CHAPTER VI.

Differences and Relations between Parts and Organs—"Homology" and "Analogy"—Definition of Homology, and Illustrations of "Homologues"—Modes of Investigating Homologies—Serial and Lateral Homology — Analogy — Definition — Examples of "Analogues" — "Balancing of Organs"—Correlation of Growth and Structure—Homomorphism—Mimicry—Symmetry of Animal Forms — Relations of Symmetry and Homology.

TURNING his attention to the more intimate relations which exist between different animal or vegetable forms, the naturalist seeks to establish certain principles subsidiary to those broader ones we have just been considering, and by means of which he investigates the relation between parts or organs in the same organism, or between parts and organs situated in different organisms. In the consideration of these latter distinctions we narrow the circle of our research, and now confine our attention to what might appropriately enough be termed peculiarities of structure and function in individuals or groups of individuals. The broad principles established by the study of morphology and physiology suffice to enable us to generalise. We still require aids of more particular application, which will assist us in our more detailed examination of the constituent groups into which the respective sub-kingdoms may be divided, or of those forms or individuals of which such groups are composed.

The chief subsidiary principles which are derived from morphology and physiology, are known respectively as "homology" and "analogy." We shall therefore consider these two points in the first place, and thereafter briefly notice several features which may be said to depend upon or take origin from them.

By "Homology" we express the relationship or connection between organs, parts, or structures, which are constructed on the same fundamental plan, or according to the same primary type; whether these organs be situated in the same animal or in different animals. Two organs exhibiting this relationship are accordingly said to be "homologous," or they may be termed "homologues." And the relationship or connection so expressed is at once seen to be of a *morphological* kind, since two organs to be "homologous" must be identical in "structure;" or, more correctly speaking, they must be identical in the fundamental or primary structure. We have thus, in the present instance, nothing whatever to do with the *functions* of such parts or organs. The "homologue" possesses a morphological value only, and has no kinship, other than an accidental one, with any physiological or *functional* relations. Identity or agreement in fundamental structure being the sole and principal characteristic of homology, we are prepared to admit, from the mere verbal significance of the word "fundamental," that homologous organs or parts may present variation in form; and that in some cases to a very considerable extent. Indeed it is the recognition of these variations which has chiefly prompted the work of tracing homologies, and caused the necessity for the establishment of some such sure clue, in disentangling and unravelling the tangled skein into which animal and plant structures are sometimes wound.

A very superficial consideration of the structural relations of animal forms will bring to light many prominent examples of "homology." Primarily indeed the members of any one of the great "morphological types" may be said to present among themselves a broad homological series, but it is the more suitable and peculiar province of homology to trace the structural relations between individual members of the type, and to thus narrow the broader limits and extend the more intimate details of its working. As very obvious and patent examples of "homologous" organs or "homologues," we may select the arm of man, the wing of the bird, the fore-limb of the horse, ox, or dog, the paddle of the whale, and the "pectoral" or breast-fin" of the fish. All these members are identical in structure. A very cursory examination would show that the fundamental parts are the same in each; subject to variations in form and number perhaps, but leaving no doubt in the mind that one structural plan pervades them all. In the arm of man (Fig. 18, A) the following

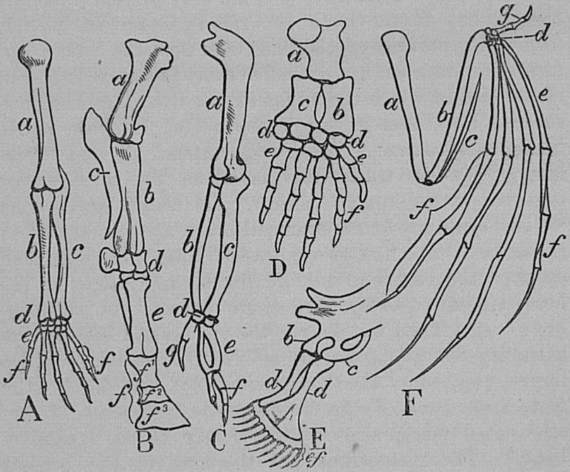

Fig. 18. Illustrations of Homology.

A, Skeleton of the arm of man: *a*, humerus; *b*, radius; *c*, ulna; *d*, carpus or "wrist;" *e*, metacarpus or "palm;" *f*, phalanges or bones of fingers. B, Bones of the fore-leg of the horse: f_1, greater pastern bone; f^2, lesser pastern-bone; f^3, coffin-bone. C, Skeleton of the wing of a bird; *g*, rudimentary thumb. D, Bones of the paddle or anterior extremity of whale. E, Skeleton of the "pectoral" or "breast-fin" of fish. F, Skeleton of fore-limb or wing of bat: *g*, rudimentary thumb. (The letters refer to the same parts as in the first figure.)

parts are found. Firstly, a single bone, the "humerus" (*a*), forming the upper arm; then two bones, "radius" (*b*) and "ulna" (*c*), forming the forearm; next, a series of small bones (*d*) disposed in two rows, and forming the "carpus" or "wrist;" then another series, forming the palm of the hand, or "metacarpus" (*e*); and lastly, a terminal series, known as the "phalanges" or "fingers" (*f*).

Examine now the skeletal elements of the fore-limb of the horse, ox, or dog; that of the first-mentioned animal (Fig. 18, B) being probably the example best suited to our present purpose. We have no difficulty in at once recognising the "humerus" (*a*), and the two bones of the "forearm" (*b c*) are still present; but we observe how in the horse the radius (*b*) almost entirely forms this portion of the limb, and how the "ulna" (*c*) so distinct in man, has dwindled away to a mere fragment of the size to which we might expect it to attain. Then succeed the bones of the "carpus" (*d*); but we notice in the disposition of the "metacarpus" (*e*) and "phalanges" (*f*) a wide variation from the arrangement observed in the human subject. On close examination we find that only four metacarpal bones are represented in the horse. The first two represent those which in man support the ring and middle fingers, and these in the horse are united to form the single "shank" or "cannon-bone" (*e*). Then we observe the metacarpal bone of the little finger, forming a mere splint-like appendage of its larger neighbour, the "cannon-bone;" and lastly, the metacarpal bone of the fore-finger is represented by an attenuated piece, also applied closely to the "cannon-bone." The metacarpus has therefore in the present case undergone a very considerable modification, but not so great as to render our identification of its separate elements a matter of extreme difficulty. Next succeed the bones of the fingers or "phalanges" (*f*), and in these latter parts still greater modification is met with. A single finger only—the third—is represented in the fore-foot of the horse, and this solitary digit consists of three "phalanges" or pieces. The first phalanx or piece is composed of two phalanges united together, and in the horse this is named the "great pastern" or "fetter" bone (f^1). The second piece, or middle phalanx of the finger, is known as the "lesser pastern" or "coronary bone" (f^2); whilst the last phalanx or joint of the finger (f^3) is of expanded and crescentic shape, and is known as the "coffin-bone." In the fore-limb of the horse, therefore, we are presented with a series of deviations from the human type of structure; yet we have no difficulty in at once determining that both of these members are constructed on the same type or plan, and they are therefore "homologous" in the truest sense of the word.

It would be needless to follow out in detail the other examples we have selected to illustrate the principle of homology. A glance at the illustration, and an examination of the corresponding parts in each member, will demonstrate the adherence to the primary type amid even great modification or alteration of structure. Thus, in the wing of the bird (Fig. 18, C), the humerus (*a*), radius (*b*), and ulna (*c*), are readily recognised; the distinct carpal bones (*d*) are two in number only; three metacarpals (*e*) exist—two being united at their extremities, whilst the third is distinct: and the fingers (*f*) number three in all—two being fingers, and the third a small rudimentary thumb (*g*). Here the fundamental structure, seen in the arm of man, still prevails throughout.

Similarly, in the paddle of the whale (Fig. 18, D), or in the bat's wing (F), where we have the humerus (*a*) distinct, the radius and ulna (*b c*) are readily recognised, and there is no difficulty in distinguishing the "carpus" (*d*), "metacarpus" (*e*), and "phalanges" (*f*). Or, lastly, in the pectoral or breast fin of the fish (Fig. 18, E) we can still trace the homology of the limb. The humerus is generally rudimentary, or may be wanting; the radius and ulna (*b c*) are usually to be distinguished; the carpal bones (*d*) vary greatly in number; whilst there is little difficulty in regarding the "fin-rays" (*e f*), as representing the "metacarpus" and "phalanges" of higher forms.

In the tracing of homologies there are three chief modes which may be either singly or conjointly pursued. The first and simplest of these modes consists in the *direct examination* and comparison of the organs between which we seek to find homologies. Then, secondly, if this mode of examination fail to afford us the desired result, we may trace the *development* of such organs or structures, and observe whether they may not exhibit, in their earlier stages of growth, that resemblance and relationship which, in their mature state, and from alterations in the progress of development, we fail to find. Or lastly, we may require to trace the organ through the examination of a long series of forms, and seek in these latter to find *successive stages of alteration and change*, by means of which we may connect the aberrant and altered structure with that of the more typical and readily recognised organ or part.

Very briefly let us exemplify each of these modes of pursuing this most important inquiry. The comparison of the fore-limbs of the mammal, bird, and fish, illustrates the first mode of procedure. A simple examination and comparison served, without further investigation, to convince us of the homological relationship which existed between them.

The second mode of investigating the homologies of organs is opened to us by the study of development; that is, by watching the growth of the organism, and observing if, in its earlier form, it presents us with a community of type and structure from which the modifications which puzzle us are afterwards evolved. The bodies of many of the higher *Annulosa* present us with very familiar and excellent illustrations of this second mode of conducting our homological inquiries. Take the lobster as an example, and try to trace the homologies of the various segments of which its body is composed. We can readily demonstrate that all the segments of the lobster's body, and the appendages of these segments, without exception, are constructed on an exactly similar plan, or are, in other words "homologous." If we examine one of the segments of the tail, we find it readily divisible into a "body" and "appendages." The "body" of each segment consists of a ring-like structure, bearing two appendages, and each of these latter is composed of a little stalk carrying two flattened oar-like pieces. This simple structure is partaken of by all the joints forming the abdomen or tail of the lobster; the last segment of all exhibiting a flattening and expansion of its appendages, but being otherwise readily reconcilable to the typical structure of the neighbouring joints.

The front part of the body, however, presents us with a totally different structural aspect from that we have been investigating in the tail. The head and chest of the lobster are massed together, and the various segments composing these regions are so united as apparently to defy recognition or correspondence with the structure of the tail-segments. Yet if we with care dissect out and separate the united parts, we shall find that not only are the segments which enter into the formation of the head and chest conformable to the typical plan of structure, but all the "appendages" of these segments similarly exhibit the same identity of structure. We can thus demonstrate that even the eyes, antennæ, or "feelers," the greater and lesser pairs of jaws; the foot-jaws; and the ordinary legs of the creature, are constructed on the same uniform plan, or are all "homologous" organs. Thus then we learn the important fact that each of the twenty-one segments of the lobster's body belongs to a common structural plan; and that the appendages, however diversified in function, are also entirely homologous.

Now we have here an example, not only of how the progress of development teaches us the homology of parts, but also of how it demonstrates and proves what a simple examination reveals. If we watch the development of the lobster, or of any typical member of its class, we find that after the segmented nature of the body has become apparent, the appendages are developed; those of the front portion of the body preceding the posterior segments in the order of development. But more important for our present purpose is the fact that all the appendages at first present a common plan of structure. Each consists, primarily, of the essential parts which we see in the tail-segments of the full-grown lobster, the subsequent phases of development tending to modify the anterior segments and their appendages in a great degree, whilst the posterior or hinder segments exhibit but a very slight alteration from the primary and embryonic type. In other words, all the varied segments and appendages of the lobster—eyes, feelers, jaws, legs, and swimmerets—are merely modifications of a common structural plan; in their embryonic condition they are all exactly similar to each other. How has development assisted us here? It has shown us that the nature of homologies is in truth far more intricate and more closely bound up with the nature of the organism than at first sight we might think; and it also tends to impress the fact, with which we commenced our latter considerations—namely, that if we fail to trace the homology of organs and parts in the animal as a fully-formed being, we will readily and satisfactorily observe the community of structure in the embryonic form.

Lastly, it may be found the most convenient mode of investigating this subject, to trace the modifications of an organ, or series of organs, through a succession of forms, noting the various stages through which the organ passes in its way to become more typical, or, on the other hand, to deviate more widely from the original and recognised plan. We find in the swimming or air-bladder of the fish an excellent example of the manner in which this last mode of examination may be pursued. This organ is of very general presence throughout the class of fishes, and exists in the form least reconcilable with its homological relationship as a bladder-like body, filled with atmospheric air or certain gases, and situated beneath the spine of the fish. Its function is that of altering the specific gravity of the fish, and, by rendering the animal heavier or lighter, enabling it to sink or rise in the water. Now this swimming-bladder is homologous with the lungs of the Mammal or higher Vertebrate, and at first sight no two structures can be conceived which are more unlike to each other than these. The present, therefore, is a case in which we determine the homologies of the organ by tracing it throughout the group, and by following it through its variations and development, until we perceive its relationship with the typical organ to which we have asserted it is allied.

The air-bladder is by no means universal in its occurrence throughout the group of fishes. Indeed some fishes, to which it would appear to be of most service, are destitute of it; whilst others which possess it could apparently, in their habits and mode of life, dispense with its presence. Yet this at first sight inexplicable fact, is at once explained by the consideration that we are not dealing with any mere empirical law, but with a deep-seated principle, in which mere exceptional instances of occurrence or absence of structures are of little moment or import, in the face of an ulterior scheme of progress towards unity of type or plan.

We start in our homological journey with the simple closed air-bladder of many fishes. The first step perceptible in the direction of the lung is the presence in some fishes of a duct or tube leading from the air-bladder, and opening at the upper and back part of the throat of the fish. This "pneumatic duct," as it is called, is soon perceived to be the early representative of the "trachea" or windpipe of the higher vertebrate; and we note this fact, not only from its position as regards the gullet, but from the possession by certain fishes of a rudimentary larynx or organ of voice. Already the examination of forms is assisting our tracing of homology, and we have now advanced from the shut and closed sac to a structure not only exhibiting divisions of its substance imitative of the double nature of lungs, but also provided with a "trachea" or windpipe, and a larynx in a rudimentary state of development.

A further stage shows us forms in which not only the external division of the air-bladder undergoes an advance, but where its internal surface becomes essentially of lung-like structure, and where the vascular arrangements also partake of the nature of those seen in the true lung. And so we latterly find the swimming-bladder actually transformed into a lung, and performing, in the economy of certain forms, all the functions which pertain to that higher type of respiratory organ. This latter mode of tracing homologies will be found in practice one of the

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most useful and satisfactory of the means for determining this important relationship between the structures or organs of animals or plants.

Before leaving the subject of Homology, there are a few considerations which may most appropriately be noticed at this present stage. The first of these latter considerations relates to the nature of that form of homology to which the name of "Serial Homology" has been applied. This term indicates the presence, in a single animal form, of a number of parts possessing the same fundamental structure, and which are placed or arranged in a longitudinal "series," or after one another in a straight line. The body of a worm, of a centipede, or of a lobster, accordingly exemplifies this condition of parts; these animals respectively presenting us with a "series" of segments exactly similar to each other, in respect of the primary or common plan of structure on which they are built up. And in the *Vertebrata*, in which "zonal" symmetry is also represented, we find the segments of the vertebral column, and even the deeper and less evident segmentation of the body itself, similarly exemplifying this form of homology. The appendages of the body may also exhibit the "serial homology" in a marked degree. Thus we have seen how an examination of the appendages of the lobster's body bears out this fact; and we also observe this relationship in the limbs of the *Vertebrata*, the fore and hind limbs being constructed on the same primary type, and exhibiting exactly corresponding and homologous parts.

The only condition which is apt to mimic this "serial homology" is that of a compound animal, where the single "individuals" which collectively constitute such an organism, may readily enough be mistaken for similar or homologous parts, arranged in a "serial" manner. In the *Tæniada* or tapeworms we have an illustration of such a case, the entire tapeworm consisting of numerous "joints" closely resembling each other, but which are in reality distinct "individuals," or "zöoids," as the naturalist terms them. We had occasion previously to notice the obvious distinction between the nature of the so-called "vegetative repetition of parts," and the repetition of "individuals." The serial segments of the worm or centipede exemplify the "vegetative repetition of parts;" the tapeworm, on the contrary, repeats true "zöoids" or "individuals," and not mere "parts." Hence in most instances the "vegetative repetition of parts" also exemplifies for us the arrangement we know as "serial homology." The mode of origin of such repeated parts concerns us but little, so long as we can demonstrate, firstly, that they are all "parts" of a single organism or individual; secondly, that they are constructed on the same fundamental plan; and thirdly, that they are arranged in a longitudinal "series." Any succession of organs or parts fulfilling these three conditions falls to be considered under the head of "serial homology."

The term "Lateral Homology," or "Bilateral Symmetry," has been applied by Mr. Spencer to indicate the "resemblance between the right and left sides of an animal;" or, in other words, the homology of the two sides of any animal form. The result of this correspondence in fundamental structure between the two sides of a form, is to render the body "bilaterally symmetrical." Thus, any animal, the two sides of whose body exhibit a similar structure or resemblance, would be regarded as "homologous" in this latter sense. The two sides of a *Vertebrate* or *Annulose* animal may therefore be said to exhibit "lateral homology" in one sense; namely, in that the appendages of the body are identical in structure, and in that the body can be divided, externally at least, into an equal right and left half.

Mr. Spencer explains the existence of this "lateral homology," and, indeed, the existence of other forms of structural identity, by supposing them to be the result of "the similar ways in which 'external' conditions" affect the right and left sides and deeper structures of the body respectively. But a very little consideration will show us that the term "lateral homology" is one which is applicable to only the superficial conditions of an organism, and which does not at all suffice to explain, or, indeed, agree with, the internal disposition of organs or parts. For although an animal may appear "bilaterally symmetrical" when viewed externally, yet its internal symmetry, or the arrangement of its internal parts, may not, and generally does not, present a similar and homologous arrangement. And when we further reflect that, in a body exhibiting externally this "lateral homology," we may find organs single in nature, and disposed to one side more than to the other, it becomes evident that the theory upon which the existence of a "lateral homology" is based, is not of an unquestionable or satisfactory kind. Then the theory is also insufficient to account for or explain the conditions in virtue of which certain deep-seated and normally symmetrical organs become asymmetrical. Why it is, for example, that one lung becomes shrivelled up, abortive, and functionally useless in most snakes, or that the right ovary and oviduct of birds is generally wanting or rudimentary, we cannot tell; nor is the presumption of Mr. Spencer's "external conditions" at all adequate to explain the cause of such phenomena. Or even, in the case of external appendages, such as the great "chelæ" or claws of the lobster and hermit-crab, where we observe that one claw is developed to a greater extent than the other, the theory cannot be said to render the cause of this asymmetrical and superficial condition plain or apparent.

Hence, although the term "bilateral symmetry" may be conveniently used to express a superficial character in the external form of animal organisms, it cannot be held to apply to the conditions or arrangement of deep-seated structures. And so far from the "external conditions" of the evolutionist being proved to be the *cause* of the "lateral homology" seen in any organism or organisms, the mere sequence between the homology and such conditions has not been made plain. It appears much more probable that the symmetrical disposition of superficial or deep-seated organs, or, on the other hand, their asymmetrical aspects, are subject to laws similar or analogous to those which regulate the growth and development of the organism as a whole. At the same time we must, of course, hold Mr. Spencer's theory in connection with the views and ideas, which, as a believer in the evolution of new forms from pre-existing species, he promulgates and supports.

We have dwelt thus at considerable length on the question of Homology, and its use in the differentiation of animal structures and forms. We must note carefully, in the first instance, that the aim of homology is to demonstrate the structural identity of parts or organs, which are constructed on a common fundamental plan. Then, secondly, that homology is traced and exists independently of the *functions* or uses of such organs, as we shall presently observe. And, lastly, that we may trace homologies between the parts of different animals, or between the parts of the same animal. The former aspect of the science we may term "common" homology, whilst the latter we may designate "individual" homology. Of this last-mentioned division "serial" homology is a branch; and further research may add to the modes by which we may in the future be enabled to investigate the relations between parts or structures in the individual organism.

Although of subsidiary importance when considered in relation to homology, it is at the same time essential that we have correct notions of "Analogy." Homology we know to mean identity in fundamental structure. "Analogy" we may define as identity in *function*. We thus observe that whilst homology expressed a morphological distinction, analogy expresses a *physiological* one. Two organs, to be "analogous," must therefore perform a similar function in the economy of the organism or organisms in which they are situated. It is not at all essential to a correspondence of analogies that their *structure* should be similar. In other words, homology may exist without analogy; or, *vice versa*, two organs may be analogous without of necessity being also homologous. At the same time, and although these conditions are entirely independent of each other, we may find organs to be in themselves both homologous and analogous. They correspond in the latter case, both in fundamental structure and in function.

As examples of analogous organs, we may select the wing of the bird and that of the butterfly. Both possess the same function—that of serving as organs of flight. They are, however, purely analogous, in that they have no homological relations whatever. The structure of the one entirely differs from that of the other. Similarly, there is no homological identity between the jaw of a lobster or insect and that of a mammal. The former is merely a modified limb, whilst the latter consists of a distinctly developed part of the head. Yet the two organs are distinctly analogous, in that they both perform the same function, namely, that of the prehension and mastication of food.

Then, lastly, and as examples of cases in which the homology and analogy of two organs correspond, we may select the wing of the bird (Fig. 18, C), and that of the bat (Fig. 18, F); or the paddle of the whale, and the "pectoral" or "breast-fin" of the fish. If we examine the fore-limb of the bat, we shall find it to be structurally identical with that of the bird. The only notable difference, indeed, is in the immense elongation of all the digits of the hand (*e f*), save the thumb (*g*), and in the number of the digits. But both organs are entirely "homologous;" and they are also analogous in that they are used for the same purpose—that of supporting their respective possessors in the aërial medium. The paddle of the whale and the pectoral fin of the fish, are also both analogous and homologous. The same fundamental elements of structure enter into the composition of both, and their functions are also similar in every respect.

Recognising the relations and deductions to be drawn from a study of homologies and analogies, we are prepared to admit the great value of these relations in the philosophic study of living beings. Indeed, without the guiding aid of these principles, the naturalist's task in classifying and arranging the varied forms with which he has to deal, would become an almost insurmountable labour and difficulty. Yet, calling to his aid the generalisations in which the study of Homology and Analogy result, he is enabled to unravel the mysteries in which similarity of appearance shrouds the real nature of organisms considered singly or in groups. And below this superficial consideration lies the deeper and more complicated task of tracing out unities of plan and structure and type through endless forms of variation and modification—a labour to be ranked among the most important of those which the biologist has given him to do, and in which the value of all his modes of investigation is surely tested and tried. It is in such a task that the deductions of true homology and analogy prove of the utmost service and avail.

And, lastly, the thorough investigation of these principles is the best corrective to those very popular, but at the same time very erroneous notions, that animals or their organs were specially created to fulfil special ends. That this doctrine of the "final causation" of living beings,—resulting in the discovery of "special" and often misconstrued uses of animal and plant forms,—is the *ultimatum* of biological investigations, few who correctly appreciate the deductions of homology will allow. The entire organisation of nature in truth reveals a grand unity of type and plan, regulated by well-defined laws, and not a mere collection of scattered shifts and expedients, designed to fulfil as many incongruous and petty ends.

The present seems the most fitting opportunity for saying a few words regarding several points allied in nature to the questions in the study of which we have just been engaged.

These latter points are included under the respective terms of "*Balancing of Organs*," "*Correlation of Growth*," "*Homomorphism*," and "*Mimicry*."

By the term "Balancing of Organs," is meant the principle, insisted on by some authorities, "that excess of development in one organ or part is frequently accompanied by a corresponding or proportional deficiency in a neighbouring or connected organ." And by means of this principle it has been attempted to account for numerous deficiencies in structures and parts, which deficiencies do not appear to admit of easy or ready explanation according to the ordinary laws of growth. The considerations which militate against the adoption of the principle thus laid down, are similar to those already enumerated when treating of "Lateral Homology." And the fact that such excess of development in one organ is not invariably accompanied by atrophy or deficiency of another organ, leaves the supporter of the principle in the twofold dilemma of endeavouring to account for cases in which the deficiency occurs, and also for those cases in which no such deficiency is present. Then, in such cases as those exemplified by the absence of the one ovary and oviduct of birds, the principle of the "balancing of organs" does not explain the cause or conditions on which such non-development depends, any more than it can account for the reason why the other oviduct should persistently be developed, and retain its normal size, structure, and functions.

We must, however, carefully distinguish between excesses, or want of development, in a pathological or diseased state, and those which exist irrespectively of states of altered or abnormal nutrition. The connection between an obstructed or diseased circulation, and an enlarged or diminished size of the heart, for example, are referable to the ascertained relations of cause and effect. But in the absence of diseased states it is impossible in the same way to account for the results which the principle of the "balancing of organs" seeks to explain.

Several points of curious interest are included in the consideration of the term "Correlation of Growth," or "Correlation of Forms." By this term we express the fact of certain organs, parts, or structures, not necessarily related to each other by structural, or even functional, peculiarities, being invariably found to co-exist or to be associated with one another. In other words, these organs or parts are invariably co-existent, irrespective of their differences in nature. Thus all animals which suckle their young, or are provided with mammary glands, invariably possess two "condyles," or articular processes of characteristic structure, on the occipital bone of the skull, and also possess non-nucleated red blood-corpuscles. Or again, we find that "rumination," or the power of "chewing the cud," is invariably associated with a cloven or cleft condition of the feet. And many other instances might be offered as illustrations of this curious fact.

Regarding the essential nature and cause of these correlations of growth or structure, we know absolutely nothing. The facts, upon which this principle is built up, have been simply ascertained from a careful examination and comparison of forms, and we can only limit ourselves to a plain statement of these facts. Morphological science does not warrant us in seeking to establish "a causal relationship between the organs thus associated together." And although theory and hypothesis are not wanting, by means of which the relations between the cause and result of this "correlation" are sought to be explained, yet there are few who, recognising the plain path of inquiry, will be tempted from that path by a theory obviously moulded to the facts, and so unworthy of our support or countenance. It is more consistent with a true scientific spirit to own our inability to explain this correlation, and simply to recognise this co-existence of structures, than to seek a convenient explanatory bye-road which the higher knowledge of to-morrow may close.

We therefore are forced to content ourselves with the simple recognition of the facts included under the term "correlation of growth," and at the same time we own the mere empirical nature of the law. It is one deduced solely from observation and experiment, but at the same time it would appear to be dependent on other than merely accidental causes.

As subsidiary to the more typical condition of "correlative" structures, it may not be out of place to remind the reader of the presence of a certain amount of "sympathy" between certain organs in the animal economy; these latter organs, however, being connected together, often forming part of one system, and being otherwise bound to each other by relationships evinced through the medium of the nervous system. Such instances of "sympathy" are well known to the medical world; and as an example of these, the intimate "sympathy" between the reproductive organs and the breasts or "mammæ" may be cited. Such conditions, occurring in instances admitting of obvious explanation, may be regarded, and rightly so, as falling without the boundaries of the considerations we have just been noting; but they serve, at the same time, to show the presence of "correlation," manifested in a great degree between organs of the same economy.

But quite as important a consideration lies in the fact that the apparently constant nature of the law of correlation is of the greatest possible service in determining the relations of animals in the past, and in settling their affinities with forms now existent. We know, for example, that all mammals possess the certain and distinctive features before mentioned, and that these, in virtue of the law of correlation, are invariably associated. Hence if we ascertain the presence of one of these features, we can safely affirm the existence of all the others. Thus, if we know an animal possesses two occipital condyles of a certain structure, we may predict that it will also possess non-nucleated red blood-corpuscles and mammary glands. And in the researches of the palæontologist, employing as he does the inductive method of reasoning, by means of which he argues of the unknown from his knowledge of the known, or argues "respecting a whole class what has been ascertained respecting one or more individuals of that class," this unvarying nature of the "law of correlation" assists him in framing, from a part or possession of one character, a correct generalisation regarding the whole.

This law, it is however to be borne in mind, is subject to the conditions and fate of all merely empirical generalisations; that is, it *may* be proved erroneous by subsequent observation or experiment. Whilst, therefore, we are fully entitled to found our belief on the constant results of experience, we must at the same time be prepared to have our conclusions tested, or even set aside, by the progressive march of inquiry, and in the light of new truths which further observation may disclose. Huxley sums up the matter very succinctly when he says—"Not that it is to be supposed that the correlations of structure expressed by these empirical laws are in any sense accidental, or other than links in the general chain of causes and effects. Doubtless there is some very good reason why the characteristic occiput of a Mammal should be found in association with mammæ and non-nucleated blood-corpuscles; but it is one thing to admit the causal connection of these phenomena with one another, or with some third; and another thing to affirm that we have any knowledge of that causal connection, or that physiological science, in its present state, furnishes us with any means of reasoning from the one to the other."

The term *Homomorphism* has been applied to indicate a series of resemblances, traceable between organisms which are themselves far removed from one another in structure and organisation. Examples of this "homomorphic" resemblance are seen in the close likeness between some of the *Hydrozoa* or Zoophytes (Fig. 4), and the *Polyzoa* or "Sea-mat" class (Fig. 6). And similar resemblances may be traced between the *Infusoria* and *Rotifera*. Such a resemblance is, in itself, an apparently trivial matter, seeing that the structural affinities of such organisms are usually and widely different. But modern theories profess to see an ulterior and deeper meaning in such resemblances—firstly, in that such forms may take the place and functions of one another; and secondly, in respect of their origin, in that certain "conditions" are supposed to have affected, in a greater or less degree, the resemblances which they bear to each other.

A survey of the geographical distribution of animals and plants, furnishes us with many examples of certain so-called "representative" or "homomorphic" forms, taking on themselves, in a particular area, the place and functions of those forms to which they bear a resemblance. But this is not always the case, and so far from being widely separated from each other, we may find "homomorphic" forms living side by side. The tendency of a section of modern thought would seem to be that of regarding such forms as springing primitively from a common origin, and that, under certain conditions, changes in organisation took place, affecting their structure and relations, but leaving their external configuration comparatively unaltered. The older theory of Forbes advocates the idea of special creations in special centres; the conditions surrounding each organism or group being nearly or exactly similar, and producing structures of close identity in appearance and form. Neither view appears wholly adequate to explain all the circumstances; but of the two, the latter has the merit of being supported in some degree by facts as they stand.

Mimicry is the name given to those conditions in virtue of which an animal form assumes the outward characters and appearance of another animal form, or of a plant, or even of some lifeless or inorganic object; these resemblances being destitute of any connection with the position or structural relations of the animal. Such conditions appear to be in some degree explained by the supposition that they are assumed for the purposes of defence or protection against enemies. The observations of Messrs. Bates and Wallace on the subject of "mimicry," form the chief sources from which our information regarding these curious conditions has been derived. Throughout the class *Insecta*, we find instances of "mimicry" of most frequent occurrence; and the accounts given by the observers just mentioned, of the circumstances under which the mimetic resemblances are assumed, will be found exceedingly interesting, and worthy of perusal. The mere mention of a few examples of this peculiarity will suffice in the present instance. We thus find that among the *Orthopterous* insects, the so-called "walking leaves" or *Phylliidæ*, possess wings, in which not only the texture, but also the colours and shades of leaves are exactly imitated; so that these insects could not, without very minute examination, be detected among leaves, the appearance of which they so accurately mimic. Similarly the *Phasmidæ* or "walking-stick" insects, also included among the *Orthoptera*, present us with perfect resemblances of the dried twigs of trees. And in other cases we find that even the parasitic fungi which grow upon leaves, are, in the case of certain tropical butterflies, most naturally reproduced in the mimicry; and the delusion, if one may so term it, is thus rendered the more apparent and real.

Of these mimetic phenomena we have as yet had no explanation which can be considered wholly free from being enlisted under the banner of some special theory, and so in some degree made subservient to the ends and ulterior purposes of the theorist. We may, at any rate, and without looking at the deeper causes of the condition, assume that it is, in all probability, made subservient, if not specially adapted, to the defensive requirements of the creatures in whose economy it is exhibited.

The term *Symmetry* so frequently occurs in discussing the relations of animal and plant forms, that it may be well, in concluding the present chapter, to briefly indicate the meaning and import of the term. By "symmetry," used in the common acceptation of the term, we mean the form or arrangement of parts of any particular object or organism. And, as applied technically to the parts or structures of an organism, or to the organism as a whole, we indicate by its "symmetry" the apt and similar arrangement of its "elements of form." Viewed thus, and apart from its subsidiary meanings, we speak of animals or plants possessing certain kinds of symmetry, and we thereby express the particular arrangement of those elementary parts, of which a philosophic morphology may conceive their bodies to be composed. For convenience sake the morphologist invents or supposes the existence of a purely ideal "element of form," to which the term "merosome" has been applied; and the particular kind or kinds of symmetry characteristic of any form are viewed as the result of the regular and defined "repetition of the same element of form."

Three kinds of symmetry, or modes of disposition of the primary elements of form or "merosomes," may be enunciated, and we have already had occasion, in discussing the characters of the great "morphological types," to refer to these varieties of form. Thus, we have firstly *Bilateral* or "two-sided" symmetry, in which the elements of form are equally disposed on each side of the middle line or mesial plane of the body: in other words, the body, which is bilaterally symmetrical, can be divided into equal right and left halves. The second kind of symmetry is termed *Radial;* and in this variety we find the "merosomes" disposed radially around a central point or axis. Whilst in *Zonal* symmetry the elements of form are arranged in "zones" or segments, one after the other, in a horizontal or longitudinal axis.

Examples of these various dispositions of form will be readily suggested from a cursory consideration and review of the characteristic features of the "types." Thus the *Vertebrata* and *Annulosa* each exemplify the "bilateral" and "zonal" symmetries—that is, we find that the body of every vertebrate and of every annulose animal can be divided through the mesial plane into equal halves, and we further notice the "zonal" symmetry in the arrangement of the segments of the vertebrate spine, and in the disposition of the joints or "zones" in the body of the annulose animal. The "radial" symmetry is typically seen in the *Annuloida;* where, in the body of such a form as a sea-urchin or star-fish, the radial disposition of parts can be readily perceived.

The relationship between symmetry and homology will be sufficiently apparent. Symmetry is a homology of a superficial kind, or of external surfaces. We may in many instances find that symmetrical parts are also homologous; but the two conditions, viewed simply, and without their connection with any theoretical considerations, are perfectly and naturally distinct. The "external conditions" of Spencer, would, on the contrary, seek to establish a definite connection, not only between mere symmetry of external form, and the deeper symmetry we term "homology," but also between the causes which give rise to each. Such causes are said to be those affecting the organism and its descendants from without; or through the operation of conditions which are external to the organism. We have already seen how these external causes are incompetent to give rise to such conditions; and how, in all probability, the conditions are at once deep-seated, internal, and intimately bound up with the laws regulating the inner life and economy of the form.