THE GENESIS OF SPECIES.

CHAPTER VIII.

HOMOLOGIES.

Animals made up of Parts mutually related in Various Ways. - What Homology is. - Its Various Kinds. - Serial Homology. - Lateral Homology. - Vertical Homology. - Mr. Herbert Spencer's Explanations. - An Internal Power necessary, as shown by Facts of Comparative Anatomy. - Of Teratology. - M. St. Hilaire. - Prof. Burt Wilder. - Foot-wings. - Facts of Pathology. - Mr. James Paget. - Dr. William Budd. - The Existence of such an Internal Power of Individual Development diminishes the Improbability of an Analogous Law of Specific Origination.

THAT concrete whole which is spoken of as "an individual" (such, e. g., as a bird or a lobster) is formed of a more or less complex aggregation of parts which are actually (from whatever cause or causes) grouped together in a harmonious interdependency, and which have a multitude of complex relations among themselves.

The mind detects a certain number of these relations as it contemplates the various component parts of an individual in one or other direction - as it follows up different lines of thought. These perceived relations, though subjective, *as relations*, have nevertheless an objective foundation as real parts, or conditions of parts, of real wholes; they are, therefore, true relations - such, e. g., as those between the right and left hand, between the hand and the foot, etc.

The component parts of each concrete whole have also a relation of resemblance to the parts of other concrete wholes, whether of the same or of different kinds, as the resemblance between the hands of two men, or that between the hand of a man and the fore-paw of a cat.

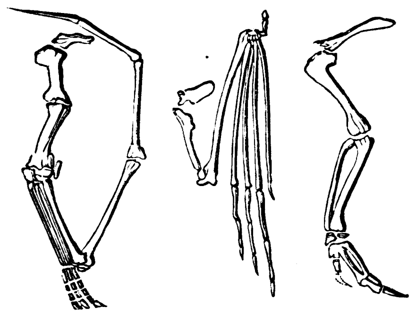
Now, it is here contended that the relationships borne one to another, by various component parts, imply the existence of some innate, internal condition, conveniently spoken of as a power or tendency, which is quite as mysterious as is any innate condition, power, or tendency, resulting in the orderly evolution of successive specific manifestations. These relationships, as also this developmental power, will doubtless, in a certain sense, be somewhat further explained as science advances. But the result will be merely a shifting of the inexplicability a point backward, by the intercalation of another step between the action of the internal condition or power and its external result. In the mean time, even if by "Natural Selection" we could eliminate the puzzles of the "origin of species," yet other phenomena, not less remarkable (namely, those noticed in this chapter), would still remain unexplained and as yet inexplicable. It is not improbable that, could we arrive at the causes conditioning all the complex inter-relations between the several parts of one animal, we should at the same time obtain the key to unlock the secrets of specific origination.

It is desirable, then, to see what facts there are in animal organization which point to innate conditions (powers and tendencies), as yet unexplained, and upon which the theory of "Natural Selection" is unable to throw any explanatory light.

The facts to be considered are the phenomena of "homology," and especially of serial, bilateral, and vertical homology.

The word "homology" indicates such a relation between two parts that they may be said in some sense to be "the same," or at least "of similar nature." This similarity, however, does not relate to the *use* to which parts are put, but only to their relative position with regard to other parts, or to their mode of origin. There are many kinds of homology, [1] but it is only necessary to consider the three kinds above enumerated.

The term "homologous" may be applied to parts in two individual animals of different kinds, or to different parts of the same individual. Thus "the right and left hands," or "joints of the backbone," or "the teeth of the two jaws," are homologous parts of the same individual. But the arm of a man, the fore-leg of the horse, the paddle of the whale, and the wing of the bat and the bird are all also homologous parts,



WING-BONES OF PTERODACTYL, BAT, AND BIRD.

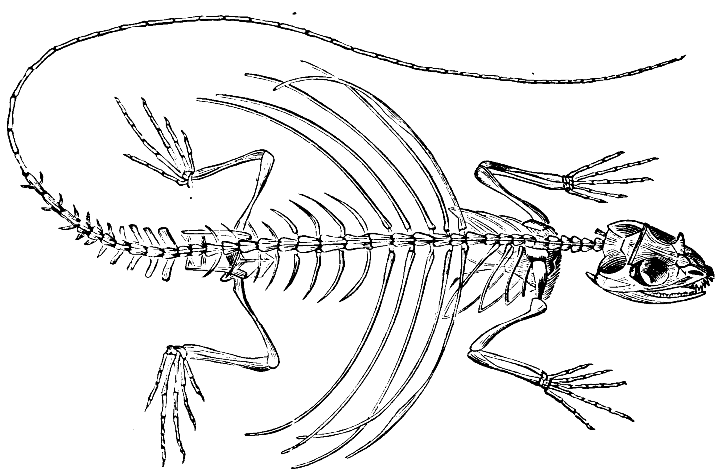
yet of another kind, i. e., they are the same parts existing in animals of different species.

On the other hand, the wing of the humming-bird and the wing of the humming-bird moth are not homologous at all, or in any sense; for the resemblance between them consists solely in the use to which they are put, and is therefore only a relation of *analogy*. There is no relation of *homology* between them, because they have no common resemblance as to their relations to surrounding parts, or as to their mode of origin. Similarly, there is no homology

[1] "For an enumeration of the more obvious homological relationships see Ann. and Mag. of Nat. Hist. for August, 1870, p. 118.

between the wing of the bat and that of the flying-dragon, for the latter is formed of certain ribs, and not of limb-bones.

Homology may be further distinguished into (1) a relationship which, on evolutionary principles, would be due to descent from a common ancestor, as the homological relation between the arm-bone of the horse and that of the ox, or between the singular ankle-bones of the two lemurine

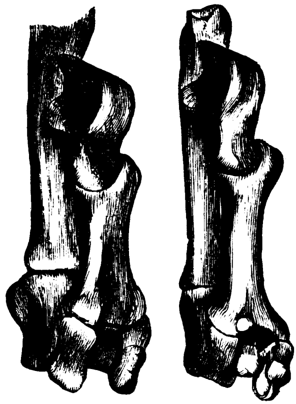


SKELETON OF THE FLYING-DRAGON.
(Showing the elongated ribs which support the flitting organ.)

genera, cheirogaleus and galago, and which relation has been termed by Mr. Ray Lankester "homogeny ;[2] and (2) a relationship induced, not derived - such as exists between parts closely similar in relative position, but with no genetic affinity, or only a remote one, as the homological relation between the chambers of the heart of a bat and those of a bird, or the similar teeth of the thylacine and

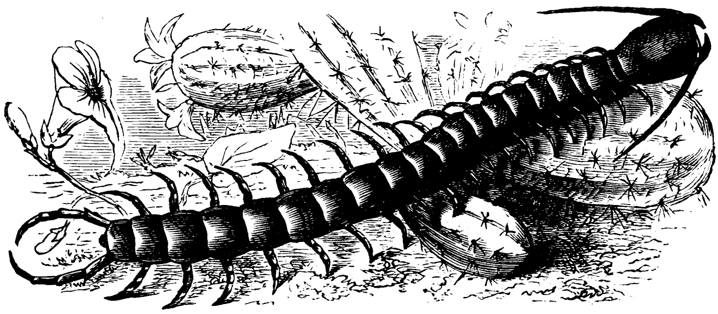
[2] See Ann. and Mag. of Nat. Hist., July, 1870.

the dog before spoken of. For this relationship Mr. Ray Lankester has proposed the term "homoplasy."



TARSAL BONES OF DIFFERENT LEMUROIDS.
(Right tarsus of Galago; left tarsus of Cheirogaleus.)

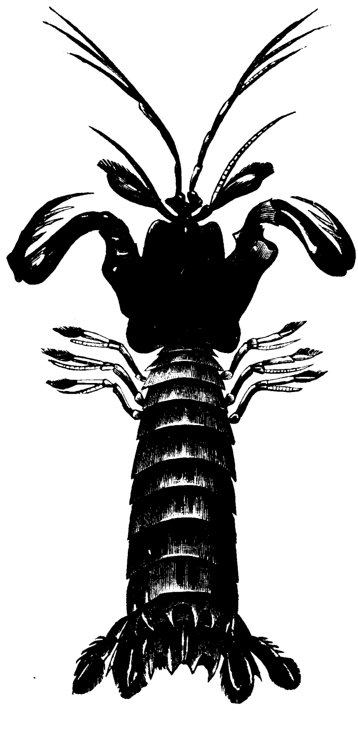
"Serial homology" is a relation of resemblance existing between two or more parts placed in series one behind the other in the same individual. Examples of such homologues



A CENTIPEDE.

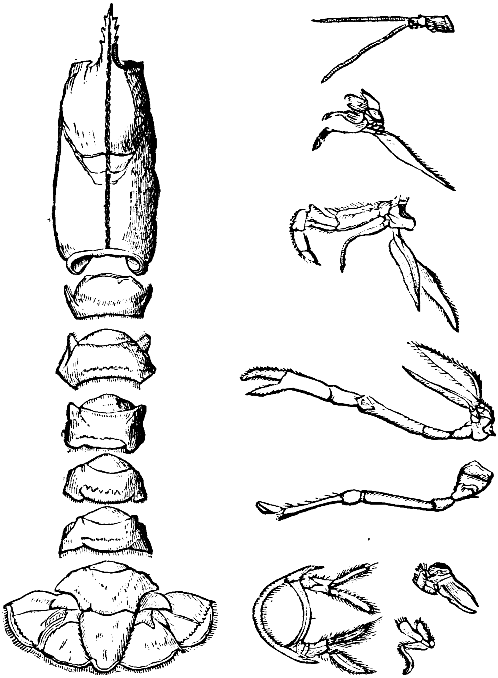
are the ribs, or joints of the backbone of a horse, or the limbs of a centipede. The latter animal is a striking example of serial homology. The body (except at its two ends) consists of a longitudinal series of similar segments. Each segment supports a pair of limbs, and the appendages of all the segments (except as before) are completely alike.

A less complete case of serial homology is presented by Crustacea (animals of the crab class), notably by the squilla and by the common lobster. In the latter animal we have



SQUILLA.

Now a six-jointed abdomen (the so-called tail), in front of which is a large solid mass (the cephalo-thorax), terminated anteriorly by a jointed process (the rostrum). On the under surface of the body we find a quantity of movable appendages. Such are, e. g., feelers (Fig. 9), jaws (Figs. 6, 7 and 8), foot-jaws (Fig. 5), claws and legs (Figs. 3 and 4), beneath the cephalothorax; and flat processes (Fig. 2), called "swimmerets," beneath the so-called tail or abdomen.

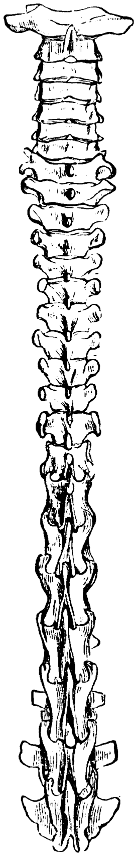


PART OF THE SKELETON OF THE LOBSTER.

Now, these various appendages are distinct and different enough as we see them in the adult, but they all appear in the embryo as buds of similar form and size, and the thoracic limbs at first consist each of two members, as the swimmerets always do.

(Editor's note: the Figures are not labeled in the original)

This shows what great differences may exist in size, in form, and in function, between parts which are developmentally the same, for all these appendages are modifications of one common kind of structure, which becomes differently modified in different situations; in other words, they are serial homologues.



SPINE OF GALAGO ALLENII

The segments of the body, as they follow one behind the other, are also serially alike, as is plainly seen in the abdomen or tail. In the cephalo-thorax of the lobster, however, this is disguised. It is therefore very interesting to find that in the other crustacean before mentioned, the squilla, the segmentation of the body is more completely preserved, and even the first three segments, which go to compose the head, remain permanently distinct.

Such an obvious and unmistakable serial repetition of parts does not obtain in the highest or back-boned animals, the Vertebrata. Thus, in man and other mammals, nothing of the kind is *externally* visible, and we have to penetrate to his skeleton to find such a series of homologous parts.

There, indeed, we discover a number of pairs of bones, each pair so obviously resembling the others, that they all receive a common name - the ribs. There also (i. e., in the skeleton) we find a still more remarkable series of similar parts, the joints of the spine or backbone (vertebræ), which are admitted by all to possess a certain community of structure.

It is in their limbs, however, that the Vertebrata present the most obvious and striking serial homology - almost the only serial homology noticeable externally.

The facts of serial homology seem hardly to have excited the amount of interest they certainly merit.

Very many writers, indeed, have occupied themselves with investigations and speculations as to what portions of the leg and foot answer to what parts of the arm and hand, a question which has only recently received a more or less satisfactory solution through the successive concordant efforts of Prof. Humphry, [3] Prof. Huxley, [4] the author of this work, [5] and Prof. Flower. [6] Very few writers, however, have devoted much time or thought to the question of serial homology in general. Mr. Herbert Spencer, indeed, in his very interesting "First Principles of Biology," has given forth ideas on this subject which are well worthy careful perusal and consideration, and some of which apply also to the other kinds of homology mentioned above. He would explain the serial homologies of such creatures as the lobster and centipede thus: Animals of a very low grade propagate themselves by spontaneous fission. If certain creatures found benefit from this process of division remaining incomplete, such creatures (on the theory of "Natural Selection") would transmit their selected tendency to such incomplete division to their posterity. In this way, it is conceivable that animals might arise in the form of long chains of similar segments, each of which chains would consist of a number of imperfectly separated individuals, and be equivalent to a series of separate individuals belonging to kinds in which the fission was complete. In other words, Mr. Spencer would explain it as the coalescence of organisms of a lower

[3] Treatise on the Human Skeleton, 1858.

[4] Hunterian Lectures for 1864.

[5] Linnæan Transactions, vol. xxv. p. 395, 1866.

[6] Hunterian Lectures for 1870, and Journal of Anat. for May, 1870.

degree of aggregation in one longitudinal series, through survival of the fittest aggregations. This may be so. It is certainly an ingenious speculation, but facts have not yet been brought forward which demonstrate it. Had they been so, this kind of serial homology might be termed "homogenetic."

The other kind of serial repetitions, namely, those of the vertebral column, are explained by Mr. Spencer as the results of alternate strains and compressions acting on a primitively homogeneous cylinder. The serial homology of the fore and hind limbs is explained by the same writer as the result of a similarity in the influences and conditions to which they are exposed. Serial homologues so formed might be called, as Mr. Ray Lankester has proposed, "homoplastic." But there are, it is here contended, abundant reasons for thinking that the predominant agent in the production of the homologies of the limbs is an internal force or tendency. And if such a power can be shown to be necessary in this instance, it may also be legitimately used to explain such serial homologies as those of the centipede's segments and of the joints of the backbone. At the same time it is not, of course, pretended that external conditions do not contribute their own effects in addition. The presence of this internal power will be rendered more probable if valid arguments can be brought forward against the explanations which Mr. Herbert Spencer has offered.

Lateral homology (or bilateral symmetry) is the resemblance between the right and left sides of an animal, or of part of an animal; as, e. g., between our right hand and our left. It exists more or less, at one or other time of life, in all animals, except some very lowly-organized creatures. In the highest animals this symmetry is laid down at the very dawn of life, the first trace of the future creature being a longitudinal streak - the embryonic "primitive groove." This kind of homology is explained by Mr. Spencer as the result of the similar way in which conditions affect the right and left sides respectively.

Vertical homology (or vertical symmetry) is the resemblance existing between parts which are placed one above the other beneath. It is much less general and marked than serial or lateral homology. Nevertheless, it is plainly to be seen in the tail-region of most fishes, and in the far extending dorsal (back) and ventral (belly) fins of such kinds as the sole and the flounder.

It is also strikingly shown in the bones of the tail of certain efts, as in *Chioglossa*, where the complexity of the upper (neural) arch is closely repeated by the inferior one. Again, in *Spelerpes rubra*, where almost vertically ascending articular processes above are repeated by almost vertically descending articular processes below. Also in the axolotl, where there are double pits, placed side by side, not only superiorly but at the same time inferiorly.[7]

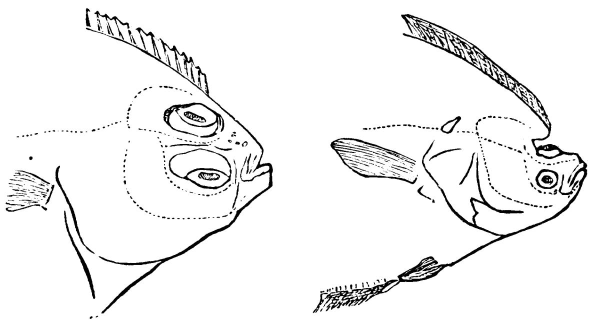
This kind of homology is also explained by Mr. Spencer as the result of the similarity of conditions affecting the two parts. Thus he explains the very general absence of symmetry between the dorsal and ventral surfaces of animals by the different conditions to which these two surfaces are respectively exposed, and in the same way he explains the asymmetry of the flat fishes (*Pleuronectidæ*), of snails, etc.

VERTEBRÆ OF AXOLOTL

Now, first, as regards Mr. Spencer's explanation of animal forms by means of the influence of external conditions, the following observations may be made: Abundant instances are brought forward by him of admirable adaptation of structure to circumstances, but as to the immense majority

[7] See a Paper on the "Axial Skeleton of the Urodela," in Proc. Zool. Soc., 1870 p. 266.

of these it is very difficult, if not impossible, to see *how* external conditions can have produced, or even tended to have produced them. For example, we may take the migration of one eye of the sole to the other side of its head. What is there here either in the darkness, or the friction, or in any other conceivable external cause, to



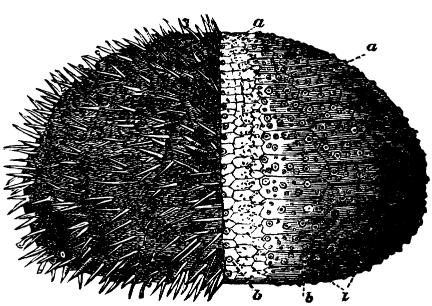
PLEURONECTIDÆ, WITH THE PECULIARLY-PLACED EYE IN DIFFERENT POSITIONS.

have produced the first beginning of such an unprecedented displacement of the eye? Mr. Spencer has beautifully illustrated that correlation which all must admit to exist between the forms of organisms and their surrounding external conditions, but by no means proved that the latter are *the cause* of the former.

Some internal conditions (or in ordinary language some internal power and force) must be conceded to living organisms, otherwise incident forces must act upon them and upon non-living aggregations of matter in the same way, and with similar effects.

If the mere presence of these incident forces produces so ready a response in animals and plants, it must be that there are, in their case, conditions disposing and enabling them so to respond, according to the old maxim, *Quicquid recipitur, recipitur ad modum recipientis*, as the same rays of light which bleach a piece of silk, blacken nitrate of silver. If, therefore, we attribute the forms of organisms to the action of external conditions, i. e., of incident forces on their modifiable structure, we give but a partial account of the matter, removing a step back, as it were, the action of the internal condition, power, or force which must be conceived as occasioning such ready modifiability. But indeed it is not at all easy to see how the influence of the surface of the ground or any conceivable condition or force can produce the difference which exists between the ventral and dorsal shields of the carapace of a tortoise, or by what differences of merely external causes the ovaries of the two sides of the body can be made equal in a bat and unequal in a bird.

There is, on the other hand, an *a priori* reason why we should expect to find that the symmetrical forms of all animals are due to internal causes. This reason is the fact



AN ECHINUS, OR SEA-URCHIN.

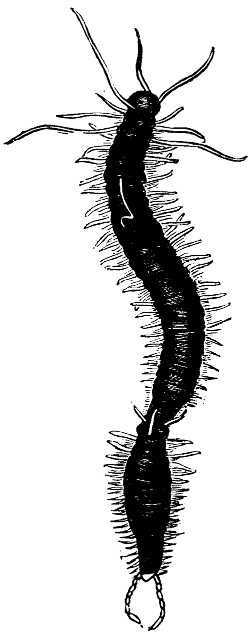
(The spines removed from one-half.)

that the symmetrical forms of minerals are undoubtedly due to such causes. It is unnecessary here to do more than allude to the beautiful and complex forms presented by inorganic structures. With regard to organisms, however, the wonderful Acanthometræ and the Polycystina may be mentioned as presenting complexities of form which can hardly be thought to be due to other than *internal* causes. The same may be said of the great group of Echinoderms, with their amazing variety of component parts. If, then, internal forces can so build up the most varied structures, they are surely capable of producing the serial, lateral, and vertical symmetries which higher animal forms exhibit. Mr. Spencer is the more bound to admit this, inasmuch as in his doctrine of "physiological units" he maintains that these organic atoms of his have an innate power of building up and evolving the whole and perfect animal from which they were in each case derived. To build up and evolve the various symmetries here spoken of is not one whit more mysterious. Directly to refute Mr. Spencer's assertion, however, would require the bringing forward of examples of organisms which are ill-adapted to their positions, and out of harmony with their surroundings - a difficult task indeed. [8]

Secondly, as regards the last-mentioned author's explanation of such serial homology as exists in the centipede and its allies, the very groundwork is open to objection. Multiplication by spontaneous fission seems from some recent

[8] Just as Buffon's superfluous lament over the unfortunate organization of the sloth has been shown, by the increase of our knowledge, to have been uncalled for and absurd, so other supposed instances of nonadaptation will, no doubt, similarly disappear. Mr. Darwin, in his "Origin of Species," 5th edition, p. 220, speaks of a woodpecker (*Colaptes campestris*) as having an organization quite at variance with its habits, and as never climbing a tree, though possessed of the special arboreal structure of other woodpeckers. It now appears, however, from the observations of Mr. W. H. Hudson, C. M. Z. S., that its habits are in harmony with its structure. See Mr. Hudson's third letter to the Zoological Society, published in the Proceedings of that Society for March 24, 1870, p. 159.

researches to be much less frequent than has been supposed, and more evidence is required as to the fact of the habitual propagation of *any* planariæ in this fashion. [9] But even if this were as asserted, nevertheless it fails to explain



AN ANNELID DIVIDING SPONTANEOUSLY. (A new head having been formed toward the hinder end of the body of the parent.)

the peculiar condition presented by *Syllis* and some other annelids, where a new head is formed at intervals in certain segments of the body. Here there is evidently an innate

[9] Dr. Cobbold has informed the author that he has never observed a planaria divide spontaneously, and he is skeptical as to that process taking place at all. Dr. H. Chariton Bastian has also stated that, in spite of much observation, he has never seen the process in *vorticella*.

tendency to the development at intervals of a complex whole. It is not the budding out or spontaneous fission of certain segments, but the transformation in a definite and very peculiar manner of parts which already exist into other and more complex parts. Again, the processes of development presented by some of these creatures do not by any means point to an origin through the linear coalescence of primitively distinct animals by means of imperfect segmentation. Thus in certain Diptera (two-winged flies) the legs, wings, eyes, etc., are derived from masses of formative tissue (termed imaginal disks), which by their mutual approximation together build up parts of the head and body, [10] recalling to mind the development of Echinoderms.

Again, Nicholas Wagner found in certain other Diptera, the Hessian flies, that the larva gives rise to secondary larva within it, which develop and burst the body of the primary larva. The secondary larvæ give rise, similarly, to another set within them, and these again to another [11] set.

Again, the fact, that in *Tænia echinococcus* one egg produces numerous individuals, tends to invalidate the argument that the increase of segments during development is a relic of specific genesis.

Mr. H. Spencer seems to deny serial homology to the mollusca, but it is difficult to see why the shell segments of chiton are not such homologues because the segmentation is superficial. Similarly the external processes of eolis, doris, etc., are good examples of serial homology, as also are plainly the successive chambers of the orthoceratidæ. Nor are parts of a series less serial, because arranged spirally, as in most gasteropods. Mr. Spencer observes of the molluscous as of the vertebrate animal, "You cannot cut it into transverse slices, each of which contains a digestive organ, a respiratory organ, a reproductive organ, etc." [12] But

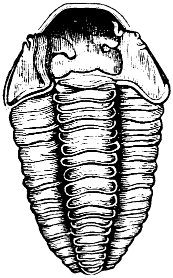
[10] Prof. Huxley's Hunterian Lecture, March 16, 1868.

[11] Ibid., March 18.

[12] "Principles of Biology," vol. ii., p. 105

the same may be said of every single arthropod and annelid if it be meant that all these organs are not contained in every possible slice. While if it be meant that parts of all such organs are contained in certain slices, then some of the mollusca may also be included.

Another objection to Mr. Spencer's speculation is derived from considerations which have already been stated, as to past time. For if the annulose animals have been formed by aggregation, we ought to find this process much less perfect in the oldest form. But a complete development, such as already obtains in the lobster, etc., was reached by the Eurypterida and Trilobites of the palæozoic strata; and annelids, probably formed mainly like those of



TRILOBITE.

the present day, abounded during the deposition of the oldest fossiliferous rocks.

Thirdly, and lastly, as regards such serial homology as is exemplified by the backbone of man, there are also several objections to Mr. Spencer's mechanical explanation.

On the theory of evolution most in favor, the first Vertebrata were aquatic. Now, as natation is generally effected by repeated and vigorous lateral flexions of the body, we ought to find the segmentation much more complete laterally than on the dorsal and ventral aspects of the spinal column.

Nevertheless, in those species which, taken together, constitute a series of more and more distinctly segmented forms, the segmentation gradually increases *all around* the central part of the spinal column.

Mr. Spencer [13] thinks it probable that the sturgeon has retained the notochordal (that is, the primitive, unsegmented) structure because it is sluggish. But Dr. Günther informs me that the sluggishness of the common tope (*Galeus vulgaris*) is much like that of the sturgeon, and yet the bodies of its vertebræ are distinct and well ossified. Moreover, the great salamander of Japan is much more inert and sluggish than either, and yet it has a well-developed, bony spine.

I can learn nothing of the habits of the sharks *Hexanchus*, *Heptanchus*, and *Echinorhinus*, but Müller describes them as possessing a persistent *chorda dorsalis*). [14] It may be they have the habits of the tope, but other sharks are among the very swiftest and most active of fishes.

In the bony pike (*lepidosteus*), the rigidity of the bony scales by which it is completely enclosed must prevent any excessive flexion of the body, and yet its vertebral column presents a degree of ossification and vertebral completeness greater than that found in any other fish whatever.

Mr. Spencer supports his argument by the non-segmentation of the anterior end of the skeletal axis, i. e., by the non-segmentation of the skull. But in fact the skull *is* segmented, and, according to the quasi-vertebral theory of the skull put forward by Prof. Huxley,[15] is probably formed of a number of coalesced segments, of some of which the trabeculæ cranii and the mandibular and hyoidean arches are indications. What is, perhaps, most remarkable, however,

[13] "Principles of Biology," vol. ii., p. 203.

[14] Quoted by H. Stannius in his "Handbuch der Anatomie der Wirbelthiere," Zweite Auflage, Erstes Buch, § 7, p. 17.

[15] In his last Hunterian Course of Lectures, 1869

is, that the segmentation of the skull - its separation into the three occipital, parietal, and frontal elements - is most complete and distinct in the highest class, and this can have nothing, however remotely, to do with the cause suggested by Mr. Spencer.

Thus, then, there is something to be said in opposition to both the aggregational and the mechanical explanations of serial homology. The explanations suggested are very ingenious, yet repose upon a very small basis of fact. Not but that the process of vertebral segmentation may have been sometimes assisted by the mechanical action suggested.

It remains now to consider what are the evidences in support of the existence of an internal power, by the action of which these homological manifestations are evolved. It is here contended that there *is* good evidence of the existence of some such special internal power, and that not only from facts of comparative anatomy, but also from those of teratology [16] and pathology. These facts appear to show, not only that there are homological internal relations, but that they are so strong and energetic as to reassert and reexhibit themselves in creatures which, on the Darwinian theory, are the descendants of others in which they were much less marked. They are, in fact, sometimes even more plain and distinct in animals of the highest types than in inferior forms; and, moreover, this deep-seated tendency acts even in diseased and abnormal conditions.

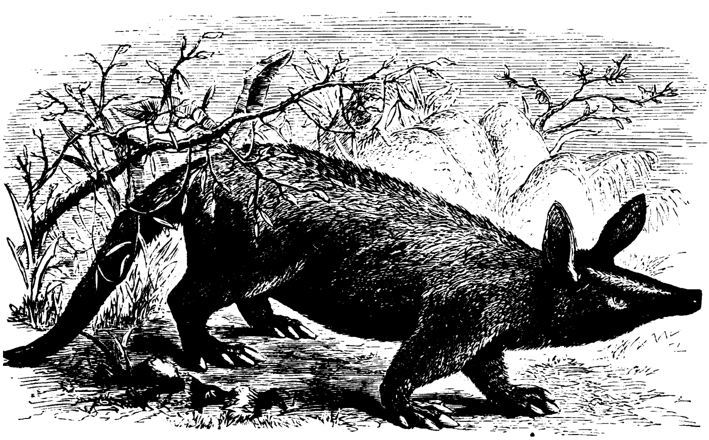
Mr. Darwin recognizes [17] these homological relations, and does "not doubt that they may be mastered more or less completely by Natural Selection." He does not, however, give any explanation of these phenomena other than the imposition on them of the name "laws of correlation;"

[16] "The Science of Abnormal Forms."

[17] "Animals and Plants under Domestication," vol. ii., p. 322; and "Origin of Species," 5th edit., 1869, p. 178.

and indeed he says, "The nature of the bond of correlation is frequently quite obscure." Now, it is surely more desirable to make use, if possible, of one conception than to imagine a number of, to all appearance, separate and independent "laws of correlation" between different parts of each animal.

But even some of these alleged laws hardly appear well founded. Thus Mr. Darwin, in support of such a law of concomitant variation as regards hair and teeth, brings forward the case of Julia Pastrana, [18] and a man of the Burmese court, and adds: [19] "These cases and those of the hairless dogs forcibly call to mind the fact that the two orders of mammals; namely, the Edentata and Cetacea, which are the most abnormal in their dermal covering, are likewise



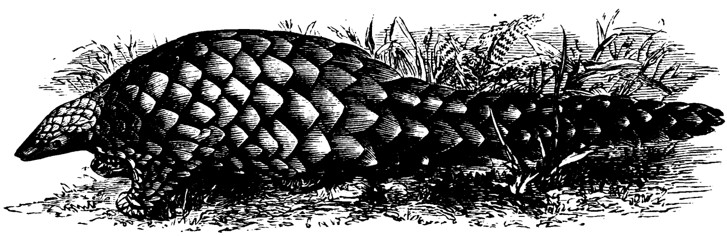
THE AARD-VARK (ORYCTEROPUS).

the most abnormal either by deficiency or redundacy of teeth." The assertion with regard to these orders is certainly

[18] A remarkable woman exhibited in London a few years ago.

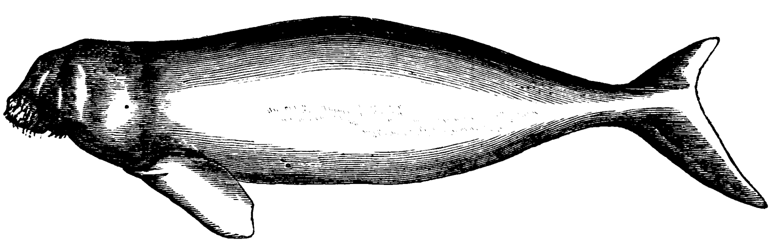
[19] "Animals and Plants under Domestication," vol. ii., p. 328.

true, but it should be borne in mind at the same time that the armadillos, which are much more abnormal than are the American ant-eaters as regards their dermal covering, in their dentition are less so. The Cape ant-eater, on the other hand, the Aard-vark (Orycteropus), has teeth formed on a type quite different from that existing in any other mammal; yet its hairy coat is not known to exhibit



THE PANGOLIN (MANIS).

any such strange peculiarity. Again, those remarkable scaly ant-eaters of the Old World - the pangolins (Manis) - stand alone among mammals as regards their dermal covering; having been classed with lizards by early naturalists on account of their clothing of scales, yet their mouth is



DUGONG.

like that of the hairy ant-eaters of the New World. On the other hand, the duck-billed platypus of Australia (Ornithorhynchus) is the only mammal which has teeth formed of horn, yet its furry coat is normal and ordinary. Again, the Dugong and Manatee are dermally alike, yet extremely different as regards the structure and number of their teeth. The porcupine also, in spite of its enormous armature of quills, is furnished with as good a supply of teeth as are the hairy members of the same family, but not with a better one; and in spite of the deficiency of teeth in the hairless dogs, no converse redundancy of teeth has, it is believed, been remarked in Angora cats and rabbits. To say the least, then, this law of correlation presents numerous and remarkable exceptions.

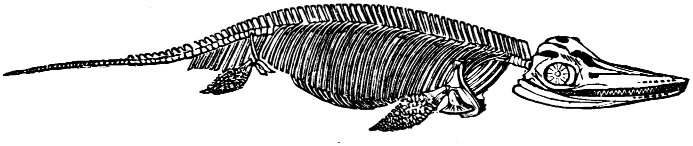
To return, however, to the subject of homological relations: it is surely inconceivable that indefinite variation with survival of the fittest can ever have built up these serial, bilateral, and vertical homologies, without the action of some special innate power or tendency so to build up, possessed by the organism itself in each case. By "special tendency" is meant one the laws and conditions of which are as yet unknown, but which is analogous to the innate power and tendency possessed by crystals similarly, to build up certain peculiar and very definite forms.

First, with regard to comparative anatomy. The correspondence between the thoracic and pelvic limbs is notorious. Prof. Gegenbaur has lately endeavored [20] to explain this resemblance by the derivation of each limb from a primitive form of fin. This fin is supposed to have had a marginal external (radial) series of cartilages, each of which supported a series of secondary cartilages, starting from the inner (ulnar) side of the distal part of the supporting marginal piece. The root marginal piece would become the humerus or femur, as the case might be: the second marginal piece, with the piece attached to the inner side of the distal end of the root marginal piece, would

[20] "Ueber das Gliedmaassenskelet der Enaliosaurier, Jenaischen Zeitschrift," Bd. v. Heft 3, Taf. xiii.

together form either the radius and ulna or the tibia and fibula, and so on.

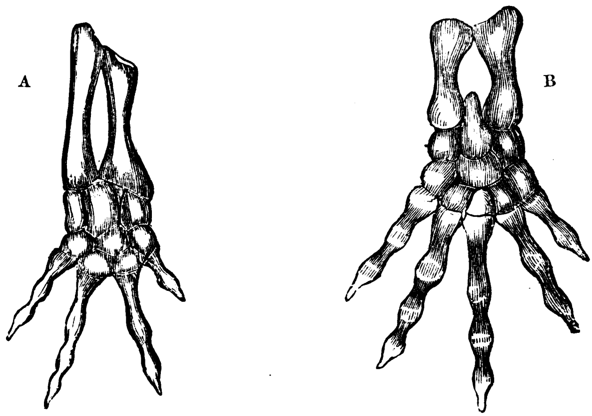
Now there is little doubt (from *a priori* considerations) but that the special differentiation of the limb-bones of the higher Vertebrates has been evolved from anterior conditions existing in some fish-like form or other. But the particular view advocated by the learned professor is open to criticism. Thus, it may be objected against this view, first, that it takes no account of the radial ossicle which becomes so enormous in the mole; secondly, that it does not explain the extra series of ossicles which are formed on the outer (radial or marginal) side of the paddle in the Ichthyosaurus; and thirdly, and most importantly, that even if this had been the way in which the limbs had been differentiated, it would not be at all inconsistent with the possession of an innate power of producing, and an innate tendency to produce similar and symmetrical homological resemblances. It would not be so because resemblances of the kind are found to exist, which, on the Darwinian theory, must be subsequent and secondary, not primitive and ancestral. Thus we find in animals of the eft kind



SKELETON OF AN ICHTHYOSAURUS.

(certain amphibians), in which the tarsus is cartilaginous, that the carpus is cartilaginous likewise. And we shall see in cases of disease and of malformation what a tendency there is to a similar affection of homologous parts.

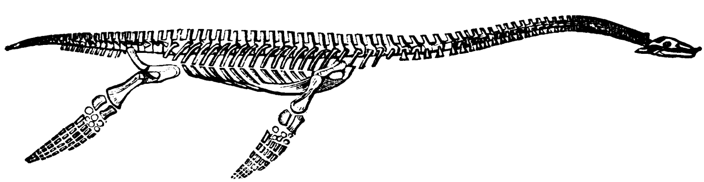
In efts, as Prof. Gegenbaur himself has pointed out, [21] there is a striking correspondence between the bones or cartilages supporting the arm, wrist, and fingers, and those



A. SKELETON OF ANTERIOR EXTREMITY OF AN EFT.
B. SKELETON OF POSTERIOR EXTREMITY OF THE SAME.

sustaining the leg, ankle, and toes, with the exception that the toes exceed the fingers in number by one.

Yet these animals are far from being the root-forms from



SKELETON OF A PLESIOSAURUS.

which all the Vertebrata have diverged, as is evidenced from the degree of specialization which their structure presents.

[21] In his work on the Carpus and Tarsus.

If they have descended from such primitive forms as Prof. Gegenbaur imagines, then they have built up a secondary serial homology - a repetition of similar modifications - fully as remarkable as if it were primary. The Plesiosauria - those extinct marine reptiles of the Secondary period, with long necks, small heads, and paddle-like limbs - are of yet higher organization than are the efts and other Amphibia. Nevertheless they present us with a similarity of structure between the fore and hind limb, which is so great as almost to be identity. But the Amphibia and Plesiosauria, though not themselves primitive vertebrate types, may be thought by some to have derived their limb structure by direct descent from such. Tortoises, however, must be admitted to be not only highly differentiated organisms, but to be far indeed removed from primeval vertebrate structure. Yet certain tortoises [22] (notably *Chelydra Temminckii*) exhibit such a remarkable uniformity in fore and hind limb structure (extending even up to the proximal ends of the humerus and femur) that it is impossible to doubt its independent development in these forms.

Again, in the Potto (Perodicticus) there is an extra bone in the foot, situated in the transverse ligament enclosing the flexor tendons. It is noteworthy that in the *hand* of the same animal a serially homologous structure should also be developed.[23] In the allied form called the slow lemur (Nycticebus) we have certain arrangements of the muscles and tendons of the hand which reproduce in great measure those of the foot, and *vice versa.* [24] And in the Hyrax another myological resemblance appears. [25] It is,

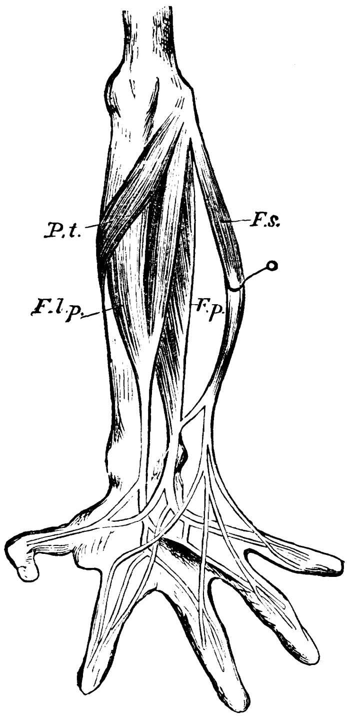
[22] An excellent specimen displaying this resemblance is preserved in the Museum of the Royal College of Surgeons.

[23] Phil. Trans., 1867, p. 353.

[24] Proc. Zool. Soc., 1865, p. 255.

[25] Ibid., p. 351.

however, needless to multiply instances which can easily be produced in large numbers if required.



LONG FLEXOR MUSCLES AND TENDONS OF THE HAND.

P.t. Pronator teres. *F.8.* Flexor sublimis digitorum. *F.p.* Flexor profusidus digitorum. *F.l.p.* Flexor longus pollicis.

Secondly, with regard to teratology, it is notorious that similar abnormalities are often found to coexist in both the pelvic and thoracic limbs.

M. Isidore Geoffroy St.-Hilaire remarks, [26] "L'anomalie se répète d'un membre thoracique au membre abdominal du même côté." And he afterward quotes Weitbrecht, [27] who had "observé dans un cas l'absence simultanée aux deux mains et aux deux pieds, de quelques doigts, de quelques metacarpiens et metatarsiens, enfin de quelques os du carpe et du tarse."

Prof. Burt G. Wilder, in his paper on extra digits, [28] has recorded no less than twenty-four cases where such excess coexisted in both little fingers; also one case in which the right little finger and little toe were so affected; six in which it was both the little fingers and both the little toes; and twenty-two other cases more or less the same, but in which the details were not accurately to be obtained.

Mr. Darwin cites [29] a remarkable instance of what he is inclined to regard as the development in the foot of birds of a sort of representation of the wing-feathers of the hand. He says: "In several distinct breeds of the pigeon and fowl the legs and the two outer toes are heavily feathered, so that, in the trumpeter pigeon, they appear like little wings. In the feather-legged bantam, the 'boots,' or feathers, which grow from the outside of the leg, and generally from the two outer toes, have, according to the excellent authority of Mr. Hewitt, been seen to exceed the wing-feathers in length, and in one case were actually nine and a half inches in length! As Mr. Blyth has remarked to me, these leg-feathers resemble the primary wingfeathers, and are totally unlike the fine down which naturally grows on the legs of some birds, such as grouse and owls.

[26] "Hist. Générale des Anomalies," t. i., p. 228. Bruxelles, 1837.

[27] Nov. Comment. Petrop. t. ix., p. 269.

[28] Read on June 2, 1868, before the Massachusetts Medical Society. See vol. ii., No. 3.

[29] "Animals and Plants under Domestication," vol. ii., p. 322.

Hence it may be suspected that excess of food has first given redundancy to the plumage, and then that the law of homologous variation has led to the development of feathers on the legs, in a position corresponding with those on the wing, namely, on the outside of the tarsi and toes. I am strengthened in this belief by the following curious case of correlation, which for a long time seemed to me utterly inexplicable - namely, that in pigeons of any breed, if the legs are feathered, the two outer toes are partially connected by skin. These two outer toes correspond with our third and fourth toes. Now, in the wing of the pigeon, or any other bird, the first and fifth digits are wholly aborted; the second is rudimentary, and carries the so-called ‘bastard wing;’ while the third and fourth digits are completely united and enclosed by skin, together forming the extremity of the wing. So that in feather-footed pigeons not only does the exterior surface support a row of long feathers like wing-feathers, but the very same digits which in the wing are completely united by skin become partially united by skin in the feet; and thus, by the law of the correlated variation of homologous parts, we can understand the curious connection of feathered legs and membrane between the outer toes.”

Irregularities in the circulating system are far from uncommon, and sometimes illustrate this homological tendency. My friend and colleague Mr. George G. Gascoyen, assistant surgeon at St. Mary’s Hospital, has supplied me with two instances of symmetrical affections which have come under his observation.

In the first of these the brachial artery bifurcated almost at its origin, the two halves reuniting at the elbowjoint, and then dividing into the radial and ulnar arteries in the usual manner. In the second case an aberrant artery was given off from the radial side of the brachial artery, again almost at its origin. This aberrant artery anastomosed below the elbow-joint with the radial side of the radial artery. In each of these cases the right and left sides varied in precisely the same manner.

Thirdly, as to pathology. Mr. James Paget, [30] speaking of symmetrical diseases, says: “A certain morbid change of structure on one side of the body is repeated in the exactly corresponding part of the other side.” He then quotes and figures a diseased lion’s pelvis from the College of Surgeons Museum, and says of it: “Multiform as the pattern is in which the new bone, the product of some disease comparable with a human rheumatism, is deposited - a pattern more complex and irregular than the spots upon a map - there is not one spot or line on one side which is not represented, as exactly as it would be in a mirror, on the other. The likeness has more than daguerreotype exactness.” He goes on to observe: “I need not describe many examples of such diseases. Any out-patients’ room will furnish abundant instances of exact symmetry in the eruptions of eczema, lepra, and psoriasis; in the deformities of chronic rheumatism, the paralysis from lead; in the eruptions excited by iodide of potassium or copaiba. And any large museum will contain examples of equal symmetry in syphilitic ulcerations of the skull; in rheumatic and syphilitic deposits on the tibiæ and other bones; in all the effects of chronic rheumatic arthritis, whether in the bones, the ligaments, or the cartilages; in the fatty and earthy deposits in the coats of arteries.” [31]

He also considered it to be proved that, “next to the parts which are symmetrically placed, none are so nearly identical in composition as those which are homologous. For example, the backs of the hands and of the feet, or the palms and soles, are often not only symmetrically, but similarly, affected with psoriasis. So are the elbows and the

[30] “Lectures on Surgical Pathology,” 1853, vol. i., p. 18.

[31] Ibid., p. 22.

knees; and similar portions of the thighs and the arms may be found affected with icthyosis. Sometimes also specimens of fatty and earthy deposits in the arteries occur, in which exact similarity is shown in the plan, though not in the degree, with which the disease affects severally the humeral and femoral, the radial and peroneal, the ulnar and posterior tibial arteries."

Dr. William Budd [32] gives numerous instances of symmetry in disease, both lateral and serial. Thus, among others, we have one case (William Godfrey), in which the hands and feet were distorted. "The distortion of the right hand is greater than that of the left, of the right foot greater than that of the left foot." In another (Elizabeth Alford) lepra affected the extensor surfaces of the thoracic and pelvic limbs. Again, in the case of skin-disease illustrated in Plate III., "The analogy between the elbows and knees is clearly expressed in the fact that these were the only parts affected with the disease." [33]

Prof. Burt Wilder, [34] in his paper on "Pathological Polarities," strongly supports the philosophical importance of these peculiar relations, adding arguments in favor of antero-posterior homologies, which it is here unnecessary to discuss, enough having been said, it is believed, to thoroughly demonstrate the existence of these deep internal relations which are named lateral and serial homologies.

What explanation can be offered of these phenomena? To say that they exhibit a "nutritional relation" brought about by a "balancing of forces" is merely to give a new denomination to the unexplained fact. The changes are, *of course*, brought about by a "nutritional" process, and

[32] See "Medico-Chirurgical Transactions," vol. xxv. (or vii. of 2d series), 1842, P. 100, P1. III.

[33] Med.-Chirurg. Trans. vol. xxv. (or vii. of 2d series), 1842, p. 122.

[34] See *Boston Medical and Surgical Journal* for April 5, 1866, vol. lxxiv., p. 189.

the symmetry is undoubtedly the result of a "balance of forces," but to say so is a truism. The question is, What is the cause of this "nutritional balancing?" It is here contended that it must be due to an internal cause which at present science is utterly incompetent to explain. It is an internal property possessed by each living organic whole as well as by each non-living crystalline mass, and that there is such internal power or tendency, which may be spoken of as a "polarity," seems to be demonstrated by the instances above given, which can easily be multiplied indefinitely. Mr. Herbert Spencer [35] (speaking of the reproduction, by budding, of a Begonia-leaf) recognizes a power of the kind. He says, "We have, therefore, no alternative but to say that the living particles composing one of these fragments have an innate tendency to arrange themselves into the shape of the organism to which they belong. We must infer that a plant or animal of any species is made up of special units, in all of which there dwells the intrinsic aptitude to aggregate into the form of that species; just as, in the atoms of a salt, there dwells the intrinsic aptitude to crystallize in a particular way. It seems difficult to conceive that this can be so; but we see that it *is* so." . . . . "For this property there is no fit term. If we accept the word polarity, as a name for the force by which inorganic units are aggregated into a form peculiar to them, we may apply this word to the analogous force displayed by organic limits."

Dr. Jeffries Wyman, [36] in his paper on the "Symmetry and Homology of Limbs," has a distinct chapter on the "Analogy between Symmetry and Polarity," illustrating it by the effects of magnets on "particles in a polar condition."

[35] "Principles of Biology," vol. i., p. 180.

[36] See the "Proceedings of the Boston Society of Natural History," vol. xi., June 5, 1867.

Mr. J. J. Murphy, after noticing [37] the power which crystals have to repair injuries inflicted on them and the modifications they undergo through the influence of the medium in which they may be formed, goes on to say: [38] "It needs no proof that in the case of spheres and crystals the forms and the structures are the effect, and not the cause, of the formative principles. Attraction, whether gravitative or capillary, produces the spherical form; the spherical form does not produce attraction. And crystalline polarities produce crystalline structure and form; crystalline structure and forum do not produce crystalline polarities. The same is not quite so evident of organic forms, but it is equally true of them also." . . . . "It is not conceivable that the microscope should reveal peculiarities of structure corresponding to peculiarities of habitual tendency in the embryo, which at its first formation has no structure whatever;" [39] and he adds that "there is something quite inscrutable and mysterious" in the formation of a new individual from the germinal matter of the embryo. In another place [40] he says: "We know that in crystals, notwithstanding the variability of form within the limits of the same species, there are definite and very peculiar formative laws, which cannot possibly depend on any thing like organic functions, because crystals have no such functions ; and it ought not to surprise us if there are similar formative or morphological laws among organisms which, like the formative laws of crystallization, cannot be referred to any relation of form or structure to function. Especially, I think is this true of the lowest organisms, many of which show great beauty of form, of a kind that appears to be altogether due to symmetry of growth; as the beautiful star-like rayed forms of the *acanthometræ*, which are low animal organisms not very different from the Foraminifera." Their "definiteness of form does not appear

[37] "Habit and Intelligence," vol. i., p. 75. [38] Ibid., p. 112.
[39] Ibid., p. 170. [40] Ibid., vol. i., p. 229.

to be accompanied by any corresponding differentiation of function between different parts; and, so far as I can see, the beautiful regularity and symmetry of their radiated forms are altogether due to unknown laws of symmetry of growth, just like the equally beautiful and somewhat similar forms of the compound six-rayed, star-shaped crystals of snow."

Altogether, then, it appears that each organism has an innate tendency to develop in a symmetrical manner, and that this tendency is controlled and subordinated by the action of external conditions, and not that this symmetry is superinduced only *ab externo*. In fact, that each organism has its own internal and special laws of growth and development.

If, then, it is still necessary to conceive an internal law or "substantial form," moulding each organic being, [41] and directing its development as a crystal is built up, only in an indefinitely more complex manner, it is congruous to imagine the existence of some internal law accounting at the same time for specific divergence as well as for specific identity.

A principle regulating the successive evolution of different organic forms is not one whit more mysterious than is the mysterious power by which a particle of structureless sarcode develops successively into an egg, a grub, a chrysalis, a butterfly, when all the conditions, cosmical, physical, chemical, and vital, are supplied, which are the requisite accompaniments to determine such evolution.

[41] It is hardly necessary to say that the author does not mean that there is, in addition to a real objective crystal, another real, objective separate thing beside it, namely the "force" directing it. All that is meant is that the action of the crystal in crystallizing must be *ideally* separated from the crystal itself, not that it is *really* separate.