with a principle of activity that seems wanting in all our explanations of vital and chemical processes.

These views and conclusions are supported by numerous other analogical facts, which may be obtained by an impartial and candid research into physiological phenomena; but if we take into the account several facts and declarations of Holy Writ, we shall find they bear more directly upon some parts of this inquiry than any other evidence. We cannot, however, expect to find any elaborate disquisitions on physiological subjects in the sacred writings, as they are specially intended for other important purposes; yet, the informa-

tion they communicate on this subject is of a plain and satisfactory nature. In the first place we are told by the sacred historian, that the creation of light was a special act of the Creator, which took place before the creation of the sun; a statement that has been thought by some to weaken the credit of the historian; but if we admit agreeably to what has been stated, that light consists of small particles of matter endowed with a living energy, and is the vital source of all living organized structures, we shall discover the reasonableness of such a special creation to invigorate the surface of the globe, and quicken the numerous organized forms of plants and animals which rallied into existence at the will of the Almighty Creator: therefore, so far from weakening the credit of the historian, it adds another proof, if another proof were wanting, that the record of this creative event was dictated by inspiration; for it does not appear to have been deduced from any physiological

investigation, and is directly opposed to the obvious fact, that the sun is the source of all the influential light which the earth enjoys.

Another branch of physiology also derives considerable illucidation from the pages of sacred history. If we contrast the opinion of some ancient as well as modern physiologists, on the first formation of plants and animals, with the plain and simple narrative related by the sacred historian, we shall derive much satisfaction from the comparison; as the first evidently leads us into a confused labyrinth, while the latter is plain and simple, and seems equal to the most enlightened views of the subject.

Should it be allowed that the particles of light possess a living energy, which stimulates the process of organization, it might be argued agreeably to the opinions of many physiological writers, both ancient and mo-

dern, that they must possess a degree of formative intelligence, to enable them to carry forward the process of organization; a principle that must inevitably produce, as it often has done, an extreme degree of theoretic confusion, and encroach on the creating prerogative of God: but if we consult the sacred historian's account of the creation, we shall find that it was infinite power and wisdom which formed the exquisite structure of plants and animals, and gave them an unknown capability to provide for the further procreation of their species; consequently organization does not result from any directing intelligence possessed by the individual particles of any material, or immaterial, substance. That this living energy, which the Deity has diffused throughout nature, may acquire such capabilities by becoming united to the organized structure of the lower class of animals, as to become the source of those feeble mental powers we

call instincts, is not improbable; and when we see a portion of unorganized matter changed by the simple structure of a plant into a beautiful flower, and sluggish vegetable matter so converted by the superior organic structure of the animal frame, as to give birth to all the beauties and physical advantages we observe in the animal economy, may we not, without violating any just principle of analogical reasoning infer, that the exquisite structure of the human frame may so far mould and purify a portion of that active, or immaterial substance, which we have supposed to pervade nature, as to fit it for higher intellectual purposes?

These inferences flow from an extensive view of physiological phenomena, and find additional support from the creative facts related in sacred history. Several different opinions have been entertained respecting the moral situation of man, at his first

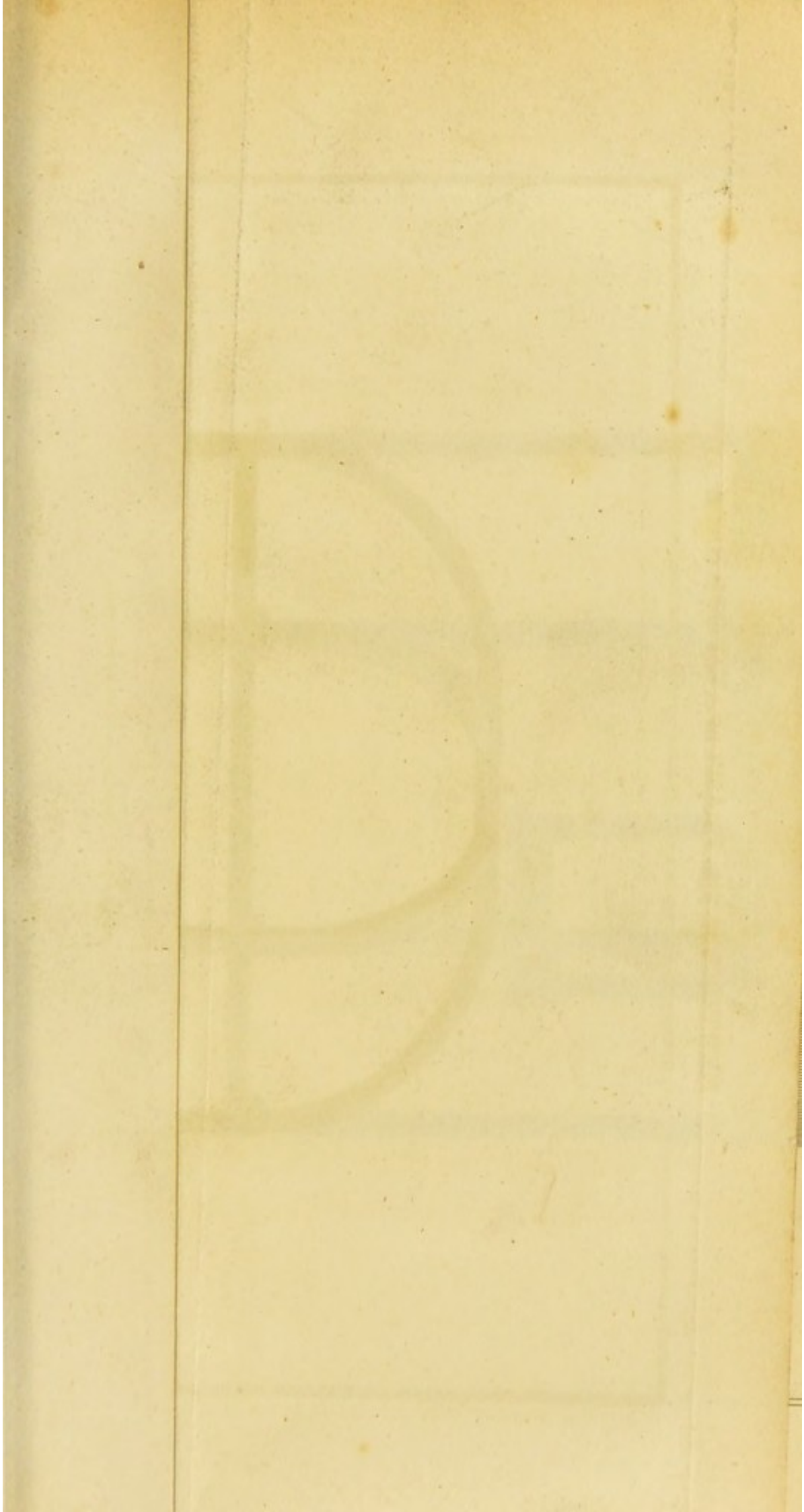
formation; but the creative facts, which bear upon him as a subject of physiological inquiry, are of a less equivocal nature. Thus we are distinctly told, that God formed man out of the dust of the earth; a declaration which, in all probability, had a reference to his physical organization; and it was on this part of man that the creative power of divine wisdom was exercised with peculiar attention; for as we proceed in the narrative we find, that in order to render his exquisite workmanship effectual, God simply breathed, or caused to pass into this wonderful structure, a portion of breath, or air containing a living principle, and that by this active energy, which no doubt flowed from a divine source, becoming united to this wonderful structure, man became a living soul, or a being possessed of the same physical and mental capabilities which we now enjoy. This statement corroborates the idea, that the organization of the body is the means

which God has appointed for the developement of intellectual capabilities, and by taking up the subject in this point of view, perhaps the angry disputants about materialism and immaterialism may find they are not so opposed to each other as they have imagined; for the organization of a certain portion of matter seems as essential to man as a living principle, and that it is in the mental results which flow from an union of these two, that the infinite wisdom and goodness of God is so wonderfully displayed in his rational creation.

That the human mind is of a divine nature is rendered evident by the sacred writings; for we find that the intellectual powers of the apostles were strengthened by a direct communication from heaven, which acted in union with their natural minds, although, on certain occasions, it carried them to a higher degree of useful activity; consequently, shews

they were both derived from the same source, and partook of a similar nature, though there might be a difference in their strength and degree of purity. Nor is it improbable, but many of the important events recorded in sacred history are more reconcilable with natural phenomena than many have supposed; and, as our scientific knowledge ascends higher on the scale of theoretic improvement, it will become more explanatory of various extraordinary facts which the volumes of revelation have promulgated.

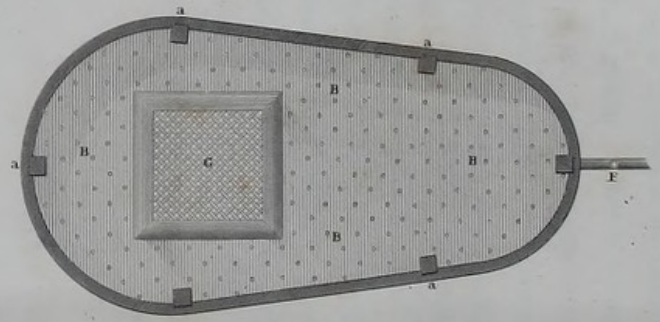
Rushton and Melling, Printers, Liverpool.



SECTION of the FRAME of a VAPOUR BATH.

Fig. 1

Fig. 2



Scale of one Inch to a Foot