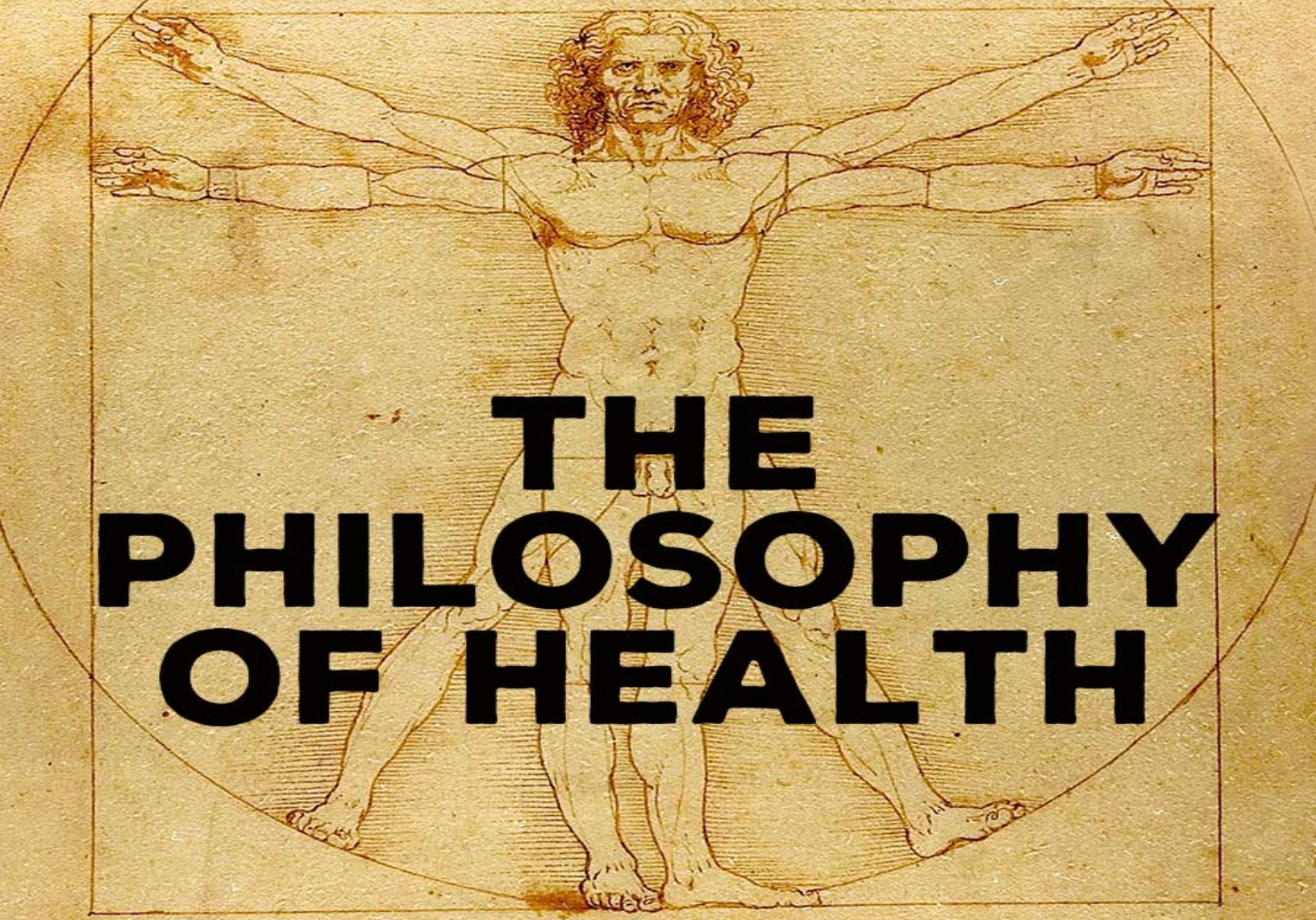
Thoman Southwood Smith



THE PHILOSOPHY OF HEALTH

(Vol.1&2)

Thoman Southwood Smith

The Philosophy of Health (Vol. 1&2)

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Volume I

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INTRODUCTION.

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The object of the present work is to give a brief and plain account of the structure and functions of the body, chiefly with reference to health and disease. This is intended to be introductory to an account of the constitution of the mind, chiefly with reference to the development and direction of its powers. There is a natural connexion between these subjects, and an advantage in studying them in their natural order. Structure must be known before function can be understood: hence the science of physiology is based on that of anatomy. The mind is dependent on the body: hence an acquaintance with the physiology of the body should precede the study of the physiology of the mind. The constitution of the mind must be understood before its powers and affections can be properly developed and directed: hence a knowledge of the physiology of the mind is essential to a sound view of education and morals.

In the execution of the first part of this work, that which relates to the organization of the body, a formidable difficulty presents itself at the outset. The explanation of structure is easy when the part described can be seen. The teacher of anatomy finds no difficulty in communicating to the student a clear and exact knowledge of the structure of an organ; because, by the aid of dissection, he resolves the various complex substances, of which it is built up, into their constituent parts, and demonstrates the relation of these elementary parts to each other. But the case is different

with him who attempts to convey a knowledge of the structure of an organ merely by the description of it. The best conceived and executed drawing is a most inadequate substitute for the object itself. It is impossible wholly to remove this difficulty: what can be done, by the aid of plates, to lessen it, is here attempted. A time may come when the objects themselves will be more generally accessible: meanwhile, the description now given of the chief organs of the body may facilitate the study of their structure to those who have an opportunity of examining the organs themselves, and will, it is hoped, enable every reader at once to understand much of their action.

Physical science has become the subject of popular attention, and men of the highest endowments, who have devoted their lives to the cultivation of this department of knowledge, conceive that they can make no better use of the treasures they have accumulated, than that of diffusing them. Of this part of the great field of knowledge, to make "the rough places plain, and the crooked places straight," is deemed a labour second in importance only to that of extending the boundaries of the field itself. But no attempt has hitherto been made to exhibit a clear and comprehensive view of the phenomena of life; the organization upon which those phenomena depend; the physical agents essential to their production, and the laws, as far as they have yet been discovered, according to which those agents act. The consequence is, that people in general, not excepting the educated class, are wholly ignorant of the structure and action of the organs of their own bodies, the circumstances which are conducive to their

own health, the agents which ordinarily produce disease, and the means by which the operation of such agents may be avoided or counteracted; and they can hardly be said to possess more information relative to the connexion between the organization of the body and the qualities of the mind, the physical condition and the mental state; the laws which regulate the production, combination, and succession of the trains of pleasurable and painful thought, and the rules deducible from those laws, having for their object such a determination of voluntary human conduct, as may secure the pleasurable and avoid the painful.

Yet nothing would seem a fitter study for man than the nature of man in this sense of the term. A knowledge of the structure and functions of the body is admitted to be indispensable to whoever undertakes, as the business of his profession, to protect those organs from injury, and to restore their action to a sound state when it has become disordered; but surely some knowledge of this kind may be useful to those who have no intention to practise physic, or to perform operations in surgery; may be useful to every human being, to enable him to take a rational care of his health, to make him observant of his own altered sensations, as indications of approaching sickness; to give him the power of communicating intelligibly with his medical adviser respecting the seat and the succession of those signs of disordered function, and to dispose and qualify him to co-operate with his physician in the use of the means employed to avert impending danger, or to remove actual disease.

But if to every human being occasions must continually occur, when knowledge of this kind would be useful, the possession of it seems peculiarly necessary to those who have the exclusive care of infancy, almost the entire care of childhood, a great part of the care of the sick, and whose ignorance, not the less mischievous because its activity is induced by affection, constantly endangers, and often defeats, the best concerted measures of the physician.

The bodily organization and the mental powers of the child depend mainly on the management of the infant; and the intellectual and moral aptitudes and qualities of the man have their origin in the predominant states of sensation, at a period far earlier in the history of the human being than is commonly imagined. The period of infancy is divided by physiologists into two epochs; the first, commencing from birth, extends to the seventh month: the second, commencing from the seventh month, extends to the end of the second year, at which time the period of infancy ceases, and that of childhood begins. The first epoch of infancy is remarkable for the rapidity of the development of the organs of the body: the processes of growth are in extreme activity; the formative predominates over the sentient life, the chief object of the action of the former being to prepare the apparatus of the latter. The second epoch of infancy is remarkable for the development of the perceptive powers. The physical organization of the brain, which still advances with rapidity, is now capable of a greater energy, and a wider range of function. Sensation becomes more exact and varied; the intellectual faculties are in almost constant operation; speech commences, the sign, and, to a certain

extent, the cause of the growing strength of the mental powers; the capacity of voluntary locomotion is acquired, while passion, emotion, affection, come into play with such constancy and energy, as to exert over the whole economy of the now irritable and plastic creature a prodigious influence for good or evil. If it be, indeed, possible to make correct moral perception, feeling, and conduct, a part of human nature, as much a part of it as any sensation or propensity—if this be possible for every individual of the human race, without exception, to an extent which would render *all* more eminently and consistently virtuous than *any* are at present (and of the possibility of this, the conviction is the strongest in the acutest minds which have studied this subject the most profoundly), preparation for the accomplishment of this object must be commenced at this epoch. But if preparation for this object be really commenced, it implies, on the part of those who engage in the undertaking, some degree of knowledge; knowledge of the physical and mental constitution of the individual to be influenced; knowledge of the mode, in which circumstances must be so modified in adaptation to the nature of the individual being, as to produce upon it, with uniformity and certainty, a given result. The theory of human society, according to its present institutions, supposes that this knowledge is possessed by the mother; and it supposes, further, that this adaptation will actually take place in the domestic circle through her agency. Hence the presumed advantage of having the eye of the mother always upon the child; hence the apprehension of evil so general, I had almost said instinctive, whenever it is proposed to take the

infant, for the purpose of systematic physical and mental discipline, from beyond the sphere of maternal influence. But society, which thus presumes that the mother will possess the power and the disposition to do this, what expedients has it devised to endow her with the former, and to secure the formation of the latter? I appeal to every woman whose eye may rest on these pages. I ask of you, what has ever been done for you to enable you to understand the physical and mental constitution of that human nature, the care of which is imposed upon you? In what part of the course of your education was instruction of this kind introduced? Over how large a portion of your education did it extend? Who were your teachers? What have you profited by their lessons? What progress have you made in the acquisition of the requisite information? Were you at this moment to undertake the guidance of a new-born infant to health, knowledge, goodness, and happiness, how would you set about the task? How would you regulate the influence of external agents upon its delicate, tender, and highly-irritable organs, in such a manner as to obtain from them healthful stimulation, and avoid destructive excitement? What natural and moral objects would you select as the best adapted to exercise and develope its opening faculties? What feelings would you check, and what cherish? How would you excite aims; how would you apply motives? How would you avail yourself of pleasure as a final end, or as the means to some further end? And how would you deal with the no less formidable instrument of pain? What is your own physical, intellectual, and moral state, as specially fitting you for this office? What is the measure of

your own self-control, without a large portion of which no human being ever yet exerted over the infant mind any considerable influence for good? There is no philosopher, however profound his knowledge, no instructor, however varied and extended his experience, who would not enter upon this task with an apprehension proportioned to his knowledge and experience; but knowledge which men acquire only after years of study, habits which are generated in men only as the result of long-continued discipline, are expected to come to you spontaneously, to be born with you, to require on your part no culture, and to need no sustaining influence.

But, indeed, it is a most inadequate expression of the fact, to say that the communication of the knowledge, and the formation of the habits which are necessary to the due performance of the duties of women, constitute no essential part of their education: the direct tendency of a great part of their education is to produce and foster opinions, feelings, and tastes, which positively disqualify them for the performance of their duties. All would be well if the marriage ceremony, which transforms the girl into the wife, conferred upon the wife the qualities which should be possessed by the mother. But it is rare to find a person capable of the least difficult part of education, namely, that of communicating instruction, even after diligent study, with a direct view to teaching; yet an ordinary girl, brought up in the ordinary mode, in the ordinary domestic circle, is intrusted with the direction and control of the first impressions that are made upon the human being, and the

momentous, physical, intellectual, and moral results that arise out of those impressions!

I am sensible of the total inadequacy of any remedy for this evil, short of a modification of our domestic institutions. Mere information, however complete the communication of it, can do little beyond affording a clearer conception of the end in view, and of the means fitted to secure it. Even this little, however, would be something gained; and the hope of contributing, in some degree, to the furtherance of this object, has supplied one of the main motives for undertaking the present work. Meantime, women are the earliest teachers; they must be nurses; they can be neither, without the risk of doing incalculable mischief, unless they have some understanding of the subjects about to be treated of. On these grounds I rest their *obligation* to study them; and I look upon that notion of delicacy, which would exclude them from knowledge calculated, in an extraordinary degree, to open, exalt, and purify their minds, and to fit them for the performance of their duties, as alike degrading to those to whom it affects to show respect, and debasing to the mind that entertains it.

Though each part of this work will be made as complete in itself as the author is capable of rendering it, and to that extent independent of any other part, yet there will be found to be a strict connexion between the several portions of the whole; and greatly as the topics included in the latter differ from those which form the earlier subjects, the advantage of having studied the former before the latter are entered on, will be felt precisely as the word *study* can be justly applied to the operation of the mind on such matters.

In the expository portion of the work I have not been anxious to abstain from the employment of technical terms, when a decidedly useful purpose was to be obtained by the introduction of them; but I have been very careful to use no such term without assigning the exact meaning of it. A technical term unexplained is a dark spot on the field of knowledge; explained, it is a clear and steady light.

In order really to understand the states of health and disease, an acquaintance with the nature of organization, and of the vital processes of which it is the seat and the instrument, is indispensable: it is for this reason that the exposition of structure and function, attempted in this first part of the work, is somewhat full; but there cannot be a question that, if it accomplish its object, it will not only enable the account of health and disease in the subsequent part of it to be much more brief, but that it will, at the same time, render that account more intelligible, exact, and practical.

S. S.

CHAPTER I.

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Characters by which living beings are distinguished from inorganic bodies—Characters by which animals are distinguished from plants—Actions common to plants and animals—Actions peculiar to animals—Actions included in the organic circle—Actions included in the animal circle—Organs and functions defined—Action of physical agents on organized structures—Processes of supply, and processes of waste—Reasons why the structure of the animal is more complex than that of the plant.

The distinction between a living being and an inorganic body, between a plant and a stone, is, that the plant carries on a number of processes which are not performed by the stone. The plant absorbs food, converts its food into its own proper substance, arranges this substance into bark, wood, vessels, leaves, and other organized structures; grows, arrives at maturity, and decays; generates and maintains a certain degree of heat; derives from a parent the primary structure and the first impulse upon which these varied actions depend; gives origin to a new being similar to itself, and, after a certain time, terminates its existence in death.

No such phenomena are exhibited by the stone; it neither absorbs food, nor arranges the matter of which it is composed into organized structure; nor grows, nor decays, nor generates heat, nor derives its existence from a parent,

nor gives origin to a new being, nor dies. Nothing analogous to the processes by which these results are produced, is observable in any body that is destitute of life; all of them are carried on by every living creature. These processes are, therefore, denominated vital, and, being peculiar to the state of life, they afford characters by which the living being is distinguished from the inorganic body.

In like manner the distinction between an animal and a plant is, that the animal possesses properties of which the plant is destitute. It is endowed with two new and superior powers, to which there is nothing analogous in the plant; namely, the power of sensation, and the power of voluntary motion; the capacity of feeling, and the capacity of moving from place to place as its feeling prompts. The animal, like the plant, receives food, transforms its food into its own proper substance, builds this substance up into structure, generates, and maintains a certain temperature, derives its existence from a parent, produces an offspring like itself, and terminates its existence in death. Up to this point the vital phenomena exhibited by both orders of living creatures are alike: but at this point the vital processes of the plant terminate, while those of the animal are extended and exalted by the exercise of the distinct and superior endowments of sensation and voluntary motion. To feel, and to move spontaneously, in accordance with that feeling, are properties possessed by the animal, but not by the plant; and therefore these properties afford characters by which the animal is distinguished from the plant.

The two great classes of living beings perform, then, two distinct sets of actions: the first set is common to all living

creatures; the second is peculiar to one class: the first set is indispensable to life; the second is necessary only to one kind of life, namely, the animal. The actions included in the first set, being common to all living or organized creatures, are called ORGANIC; the actions included in the second class, belonging only to one part of living or organized creatures, namely, animals, are called ANIMAL. The ORGANIC actions consist of the processes by which the existence of the living being is maintained, and the perpetuation of its species secured: the ANIMAL actions consist of the processes by which the living being is rendered percipient, and capable of spontaneous motion. The ORGANIC processes comprehend those of nutrition, respiration, circulation, secretion, excretion, and reproduction; the first five relate to the maintenance of the life of the individual being; the last to the perpetuation of its species. The ANIMAL processes comprehend those of sensation and of voluntary motion, often denominated processes of relation, because they put the individual being in communication with the external world. There is no vital action performed by any living creature which may not be included in one or other of these processes, or in some modification of some one of them. There is no action performed by any inorganic body which possesses even a remote analogy to either of these vital processes. The line of demarcation between the organic and the inorganic world is, therefore, clear and broad; and the line of demarcation between the two great divisions of the organic world, between the inanimate and the animate, that is, between plants and animals, is no less decided: for, of the two sets of

actions which have been enumerated, the one, as has just been stated, is common to the whole class of living beings, while the second set is peculiar to one division of that class. The plant performs only the organic actions: all the vital phenomena it exhibits are included in this single circle; it is, therefore, said to possess only organic life: but the animal performs both organic and animal actions, and is therefore said to possess both organic and animal life.

Both the organic and the animal actions are accomplished by means of certain instruments, that is, organized bodies which possess a definite structure, and which are moulded into a peculiar form. Such an instrument is called an organ, and the action of an organ is called its function. The leaf of the plant is an organ, and the conversion of sap by the leaf into the proper juice of the plant, by the process called respiration, is the function of this organ. The liver of the animal is an organ; and the conversion of the blood that circulates through it into bile, by the process of secretion, is its function. The brain is an organ; the sentient nerve in communication with it is also an organ. The extremity of the sentient nerve receives an impression from an external object, and conveys it to the brain, where it becomes a sensation. The transmission of the impression is the function of the nerve; the conversion of the impression into a sensation is the function of the brain.

The living body consists of a congeries of these instruments or organs: the constituent matter of these organs is always partly in a fluid and partly in a solid state. Of the fluids and solids which thus invariably enter in

combination into the composition of the organs, the fluids may be regarded as the primary and essential elements, for they are the source and the support of the solids. There is no solid which is not formed out of a fluid; no solid which does not always contain, as a constituent part of it, some fluid, and none which is capable of maintaining its integrity without a continual supply of fluids.

Whatever be the intimate composition of the fluids out of which the solids are formed, the investigation of which is more difficult than that of the solids and the nature of which is therefore less clearly ascertained, it is certain that all the matter which enters into the composition of the solid is disposed in a definite order. It is this disposition of the constituent matter of the living solid in a definite order that constitutes the arrangement so characteristic of all living substance. Definite arrangements are combined in definite modes, and the result is what is termed organization. From varied arrangements result different kinds of organized substances, each endowed with different properties, and exhibiting peculiar characters. By the recombination of these several kinds of organized substances, in different proportions and different modes, are formed the special instruments, or organs, of which we have just spoken; while it is the combining, or the building up of these different organized substances into organs, that constitutes structure.

In the living body, not only is each distinct organ alive, but, with exceptions so slight that they need not be noticed here, every solid which enters into the composition of the organ is endowed with vital properties. This is probably the

case with the primary substances or tissues which compose the several organs of the plant; but that the animal solids are alive is indubitable; nay, the evidence is complete, that many even of the animal fluids possess vitality. The blood in the animal is as truly alive as the brain, and the bone as the flesh. The organized body, considered as a whole, is the seat of life; but life also resides in almost every component part of it.

Yet the matter out of which these living substances is formed is not alive. By processes of which we know nothing, or, at least, of which we see only the first steps,—matter, wholly destitute of life, is converted into living substance. The inorganic matter, which is the subject of this wonderful transformation, is resolvable into a very few elementary substances. In the plant, these substances consist of three only, namely, oxygen, hydrogen, and carbon. The first two are aëriform or gaseous bodies; the last is a solid substance, and it is of this that the plant is chiefly composed: hence the basis of the plant is a solid. The elementary bodies, into which all animal substance is resolvable, are four, namely, azote, oxygen, hydrogen, and carbon. Into every animal fluid and solid this new substance azote enters so largely, that it may be considered as the fundamental and distinctive element of the animal organization: hence the basis of the animal is an aëriform or gaseous fluid. The animal is composed of air, the plant of solid matter; and this difference in their elementary nature gives origin to several distinctive characters between the plant and the animal, in addition to those which have been already stated.

Thus the characters of the plant are solidity, hardness, fixedness, and durability; while the animal is comparatively fluid, soft, volatile, and perishable; and the reason is now manifest. The basis of the animal being an aëriform fluid, its consistence is softer than that of the plant, the basis of which is a firm solid; and, at the same time, the component elements of the animal being more numerous than those of the plant, and the fluidity of these elements, and of the compounds they form, greatly favouring their action and reaction on each other and on external agents, the animal body is more volatile and perishable during life, and more readily decomposed after death.

It has been stated, that the object of every structure or organ of the living body, is the performance of some special action or function,—the ultimate object of the fluids being the production of the solids; the ultimate object of the solids being the formation of organs; the ultimate object of organs being the performance of actions or functions; while it is in the performance of actions or functions that life consists. Functions carried on by organs; organs in action; special organs performing definite actions, this it is that constitutes the state of life. Every particle of matter which enters into the composition of the living body has thus its own place, forming, or destined to form, a constituent part of some organ; every organ has its own action; all the organs of the body form the body; and all the actions of all the organs constitute the aggregate of the vital phenomena.

Every organ is excited to action, or its function is called into operation by means of some external body. The external bodies capable of exciting and maintaining the

functions of living organs, consist of a definite class. Because these bodies belong to that department of science which is called physical, they are termed physical agents. They are air, water, heat, cold, electricity, and light. Without the living organ, the physical agent can excite no vital action: without the physical agent, the living organ can carry on no vital process. The plant cannot perform the vital process of respiration without the leaf, nor, with the leaf, without air. The physical agent acts upon the living organ; the living organ reacts upon the physical agent, and the action between both is definite. In the lung of the animal a certain principle of the air unites, in definite proportions, with a certain principle of the blood; the oxygen of the air combines with the carbon of the blood; the air is changed by the abstraction of its oxygen; the blood is changed by the abstraction of its carbon. Atmospheric air goes to the lung, but atmospheric air does not return from the lung; it is converted into a new substance by the action of the organ: it is changed into carbonic acid by the union of a given quantity of oxygen, which it transmits to the organ, with a given quantity of carbon which the organ conveys to it. Venous blood goes to the lung, but venous blood does not return from the lung; it is converted, by the instrumentality of the organ, into a new substance, into arterial blood, by giving to the air carbon, and by receiving from the air oxygen. In this manner the change in the physical agent is definite and uniform; and the change in the living substance is equally definite and uniform.

It is this determinate interchange of action between the living organ and the physical agent that constitutes what is

termed a vital process. All vital processes are carried on by living organs; the materials employed in all vital processes are physical agents; the processes themselves are vital functions. All the changes produced by all the organs of the plant upon physical agents, and all the changes produced by all physical agents upon the organs of the plant, constitute all the vital processes of the plant—comprehend the whole sum of its vital phenomena. The root, the trunk, the woody substance, the bark, the ascending vessels bearing sap, the descending vessels bearing secreted fluids, the leaves, the flowers, these are the living organs of the plant. Air, water, heat, cold, electricity, light, these are the physical agents which produce in these organs definite changes, and which are themselves changed by them in definite modes; and the whole of these changes, taken together, comprehend the circle of actions, or the range of functions performed by this living being.

In the state of life, during the interchange of action which thus incessantly goes on between physical agents and vital organs, the laws to which inorganic matter is subject are resisted, controlled, and modified. Physical and chemical attractions are brought under the influence of a new and superior agency, with the laws of which we are imperfectly acquainted, but the operation of which we see, and which we call the agency of life. Air, water, heat, electricity, are physical agents, which subvert the most intimate combinations of inorganic bodies, resolving them into their simple elements, and recombining these elements in various modes, and thus forming new bodies, endowed with totally different properties; but the physical and chemical

agencies by which these changes are wrought in the inorganic, are resisted, controlled, and modified by the living body: resisted, for these physical agents do not decompose the living body; controlled and modified, for the living body converts these very agents into the material for sustaining its own existence Of all the phenomena included in that circle of actions which we designate by the general term life, this power of resisting the effects universally produced by physical agents on inorganic matter, and of bringing these very agents under subjection to a new order of laws, is one of the most essential and distinctive.

All vital processes are processes of supply, or processes of waste. By every vital action performed by the organized body, some portion of its constituent matter is expended. Numerous vital actions are constantly carried on for the sole purpose of compensating this expenditure. Every moment old particles are carried out of the system; every moment new particles are introduced into it. The matter of which the organized, and more especially the animal, body is composed, is thus in a state of perpetual flux; and in a certain space of time it is completely changed, so that of all the matter that constitutes the animal body at a given point of time, not a single particle remains at another point of time at a given distance.

All the wants of the economy of the plant are satisfied by a due supply of air, water, heat, cold, electricity, and light. Some of these physical agents constitute the crude aliment of the plant; others produce in this aliment a series of changes, by which it is converted from crude aliment into proper nutriment, while others act as stimulants, by which

movements are excited, the ultimate object of which is the distribution of the nutriment to the various parts of the economy of the plant.

The same physical agents are indispensable to the support of the animal body; but the animal cannot be sustained by these physical agents alone; for the maintenance of animal life, in some shape or other, vegetable or animal matter, or both in a certain state of combination, must be superadded: hence another distinction between the plant and the animal,—the necessity, on the part of the animal, of an elaborated aliment to maintain its existence. By the vital processes of its economy, the plant converts inorganic into organic matter; by the vital processes of its economy, the animal converts matter, already rendered organic, into its own proper substance. The plant is thus purveyor to the animal: but it is more than purveyor to it; for while it provides, it also prepares its food; it saves the animal one process, that of the transmutation of inorganic into organic matter. The ultimate end, or the final cause of the vital processes performed by the first class of living beings, is thus the elaboration of aliment for the second: the inferior life is spent in ministering, and the great object of its being is to minister to the existence of the superior.

At the point at which organization commences structure is so simple that there is no manifest distinction of organs. Several functions are performed apparently by one single organized substance. The lowest plants and the lowest animals are equally without any separate organs, as far as it is in our power to distinguish them, for carrying on the vital

actions they perform. An organized tissue, apparently of an homogeneous nature, containing fluid matter, is all that can be made out by which the most simply-constructed plant carries on its single set, and by which the most simply-constructed animal carries on its double set, of actions. But this simplicity of structure exists only at the very commencement of the organized world. Every advancement in the scale of organization is indicated by the construction of organs manifestly separate for the performance of individual functions; and, invariably, the higher the being, the more complete is this separation of function from function, and, consequently, the greater the multiplication of organs, and the more elaborate and complex the structure;—and hence another distinction between the plant and the animal. The simplicity of the structure of the plant is in striking contrast to the complexity of the structure of the animal; and this difference is not arbitrary; it is a matter of absolute necessity, and the reason of this necessity it will be instructive to contemplate.

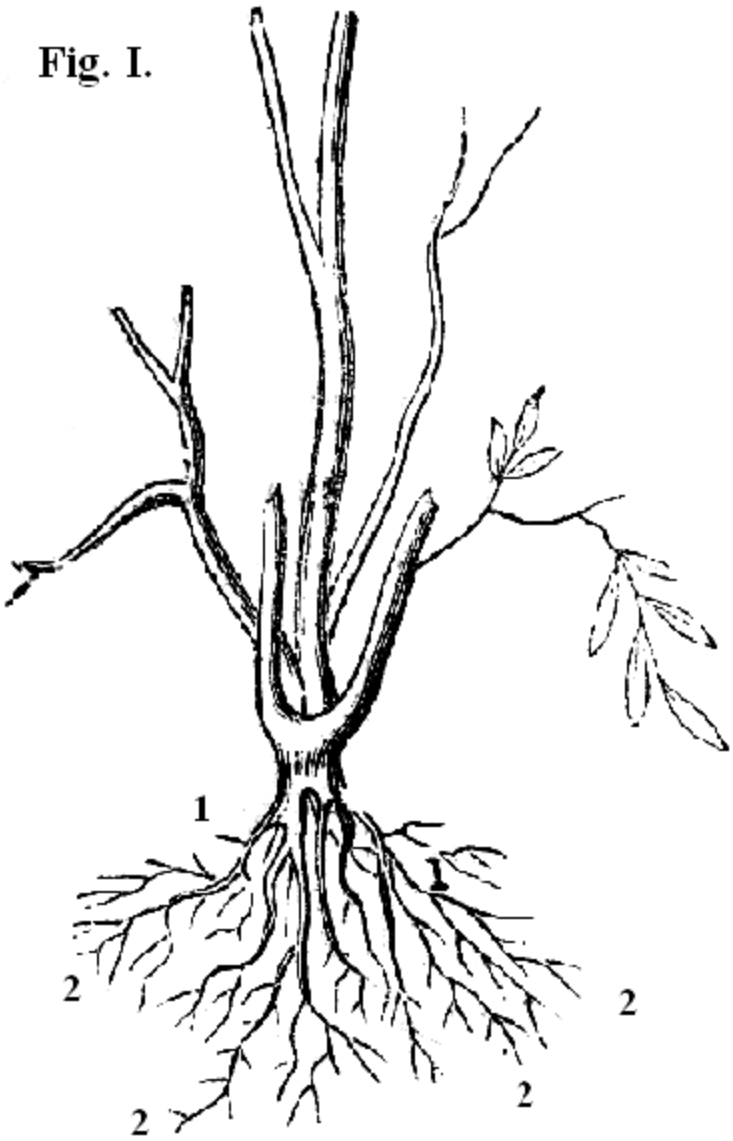
The plant, as has been shown, performs only one set of functions, the organic; while the animal performs two sets of functions, the organic and the animal. The animal, then, performs more functions than the plant, and functions of a higher order; it carries on its functions with a greater degree of energy; its functions have a more extended range, and all its functions bear a certain relation to each other, maintaining an harmonious action. The number, the superiority, the relation, the range, and the energy of the functions performed by the animal are, then, so many conditions, which render it absolutely indispensable that it

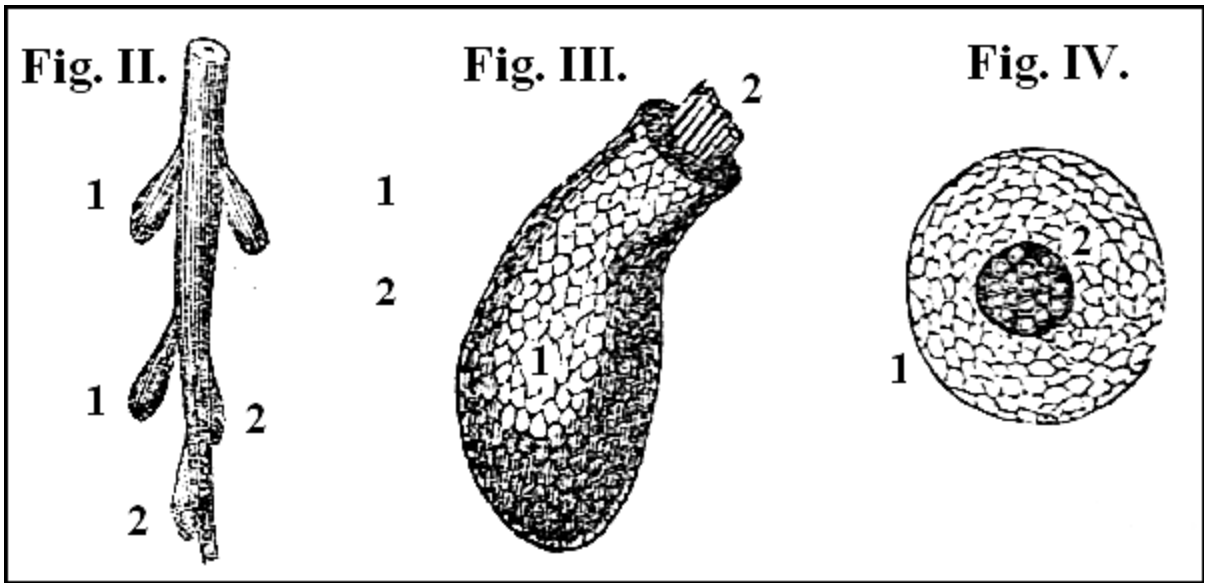
should possess a greater complexity of structure than the plant.

1. To build up structure is to create, to arrange, and to connect organs. Organs are the instruments by which functions are performed, and without the instrument there can be no action. With as many more organs than the plant possesses the animal must, therefore, be provided, as are necessary to carry on the additional functions it performs. Organs, for its organic functions, it must have as well as the plant; but to these must be superadded organs of another class, for which the plant has no need, namely, organs for its animal functions. Two sets of organs must, therefore, be provided for the animal, while the plant requires but one.

2. Some functions performed by the animal are of a higher order than any performed by the plant, and the superior function requires a higher organization. The construction of an organ is complex as its action is elevated; the instrument is elaborately prepared in proportion to the nobleness of its office.

Fig. I.

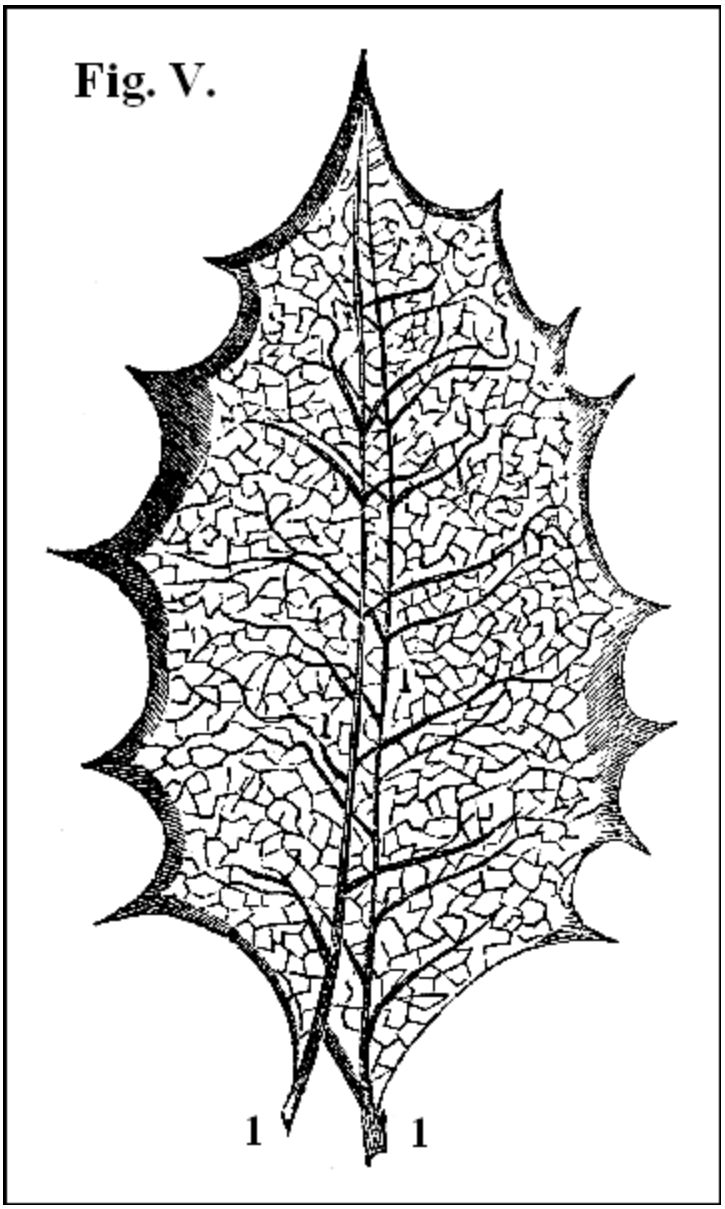




3. But this is not all; for the addition of a superior function requires not only the addition of an organ having a corresponding superiority of structure, but it requires, further, that a certain elevation of structure should be communicated to all the organs of all the inferior functions, on account of the relation which it is necessary to establish between function and function. Unless the organ of an inferior function be constructed with a perfection corresponding to that of the organ of a superior function, the inferior will be incapable of working in harmony with the superior. Take, for example, the inferior function of nutrition: nutrition is an organic function equally necessary to the plant and to the animal, and requiring in both organs for performing it; but this function cannot be performed in the animal by organs as simple as suffice for the plant. Nutrition, in the plant, is carried on in the following mode:— The root of the plant is divided, like the trunk, into numerous branches (fig. I. 1). These branches divide and subdivide into smaller and smaller branches, until at last they reach an extreme degree of minuteness (fig. I. 2 2).

The smallest of these divisions, called, from their hair-like tenuity, *capillary* (fig. I. 2 2), are provided with a peculiar structure, which is endowed with a specific function. In most plants this peculiar structure is found at the terminal point of the rootlet (fig. I. 2 2); but in some plants the capillary branches of the rootlets are provided with distinct bodies (fig. II. 1 2), scarcely to be discerned when the root has been removed some time from the soil, and has become dry (fig. II. 2 2); but which, in a few minutes after the root has been plunged in water, provided the plant be still alive, become turgid with fluid, and, consequently, distinctly visible (fig. II. 1 1 1). These bodies, when they exist, or the terminal point of the rootlet when these bodies are absent, are termed *spongeolæ*, or spongeoles; and the structure and function of the organ, in both cases, are conceived to be precisely the same. In both the organ consists of a minute cellular structure. Fig. III. 1, shows this structure as it appears when the object is magnified. The office of this organ is to absorb the aliment of the plant from the soil; and so great is its absorbing power, that, as is proved by direct experiment, it absorbs the colouring molecules of liquids, though these molecules will not enter the ordinary pores, which are of much greater magnitude. With the spongeoles are connected vessels which pass through the substance of the stem or trunk to the leaf. Fig. III. 2, shows these tubes springing from the cellular structure of the spongeole, and passing up to the stem or trunk. Fig. IV. 2, exhibits a magnified view of the appearance of the mouths of these tubes on making an horizontal section of the spongeole. Fig. V. 1 1 1, exhibits a view of these tubes passing to the leaf.

Figs. VI. and VII. 1 1 1 1, show these vessels spread out upon, and ramifying through, the leaf. The crude aliment, borne by these tubes to the leaf, is there converted into proper nutriment; and from the leaf, when duly elaborated, this proper nutriment is carried out by ducts to the various organs of the plant, in order to supply them with the aliment they need.



Now, for carrying on the process of nutrition in this mode, there must be organs to absorb the crude aliment, organs to