J. C. F. Macfarlane Esq
from the Author

ON THE

UNITY OF STRUCTURE

IN THE

ANIMAL KINGDOM.

BY

MARTIN BARRY,

M. D., F. R. S. E., M. W. S.

LATE PRESIDENT OF THE ROYAL MEDICAL SOCIETY OF EDINBURGH.

From the Edinburgh New Philosophical Journal for January 1837.

Fig. 3.

Fig. 4.

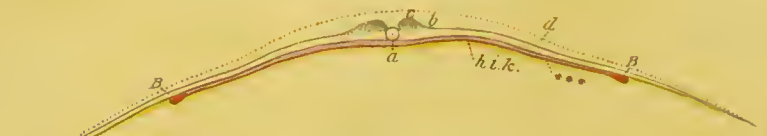


Fig. 5.

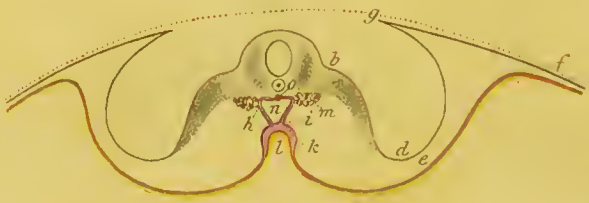
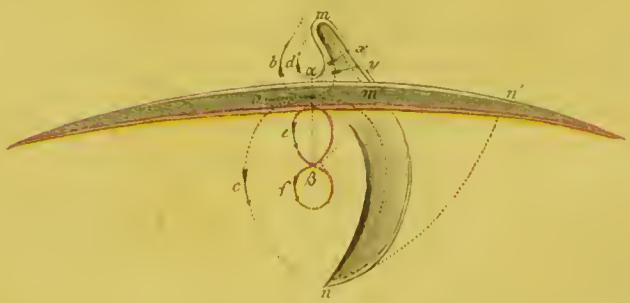


Fig. 6.

Fig. 7.



F. Mitchell. Sc

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All finite existencies presuppose design. This is a position which, happily in the present day, we may assume.

It has been usual to regard organic structure as manifesting design, because it shews adaptation to the function to be performed. It has also been suggested, that function may be equally well considered as the result of structure. And, truly so it may. Yet perhaps we are not required to shew the claim of either to priority; but may consider both structure and function,—harmonizing, as they always do,—as having been simultaneously contemplated in the same design.

The object of the present essay, is to offer a few considerations on structure only; but the subject is so vast, and our limits are so circumscribed, that these considerations must be of the most general character. Yet some details on development will be found indispensable.

The expression "organic structure," includes of course the structure of what we call animals and plants. But, while both are comprehended as beings contemplated in the same original design;—while the metamorphoses presented in a realization of this design, and the remarks that may be made on develop-

ment in general, will apply equally to both;—it is intended to restrict the further prosecution of the subject to animals alone.

The terms "lower" and "higher" animals, will be throughout this paper strenuously avoided, because they are calculated to mislead. Should they occur, it will be as forming part of a quotation. Such terms, if used in regard to the organs of relation only, are, to say the least of them, ambiguous; because we do not know what parts of structure may not contribute to constitute these organs. If they be used to describe differences in the *degree* of elaboration only, such application of them presupposes a simply "ascending" or "descending" scale of structure, differing in *degree* alone,—a thing, the existence of which, it is in part the object of this paper to question, and then acknowledge or deny. We therefore disuse them, substituting the expressions general and special,—simpler and more complex,—diffused and concentrated,—homogeneous and heterogeneous,—less or more elaborate,—less or more developed.

It is important to appreciate exactly, the difference in meaning between the terms "individual" and "individuality." An element, or a set of elements, acquires a separate or distinct existence, *i. e.* an individuality, and there is thus constituted an individual.*

The constituent parts of an individual perform certain functions, in the sum of which consists its life. These functions are reducible to changes of condition, and of relative position, —to dismissal and renewal,—of the elements of which the individual is composed; which changes are not identical in any two individuals. The effect of these continued changes, up to a certain period of life, is a more and more elaborate and special structure, performing more and more diversified and special functions.

Now, as the elements of an individual cease, in turn, to be constituent parts of the same, the identity of that *individual* must be continually changing,—can exist, indeed, at no two periods of time; inasmuch as new elements are continually enter-

* "I exhort you to be particularly on your guard against loose and indefinite expressions; they are the bane of all science, and have been remarkably injurious in the different departments of our own."—*Lawrence's* two Lectures; being an Introduction to Comparative Anatomy and Physiology. 1826. P. 118.

ing into its constitution, while old ones are departing. But the same separate or distinct existence—the same *individuality*—continues.*

A law, not less vast in its importance, than it seems to be general in its application, may be supposed to direct structure in the animal kingdom. This law requires that a heterogeneous or special structure, shall arise only out of one more homogeneous or general; and this by a gradual change. The importance of this law appears to have been insisted on chiefly by Von Bär, who arrived at it by long and attentive observation of development.

Let us then inquire, in the first place, what analogy there is in the states of germs in general, at the earliest period of observation; and whether they have in common, a homogeneous or general structure.

In animals presenting the most simple manifestations of life, —"in which, every point of the creature is, as it were, an epitome of the whole, without any relation to, or dependence on, the rest; and capable, therefore, when separated from the rest, of an independent existence,"†—maturity alone appears sufficient to produce offspring, and simple separation sufficient to constitute a new being. Such is the case with many zoophytes.

Reproduction becomes less simple, as vitality grows complex; because now, "each point of the creature has a more close relation to, and dependence on, the rest, than before."‡ When something like ova begin to be discernible, they consist of a half-fluid, throughout homogeneous, more or less granulous mass. This is the state of bodies regarded as ova, in some Infusoria, some Polypes, and many other Zoophytes. Bodies of this kind have been called "Germinal Granules." Such imperfect ova

* Cessation of the changes spoken of, constitutes death. The state of being subsequently, forms a subject, of which it would here be out of place to treat. It is sufficient that revelation makes us acquainted with the fact, that *human* existencies continue, after they have ceased to be represented by combinations of elements, performing functions, the sum of which is called life.

† *Dick*, in the Trans. of Prov. Med. and Surg. Assoc., vol. iv. p. 344.

‡ *Dick*, l. c. p. 344.

seem to hold a middle place between "Shoots," on the one hand, and "Germinal Vesicles," on the other.*

The ovum of more elaborate structures,—perhaps of all the rest of the animal kingdom,—is a sac, containing a sort of Yolk, —the Germinal Vesicle,—and a Layer of granules. (Fig. 1. p. 120.)

The *Yolk* of ova generally, is very much the same in essential character; but performing a more important part in some animals than in others, it differs much in quantity.

The *Germinal Vesicle* is an exceedingly delicate, transparent sac; measuring in diameter sometimes less than $\frac{1}{100}$th of a line,† and containing a pellucid fluid. On the internal surface of the Germinal Vesicle, there has lately been discovered an opacity,—the *Germinal Spot* (*Macula germinativa*), consisting of extremely minute granules, more or less spherical in form. With a magnifying power of eight hundred diameters,—that is to say, magnified 640,000 times,—this spot has not yet been found to consist of other than homogeneous parts.‡ It has been already said, that it is contained within the Germinal Vesicle; the latter measuring in diameter sometimes less than $\frac{1}{100}$th of a line.

In some Infusoria, the contents of the Germinal Vesicle are rather a mass of granules, than a fluid and a spot; perhaps corresponding parts, in a less concentrated state. Indeed, may not "Shoots," "Germinal Granules," and the contents of the Germinal Vesicle, be, all of them, corresponding parts, in different states of concentration?

The *Layer of Granules (Germinal layer)*, containing perhaps, in part, the rudiments of the future Germinal Membrane, lies immediately on the internal surface of the Primary Membrane that contains the Germ and Yolk. This layer is more or less circumscribed,—often indistinct, because of its periphery coalescing with the Yolk. The Germinal Vesicle is found lying in the centre of this layer of granules, on the surface of the Yolk; though there are reasons for supposing that, originally, the Germinal Vesicle is situated in the centre of the Yolk.

* *Purkinje*, in Berlinerwörterbuch, Band x. S. 109.

† *Wagner*, in Ed. Med. and Surg. Journ. 1836. No. 127.

‡ *Wagner*, l. c.

We have then—

1*stly*, " Shoots ;" as in many Zoophytes.

2*dly*, " Germinal Granules ;" a half-fluid granulous mass, as in some Infusoria, some Polypes, and many other Zoophytes.

3*dly*, The ova of some Infusoria, in which the Germinal Vesicle contains a mass of granules.

4*thly*, Perfect ova, of more elaborate animals, viz.—

Fig. 1.

a Germinal Spot.
b Fluid contained in Germinal Vesicle.
c Germinal Vesicle.
d Layer of granules, having the Germinal Vesicle in its centre.
e Yolk.
f Primary membrane, enclosing the Germ and Yolk.

5*thly*, Superadded, in Mammals and in Man, there are the Graafian Vesicle, and its fluid,* viz.—

* In Mammals, and in Man, the part corresponding to the ovum of other animals, is called the *ovulum*.

For the discovery of the latter,—an epoch in the history of development,—we are indebted to the illustrious *Von Bär*. Von Bär was once a pupil of Döllinger, the head of the Würzburg School ; who having expressed to the former a wish, that some young naturalist should, under his own superintendence, thoroughly investigate the development of the common fowl, Von Bär would most gladly have undertaken it, but for circumstances that required for a time his estrangement from the subject. Von Bär mentioned it, however, to his friend *Pander*, who had come to Würzburg, at his suggestion, to be a fellow-pupil of Döllinger. Pander undertook those researches ; and hence his discovery of the primary separation of the Germinal Membrane into layers. *Von Bär* returned with renewed ardour to the subject, and discovered the Ovulum of Mammals ; *Purkinje* having in the mean time found the Germinal Vesicle of Birds. *Valentin* next discovered the Germinal Vesicle in Mammals ; and *Wagner* afterwards found the Germinal Spot. The last-mentioned author justly asks, Is this spot also to present some contained part ?

For a particular account and drawings of these minute bodies, see *Von Bär*, " de Ovi Mammalium et Hominis genesi ;" also the Ed. Med. and Surg. Journ. Nos. 127 and 128 ; and Müller's Archiv, 1836, Heft ii. ; likewise a paper by *Purkinje*, " Symbolæ ad Ovi Avium historiam ante incubationem ;" and one by *Bernhardt*, " Symbolæ ad Ovi Mammalium historiam ante prægnationem."

Dr Allen Thomson, one of the very few in this country who have attended to the subject of development, has given an epitomized but very comprehensive account of the changes in the Germinal Membrane of Vertebrated Animals, so far as ascertained up to the time when he wrote (1830), adding observations of his own. (See vols. ix. and x. of this Journal.)

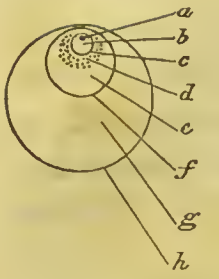


Fig. 2.

a, *b*, *c*, *d*, *e*, *f*, as above.
g Fluid contained in the Graafian Vesicle.
h Graafian Vesicle.

The following table * shews how generally, the more difficult to discover of these parts, have already been met with in the animal kingdom.

	Germinal		
	Vesicle.	Spot.	Layer.
Vertebrata.			
Mammalia, including Man,	—	—	—
Aves,	—	—	—
Reptilia,	—	—	—
Pisces,	—	—	—
Mollusca,	—	—	—
Articulata.			
Annelida,	—	—	
Crustacea,	—	—	—
Arachnida,	—	—	—
Insecta,	—	—	—
Zoophyta,			
Entozoa,	—		—
Infusoria,		—	

It is then fair to presume,—since this table contains "both ends," as they have been termed, of the animal world,—viz. Infusoria and Man,—that wherever there exists what is called a perfect ovum, all the above parts are present.

There are reasons for supposing that the Germinal Vesicle is formed before the Yolk,—one of which is afforded by its relatively greater size ; † and, if so, the Germinal Vesicle, with its contents, constitute the primitive portion of the ovum, which in all animals, where found, appears to be essentially the same. ‡

It has thus been shewn, that in all classes of animals, from Infusoria to Man, germs at their origin are *essentially the same in character ;* and that they have in common a homogeneous or general structure.

* Compiled from various sources.

† The Germinal Vesicle is met with in those ova only, that are not quite ready for impregnation ; as it bursts on the latter taking place, and pours its contents among the granules of the Germinal layer, by which it is surrounded.

‡ *Purkinje*, in Berlinerwörterbuch, Band x. S. 111.

It appears also, that essentially, the *manner* of the metamorphosis, or metamorphoses, from a more homogeneous or general structure, to one more heterogeneous and special,—*i. e.* the *manner* of development,—*is universally the same.*

Such a proposition seems deducible from what we know of development, not only in all the Vertebrata, but in many Invertebrated animals; such as the Insecta, * Crustacea, † Arachnida, ‡ and even Mollusca; § and Von Bär seems to have meant the observation to apply to animals in general, when he spoke of development proceeding by "a continued elaboration of the animal body, through growing histological and morphological separation." ‖ Zoophytes themselves, so far as their development extends, may also be included, as subject to the same law.

To the *manner* of development, we shall presently return.

The Layer of granules, already spoken of, as having in its centre the Germinal Vesicle (fig. 1. p. 120), appears, on the bursting of the latter, to contribute to the formation of the Germinal Membrane (Plate I. fig. 3): though the central and most important part of the latter is perhaps constituted, by the contents of the Germinal Vesicle.

The Germinal Membrane in some of the Vertebrata, is at first a more or less circumscribed disk, covering only a part of the Yolk, and afterwards extending itself to surround and enclose the whole of it; in others, it encloses the whole of the Yolk from the first. This membrane in the Invertebrata, presents differences in this respect, regarding which physiologists are not quite agreed.¶

In most vertebrated animals, the Embryo is at first nothing more than the exuberant growth of a part of this Germinal Membrane, *near its centre*, (see Plate I. fig. 3.); *i. e. in the*

* See *Burmeister's* Entomology, translated by Shuckard, 1836, 8vo.

† *Rathke*, über die Bildung und Entwickelung des Flusskrebses, 1829, fol.

‡ *Herold*, Untersuchungen über die Bildungsgeschichte der Wirbellosen Thiere im Eie, 1824, fol. Also *Rathke*, in Burdach's Physiologie als Erfahrungswissenschaft.

§ See *Von Bär's* observations on the development of Snails, in his "Entwickelungsgeschichte der Thiere," &c., 1836, 4to.

‖ l. c. p. 231.

¶ See *Valentin*, Entwickelungsgeschichte des Menschen, &c. pp. 144 an 602–3. Also *Herold*. l. c.; and *Rathke*, l. c.

situation occupied by the Germinal Vesicle, before the bursting of the latter; the part exuberant, projecting, but not being distinguishable from the rest, by a well-defined border. The projecting portion becomes more and more distinct, until its growing independence is manifested, in a tendency to withdraw itself from the remainder. (See Plate I. fig. 5.)

This separation of the central part of the Germinal Membrane from its periphery and from the yolk, gives rise eventually to the appended *Umbilical Vesicle* in Man and other Mammals. In Birds, the corresponding part is taken into the abdomen. In Frogs, the embryo occupies, from the first, so large a portion of the Germinal Membrane, and the latter so nearly surrounds the yolk, that the yolk becomes contained in the embryo, before the independence of the latter has time to manifest itself by a tendency to withdrawal.

Explanation of Plate I.*

Fig. 3. Transverse section of the Germinal Membrane and incipient Embryo of the Common Fowl.

Fig. 4. Ditto, more advanced.

Fig. 5. Transverse section of an Embryo of the Common Fowl.

* Primary membrane enclosing the Germ and Yolk.
** Serous, or Animal layer.
*** Mucous, or Vegetative layer.
B Sinus or Vein, bounding the Vascular Area.
a Chorda vertebralis.
b Outer margin of the Lamina dorsalis.
c Upper margin of the same; afterwards the Mesial Line of the back.
bc Lamina dorsalis.
d Outer (and afterwards under) margin of the Lamina ventralis.
bd Lamina ventralis.
e Flexure of the serous lamina.
de Membranous portion of the abdominal paries.
f Margin of the lateral envelope.
g Lateral part of the fold of the Amnion; afterwards, the closing-point of the Amnion.
deg Amnion.
h Upper angle of the mesenteric lamina.
i Under angle of the mesenteric lamina; afterwards the suture of the Mesentery.
hi The mesenteric lamina.
k The vascular lamina on the Intestine.
l Mucous lamina of the Intestine.
m Corpora Wolffiana.
n Mesenteric space.
o Aorta.

Fig. 6. Ideal transverse section of the Embryo of a Vertebrated Animal.

a Stem of the vertebral column.
b Laminæ dorsales—their union forms the upper or dorsal Tube.
c Laminæ ventrales—their union forms the under or ventral Tube.
d Central portion of the Nervous System or nervous Tube.
e Vascular Tube.
f Mucous Tube.
g Corpora Wolffiana.

* Containing *transverse* sections only: selected from *Von Bar*.

h Skin.
i Amnion.
k Serous covering, resulting from the closing of the amnion at *m*. (See also *g* of Fig. 3.)
l Yolk bag.
m n Central line, common to all the Fundamental organs.
q Vascular lamina, on the Yolk-bag.

Fig. 7. Formation of the Germinal Membrane into the Embryo of a Vertebrated Animal.

α β Central line, common to all the Fundamental organs.
a Chorda vertebralis.
b Formation-arc of the Laminæ dorsalcs.
c Formation-arc of the Laminæ ventrales.
d Formation-arc of the Nervous Tube.
e Formation-arc of the Vascular Tube.
f Formation-arc of the Mucous Tube.
m Ridge of the Lamina dorsalis.
m' That place in the Germinal Membrane out of which the ridge (*m*) arises.
n Ridge of the Lamina ventralis.
n' That place in the Germinal Membranc out of which the ridge (*n*) arises.
x Perforating formation-arc of thc Eye.
y Perforating formation-arc of the Ear.

The *manner* of development seems to be as follows:—*

The Germinal Membrane separates into two disjoined layers; viz. into a Mucous or Vegetative (Plate I. Fig. 3, ***), and a Serous or Animal layer (same Fig. **); the latter being in contact with the Primary Membrane (same Fig. *), enclosing the Germ and Yolk; the former lying immediately upon the Yolk itself. The Vegetative layer is afterwards seen to be composed of two intimately united laminæ; viz. the proper Mucous (Fig. 4, ***), and the Vascular (Figs. 4 and 5, *h*, *i*, *k*). The Animal layer also, in the embryo at least, divides itself into two laminæ, viz. into the Skin, on the one hand (Fig. 6, *h*), and into a mass containing the Fleshy layer, as well as, in vertebrated animals, the Osseous, and the Nervous layers, on the other (Fig. 6, *a*, *b*, *c*, *d*). This division into layers, is the "*primary*" separation. During the course of this separation, the layers become tubes, or Fundamental organs. (See Plate I, Fig. 7.)

There occurs, at the same time, a separation of textures, in the substance of the layers or tubes; cartilaginous, nervous, and muscular substance, separating from each other; while a part of the mass becomes fluid. Some of the elementary textures also, assume the form of laminæ, which are subordinate to the original layers; the latter therefore, (now tubes), become the

* We here present, in a very condensed form, Von Bär's observations on the Vertebrata, as contained in his work "Entwickelungsgeschichte der Thiere," &c. 1828, pp. 153-159, &c.:—so modified, however, as to make the description applicable to invertebrated animals also.

central portions of systems. This separation into textures, is the "*histological*" separation.

Besides the above, there arise differences in outward shape; single sections of the tubes being developed into distinct forms or organs, destined to perform particular functions; which functions are subordinate members of the function of the whole tube; but differ from the functions of other sections of the latter. For example, the mucous tube divides itself into the mouth, œsophagus, stomach, intestine, respiratory apparatus, liver, urinary bladder, &c.; the peculiarity in the development being connected with either an increased or diminished growth. This is the "*morphological*" separation.

Thus, by a threefold division, the mass becomes heterogeneous; and the further back we go, the more do we find, not single organs only, but histological elements united.

"Fresh parts are acquired, not by *new*, but by *trans*formation. When, for example, the foundation of a cartilage forms, there was not previously a vacancy in the place it occupies, but a homogeneous mass; the *change* in which, consists in the appearance of an assemblage of opaque granules, and a surrounding pellucid fluid. This is the *manner* of histological separation; calling forth, as it were, antitheses."

"No part is formed, that was not previously in connexion with some part, earlier formed; no part has an isolated origin, then adding itself to the rest. Nothing swims freely around, annexing itself here or there, as formerly was said of the whole embryo, and even lately, has been conceived and taught of the spinal cord.* Each organ is a modified part of a more general organ;" and development proceeds from the centre towards the periphery. This is the *manner* of morphological separation.

It was to uniformity in the *manner* of the *primary*, of the *histological*, and of the *morphological* separations, just described, that we referred in the proposition, that essentially the *manner* of the metamorphosis, or metamorphoses—*i. e.* the *manner* of development—from a more homogeneous or general, to a more

* Such is the doctrine of Serres. See his "Anatomie Comparée du Cerveau;" also his "Recherches d'Anatomie Transcendante et Pathologique." 4to, 1832.

heterogeneous or special structure, is universally the same; and we have already mentioned researches, which seem to warrant this conclusion.

The *direction* taken by development, is, however, not the same precisely, in any two animals; and in different Classes, the direction (type) differs very widely. But of *direction*, or *type*, we shall treat more particularly hereafter.

It has then been shewn,—that *germs* from Infusoria to Man, are essentially the same,—and we know that there are some structural characters, common to all animals in a *perfect* state, —especially to those of the same Class, as, for example, the Vertebrata: there are besides, resemblances between some of the more elaborate structures, in certain of their embryonal phases, and many less wrought out structures, in their permanent conditions; which resemblances are observable, not only between animals included in the same great Class, but also, though more remotely, between animals belonging to different Classes.

To sum up these important facts: If the structure of germs has been found at "both ends" of the animal kingdom, as well as in the intermediate classes, to be essentially the same;—if between the homogeneous masses, forming germinal membranes, there is found no essential difference;—if the primary separation of this membrane into layers (the vegetative layer being always directed towards the yolk), and the subdivisions of these layers—incipient in the membranal, and completed in the embryonal states—are the same in character;—if the formation, not of textures only, but of organs also, proceed in the manner just described;—and, above all, if permanent structures, among many of the less elaborate animals, resemble most obviously, different degrees of histological and morphological separation, as presented in the embryonal phases of an individual destined to be more wrought out;—are we not entitled to conclude, not only that a heterogeneous or special structure arises only out of one more homogeneous or general; but also that, essentially, the *manner* of the metamorphosis, or metamorphoses,—the *manner* of development,—from the latter to the former state, is universally the same?

And are we not then led fairly to the conclusion, *that all the*

*varieties of structure in the animal kingdom, are but modifications of, essentially, one and the same fundamental form?**

Now, seeing that not only the Vertebrata, but all Classes of animals, in their development, must pass *thus gradually* from a merely *animal* form, to the most special forms they respectively attain; further, that the *manner* of development may be considered as essentially the same in all;—is it surprising that there are resemblances between some of the embryonal phases of very different animals; and that some of the stages in embryonal life of the more elaborate structures, resemble perfect states of those that are less wrought out? Could it, indeed, have been otherwise?

Let us inquire a little more particularly into the development, firstly, of the Vertebrata; and, secondly, of some Invertebrated animals.

Firstly—Of the Vertebrata.

The layers into which the germinal membrane separates, become, as already said, tubes. (See Plate I. fig. 6.) These tubes are more or less bent towards the yolk, at each extremity; but extend the whole length of the animal, including its head and tail. Therefore, out of the upper tube,—constituted by a union of the laminæ dorsales (fig. 6, *b*.),—are formed, the arches of the caudal, lumbar, dorsal, and cervical vertebræ, the arched cranial bones, and the soft parts covering all of these; together with the central portion of the nervous system. While out of the under tube,—constituted by a union of the laminæ ventrales, (*c*) —are formed, the ribs, the soft parts of the thorax and abdomen, the hyoid bone, and all that portion of the neck, anterior (or inferior) to the vertebræ, the lower jaw, and some other parts, both osseous and fleshy, of the face. The bodies of the vertebræ, and the base of the cranium, are formed out of a portion of the animal layer of the germinal membrane, common to the upper and the under tube (fig. 6, *a*.)

The central portion of the nervous system in different animals, may, in its ultimate elaboration, produce very different struc-

* Whether this fundamental form is vesicular, as it has been supposed,—and in favour of which opinion, several facts might be brought forward,—we cannot now inquire.

tures; all grades between the splendid cerebral hemispheres in Man, and the mere rudiments of hemispheres in Fishes. The nervous portions of the organs of sense are, in all the Vertebrata, processes of the central part of the nervous system, through the Laminæ dorsales (Fig. 7. *x. y.*); so that, though so varied in different animals, not only all parts of the central portion of the nervous system, but all processes from the latter,—with a common origin, and the same *manner* of development,—may well bear a general resemblance to each other, in the perfect states of the less, and the embryonal states of the more, elaborate animals.*

(The nervous ganglia of the Cuttle, and perhaps of many other invertebrated animals, seem to correspond, not with the sympathetic, but with the spinal ganglia of the Vertebrata; a spinal cord and brain not being present.† It is remarkable, that in the Cuttle, there occur cartilaginous rudiments of vertebræ, under which the ganglia lie.)

The muscles of the trunks in different animals of the Class Vertebrata, are but modifications of the fleshy portions of the Laminæ dorsales and ventrales; and the muscles of their extremities, are only similar metamorphoses of those portions of the latter, that are carried out with the osseous (or at first cartilaginous) foundation of the extremities themselves. (See fig. 8, below.)

All the resemblances in the vascular system of different animals, are, in like manner, referrible to a common origin, and the same *manner* of development; and its varieties, to various modifications in *direction* (or *type*) and *degree*.

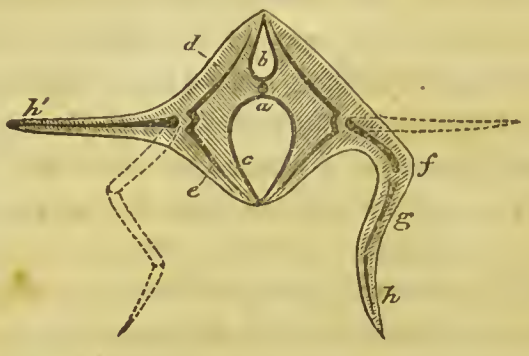
The Mucous tube originates, as processes, the mouth, œsophagus, stomach, respiratory apparatus, liver, urinary bladder, and other organs; in part also, and in conjunction with the Vascular tube, the genital organs: which parts, in all their varieties, bear a general resemblance to corresponding parts in different animals.

* It has been said that the spinal cord originates the brain. This is most untrue; the spinal cord does not exist before the brain; but there exists a central portion of the nervous system, out of which arise both brain and spinal cord.

† The term "brain" is here limited to the enlargement at one extremity of a mass, of which the other forms a spinal cord. (Von Bär, l. c.)

Fig. 8.

Ideal Transverse Section of a Vertebrated Animal, to shew the Type of the Extremities.



a Stem of the vertebral column.
b Arches of the Vertebræ.
c Ribs.
d Dorsal, *e* Ventral } radical portion.
f Upper, *g* Under } middle portion.
} of an Extremity, &c.
h Terminal portion.
h' Terminal portion as a Fin.

(This fig. is taken from Von Bär.)

In the substance of the fleshy portion of the Lamina dorsalis and ventralis of each side, there is formed a series of osseous arcs (fig 8, *d e*), constituting the radical portion of the extremities, and that part of the base of the cranium, with which the superior maxillæ are articulated; and from a point near the middle of each arc, there issues a process, corresponding to the middle (*f g*) and terminal (*h*) members of the latter. Now, it is obvious, that with this common origin, and the same manner of development, corresponding parts in different animals of the Class Vertebrata,—whether arms, legs, wings, fins, maxillæ, &c.—are likely to retain a general resemblance; though the absence of the middle members, or modification of the whole extremity, &c. may render them very dissimilar in their details.

Corresponding parts of structure may, however, in different animals, perform very different functions. Thus, besides the extremities just mentioned, many other examples might be given; such as a fact pointed out by Geoffroy St Hilaire, that certain parts of the hyoid bone in the Cat, correspond to the styloid processes of the temporal bone in Man; and the different functions of the generative organs in the two sexes, afford a still more remarkable example.

It has thus been shewn, why corresponding organs may re-

semble each other in different animals of the Class Vertebrata. Of Invertebrated animals, we shall presently speak.

In development, germs, and even embryos, belonging to different groups of the same great Class, may long be indistinguishable; and still longer, those that are more nearly allied. But those belonging to different great Classes, begin to diverge sooner; or rather, the angle of divergence being greater, a difference is appreciable at an earlier period;* and in proportion to the angle of divergence in a germinal, are the structures unlike in a perfect state. Just as, in a tree, those branches that have been given off nearest to its root, become most widely separated in their terminating twigs.

In different Classes, development, though it proceeds in the same *manner*, yet taking thus different *directions*, attains, with materials perhaps essentially the same in primordial structure, very different ends (*types*).

Thus it proceeds in the Vertebrata or Osteozoa, with especial reference to the central portion of the nervous system; in the Arthrozoa (which include, besides the Articulata, some Zoophytes), having for its chief object, the organs of locomotion. In both of these Classes, therefore, it is the Serous or Animal layer of the Germinal Membrane, that is seen first advancing; and out of this, in these two Classes, there is thus produced, a very different system of organs.

In the Gastrozoa (*i. e.* the Mollusca and most Zoophytes), on the other hand, the organs of nutrition are especially the object; and in them, therefore, development proceeds chiefly in the Mucous or Vegetative layer.

To these priorities in development, and to the important influence they have on the direction which development takes in other parts of the system, are referrible the leading characters of Classes.† Yet it is in *direction* only, that development can

* The *primitive trace* is very different in Invertebrated animals,—for example, the Crustacea,—from what it is in the Vertebrata; and even among some of the Vertebrata, there are observable, in this respect, no small differences; as between the primitive trace of Batrachian reptiles, and that Birds,—(*Valentin*, Entwickelungsgeschichte, &c.)

† Hence we cannot compare animals, belonging to different Classes, in regard to what is called their "rank," unless we keep in view, not the *degree* alone, but also the *direction* of development. For the same reason, it is absurd to say, that one Class of animals can pass into another; such, for exam-

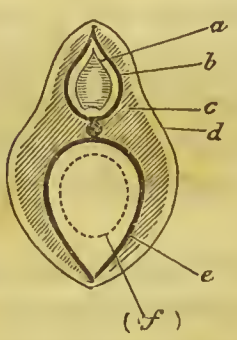
be said to differ in different animals; in *manner*, it remains the same.*

Secondly,—Of some of the Invertebrata.

The following diagrams will illustrate different *directions* of development, though the *manner* be the same.

Ideal Transverse Sections, shewing the Structures formed out of the Animal layer, respectively,

Of the Osteozoa (Vertebrata).
Fig. 9.



Upper tube—

a, Central portion of the nervous system; situated in the *upper* part of the Animal layer.

b, Arches of the vertebræ, some of the cranial bones, &c. (part of the internal skeleton.)

c, Fleshy layer.

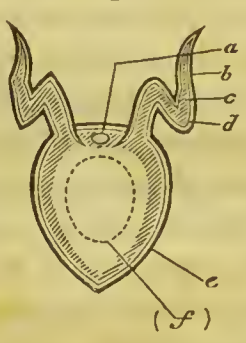
d, Skin.

Under tube—

e, Ribs, lower jaw, &c. (part of the internal skeleton); the other parts of this tube, as *c* and *d* of the upper tube.

(*f*, Mucous tube.)

Of the Arthrozoa.
Fig. 10.



Upper tube, incomplete, viz.

a, Situation of what there is, corresponding to the central portion of a nervous system: situated in the *lower* part of the Animal layer.

b, External skeleton, secreted from the skin, } forming an Extremity, a

c, Fleshy layer, such as it is, } Mandible, &c.

d, Skin, }

Under tube—

e, External skeleton, secreted from the skin; the other parts of this tube, as *c* and *d* of the upper tube.

(*f*, Mucous tube.)

The Vascular tube is not shewn in the above figures.

ple, as the Cephalopoda of the Class Mollusca, or the Crustacea of the Class Articulata, into Fishes of the Class Vertebrata. As well might it be said, that branches divergent at a tree's root, because they retain some characters in common, can be coincident in their terminal localities.

* There are, however, certain systems of organs more or less common to all beings. Among these are especially the nutritive or appropriative organs; resemblances between which, therefore, in corresponding stages of development, may be conceived to extend to existences of almost every kind. It has been justly said by Burmeister, that Osteozoa (Vertebrata), uniting in

It is obvious from the above,

1stly, That in the Osteozoa, the *central portion of the Nervous System;* in the Arthrozoa, the *organs of locomotion, mandibles,* &c., are the especial objects, in the early stages of development.

2dly, That the central part of the Animal layer is appropriated accordingly. Thus it may, perhaps, be said, that parts corresponding to the Laminæ dorsales of the Osteozoa, go to form the Extremities chiefly, in the Arthrozoa.

3dly, That the upper tube in the Arthrozoa is imperfect, though there is evidently a tendency in the extremities to its formation.*

4thly, That, from the direction taken by their extremities, the Arthrozoa must move about, with the thorax and abdomen uppermost; the relative position of the Fundamental organs being reversed. The organs also, formed out of the Mucous and Vascular layers, are found to be inverted, if compared with corresponding parts in the Osteozoa; but there occurs such an adjustment in the situation of the external parts,—as, for example, in that of the mouth and organs of sense; and, as what in the Osteozoa is the extensor, becomes in the Arthrozoa the flexor side of the body;—that, so far as these are concerned, it cannot be said that the Arthrozoa move about on their backs. Rather may it be affirmed, with Valentin, that "they have no true back, but only the tendency to form one."† But their thorax and abdomen are certainly inverted.

5thly, That the situation of what these animals have of the central portion of a Nervous System, is a part of the body corresponding very nearly to that occupied by the central portion of the Nervous System in the Osteozoa; viz, it is in the former (Arthrozoa) situated in the *under*—in the latter (Osteozoa) in the *upper* part of the animal layer,—supposing each of these Classes of animals to be situated *above* the yolk.

6thly, That the term "dorsal" vessel, is calculated to mislead;

themselves, in no small degree, ventral as well as locomotive properties, exhibit formal approximations to both Gastrozoa and Arthrozoa in their development. (Burmeister, l. c. p. 419.)

* Such is the idea of Valentin, l. c. p. 608.

† Loco citato, p. 607.

he part so called, obviously corresponding to the aorta in other animals; and, according to the above diagram, having a truly thoracic and abdominal locality.*

Of the development of molluscous animals, we know very little: enough, however, to render it quite safe for us to extend to them the laws already laid down; viz. of the heterogeneous arising only out of the homogeneous, and of identity in the *manner* of histological and morphological separation (the *manner* of development),† whatever may be the *direction* which the latter takes, and however limited its *degree*.

Even to Zoophytes, the same laws may be applied. The Germinal Granule of the Polype—a homogeneous, shapeless mass—separates into a softer portion, on the one hand; and a more rigid, a horny, or calcareous substance, on the other; and assumes its proper, more or less special, form. Even shoots themselves—those, for example, of the Hydra‡—are at firs simple swellings, then cone-like, afterwards somewhat cylindrical, and gradually become funnel-shaped, like the parent: processes then appearing wart-like, at the circumference of the common cavity, and these by degrees elongating into arms.§

The whole animal kingdom then, (perhaps all organized beings?), may be considered as directed in development by the above laws; and all animals present besides, the antithesis of an

* The Germinal Membrane separates, as well in invertebrated, as in vertebrated animals, primarily into a Serous or Animal, and a Mucous or Vegetative lamina; between which, sooner or later, there is found a third, the Vascular lamina (Valentin, l, c, p. 605).

The above figure (10.) is not intended to present the *form* of any of the Arthrozoa. The form, indeed, of an *Osteozoon*, has been as far as possible adopted, in order to admit of an easy comparison of corresponding parts; the only purpose here, being to shew the appropriation of the Animal layer of the germinal membrane in the two Classes. We do not at present enter into any comparison in *form*, of parts of the external skeleton of the Arthrozoa, with the osseous system of Vertebrated animals (Osteozoa).

† See *Von Bär's* researches on Snails, already mentioned: also those of *Stiebel* and *Carus*, alluded to by *Burdach*, Physiologie als Erfahrungswissenschaft, Band ii. S. 179–180.

‡ *Carus*. plate i, fig. 1.

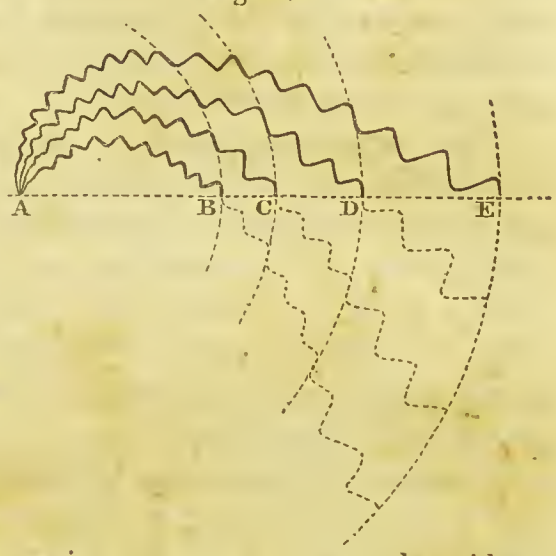
§ Burdach, l. c. p. 164–1.

internal or vegetative, and an external or animal portion of the body.

The following diagram is intended to illustrate fundamental unity, and the causes of subsequent variety in structure; the latter being acquired in development, and development being represented by curves.

Let the point A, represent the supposed coincidence in fundamental form, of four germs of the Class Vertebrata.

Fig. 11.



The curves drawn from the point A, to the points B, C, D, E, represent, respectively, the development of Fishes, Reptiles, Birds, and Mammals.

The identity of the curves, in curvature, corresponds to identity in the *manner* of development (*i. e.* in the *manner* of histological and morphological separation).

The *lengths* of the curves, together with the *degrees of undulation*, measure the *degree of aggregate elaboration* attained by each of the above, in the course of its development.*

The dotted *continuations* of the curves, measure the *differences* in the degree of elaboration.

The different *directions* of the curves, both general and particular, represent the different *directions* taken in development; *i. e.* modifications of the type of the Vertebrata; and serve to shew, that while there exist *resemblances*, *identities* are impossible.

The amount of *divergence*, measures the difference in *structure*, arising from the different *directions* taken in development, (difference in *kind*).

* This illustration is, however, a very coarse one. We cannot, for instance, represent the fact, that certain parts of structure in birds, are more wrought out, than corresponding parts in mammals. The term *aggregate* elaboration, has therefore been employed.

The *cross lines* (arcs) indicate, at the points where they cut the curves, *corresponding stages* of development. It is in corresponding stages of development that resemblances occur.

By the above diagram (Fig. 11.), resemblances between organized structures, admitting of comparison, are seen to be in the inverse ratio of the age,—the curves having a tendency to coincide, in proportion as they approach the point A; and the causes of variety, are seen to be resolvable into differences in *direction* and *degree* of development.

There are many purposes to which it may be applied, such as a comparison of the development of the primary divisions of the animal or vegetable kingdom (Classes), or of any of their subdivisions; of corresponding layers of the Germinal Membrane; of systems of organs or single organs, in different animals, or in different plants; or of systems of organs or single organs, originating in the same Fundamental organ, of the same animal or the same plant.

Perhaps the chief use of this diagram consists, firstly, in assisting the *understanding*, by affording something like an object, to which descriptions may be referred; and, therefore, secondly, in assisting the *memory*, by means of association.

Let us, for example, refer to it a fact mentioned by Oken,* and since by Burmeister,† that certain Insects, differing in the degree of elaboration in the *perfect* state, differ in a corresponding manner as *larvæ* also. Suppose that at the point A, four germs of different Insects coincide essentially in fundamental form. Let the curves represent their development in larval (*i.e.* a part of embryonal) life; and let the germs be those respectively of one of the Diptera, Hymenoptera, Coleoptera, and Lepidoptera. The larvæ of the Diptera (gnat, house-fly), whose development is represented by the curve A B, resemble the footless and headless Leech; those of the Hymenoptera (bee, wasp, ant) A C, may be compared to Nais, in which there is a distinct head, but the feet are wanting; those of the Coleoptera (May and caddis-flies), A D, are comparable to a third grade of the Annulata, "residing in tubes, and furnished with large bundles of gills."

* "Allgemeine Naturgeschichte für alle Stände," 8vo, Band iv. s. 469–470.

† Loco citato, pp. 419, 420.

Lastly, in the larval development of the Lepidoptera (butterfly, moth), curve A E, there is a resemblance to another grade of the Annulata—among which the Aphrodite—having, "besides a distinct head, many feet on the ventral side of the segments."

Now from this example it is obvious, that not only the four Families of perfect Insects, as well as their larval states,—but also those animals with which the latter, respectively, have been compared,—will be, as it were, all *located* in the diagram; and this in the order of their respective degrees of elaboration. The latter, therefore, will be easily remembered. Thus, in the curve of least elaboration, are located not only the gnat and house-fly, but also the leech. In the curve of most complete development, not the butterfly and the moth alone, but the Aphrodite, and others of the same grade in the Annulata. So also of the two other curves.

It seems as if, with the original design to create organized beings, there had arisen a scheme of more or less complete division and subdivision, continued down to species, and including in the latter, all individual forms.*

One of the supposed grand divisions may have included *animals*;† one of the first subdivisions, the type of the Vertebrata; subordinate to which, and co-ordinate to each other, we have the types of Fishes, Reptiles, Birds, and Mammals. Each of these groups presents its families,—each family, genera,—each genus, species,—and every species has its individual forms. So would the other Classes admit of being referred to subdivisions of the supposed scheme.

In thus speaking of Classes and other divisions of the animal kingdom, however, we by no means acknowledge the present arrangement to be perfect. The only sure basis for classification is—not structure, as met with in the perfect state, when func-

* Of the *order* in which the various beings were called into existence, we do not pretend to speak.

† Another of the supposed grand divisions may have comprehended *plants*; and this would explain why the resemblance should be so great, between the simplest forms of both. It is obvious, that an inappreciable shade of difference, between two general and crude structures, might occasion divergence to an almost immeasurable distance, in proceeding to the most highly organized and special states.

tion tends to embarrass, but—the *history of development*, at that period when structure presents itself alone; and, as Von Bär has justly said, this will perhaps "one day become the ground for nomenclature," * as it can be the only one on which to form a correct estimate of parts, in different animal forms.

Certain elements, proceeding from the elements of an individual, or from the elements of two individuals, constitute, by a separate or distinct existence, another individual, a germ; destined, like its parent or parents, to undergo, by a succession of elements, continued changes in its component parts; and, by degrees, to attain a state of being, represented by a form, belonging to the parent-type.

These elements, while they constituted part of the parent or parents, shared the state of being, peculiar to the latter. It is then easily conceivable, that, having themselves acquired a separate or distinct existence, the new being they constitute, should contain within itself, properties analogous to those of its parent or parents; and that therefore, in its progress towards its destined state of being, it should undergo similar changes; that it should attain the parent-type, and also more or less of individual resemblance to its parent or parents.

The elements of every germ must have innate susceptibilities of a certain definite arrangement; so that, on the application of stimuli, there results a certain structure.† These we shall in future call, innate susceptibilities of structure, or innate (plastic) properties. All innate properties are of course derived from the parent or parents. If the germ be animal, its leading properties are those characterizing *animals* in general. But it has others, common respectively to the class, order, family, genus, species, variety, and sex, to which the germ belongs. Lastly, it has properties that were previously characteristic of its parent or parents; in which, indeed, all the others are included. But no innate properties, except those merely *animal*, are at first, to our senses at least, apparent in the structure of the germ.

The sum of these innate (plastic) properties, determines the

* l. c. p. 233.

† The stimuli are those circumstances that produce development; such as nourishment, a peculiar ambient medium, and a certain degree of warmth.

direction taken in development; determines, therefore, the structure of the new being.

The *general* direction taken in the development of all the individuals of a species, is the same; but there is a *particular* direction, proper to the development of each individual, and therefore a particular structure, not identical with any other; for in no two individuals, is the sum of the innate (plastic) properties in all respects the same.

It has been already said, that as the elements of an individual cease, in turn, to be constituent parts of the same, the identity of that individual must be continually changing—can exist, indeed, at no two periods of time; inasmuch as new elements are continually entering into its constitution, while old ones are departing.

Hence, individual peculiarities in structure must, in their turn, become hereditary to succeeding sets of elements; continually renewed, as we have just asserted these elements to be There must, besides, continually present themselves, fresh peculiarities; and in their turn, these also must be inherited by sets of elements succeeding.

For the same reasons, the first set of elements, constituting a germ,—proceeding, as already said, from the elements of a parent or of parents,—must possess properties that were characteristic of the latter, at the moment when their separation took place; and can indeed possess no others, since the elements of the parents, and therefore the properties, are continually changing.

Hence it is, that the sum of the innate (plastic) properties can be in no two individuals the same; hence the *particular* direction of development proper to each *individual*; * and hence *individual* peculiarities of structure.

Strictly speaking, therefore, no two individuals of different births can have the same parentage; for though the *individuality* of the parent, or of each parent, does not change, yet, as *individuals*, the parents are continually changing.

The more nearly *cotemporaneous* separation of their elements, and the cotemporaneous derivation of nourishment from the maternal fluids, during fœtal life,—but especially the former,—are perhaps the causes why twins are sometimes so much alike in

* One *general* direction, as said before, being common to a *species*.

individual structure; and *super*-fœtation may be, in part at least, the cause why this is not always the case.*

The innate (plastic) properties include, as already said, some that are characteristic of animals generally, and others common to all the animals contained in that division of the animal kingdom, to which the species is subordinate. Now, the properties characteristic of the parent or parents, at the time of the separation of the germ, must include all of those transmitted to the latter.

This assists us to understand, why properties of the same kind should all, in a modified form, re-appear in the development of the offspring (see second paragraph of p. 22): and, indeed, since it is plain that "every step in development is possible only through the condition preceding,"† that "becoming depends upon having become,"‡ we see why those properties can re-appear in a certain order only; viz. in the order of their generality in the animal kingdom.

Thus, in development, the structure characteristic of the Vertebrata only, cannot manifest itself until there has been assumed, essentially, a structure common to *animals*,§ of which the Vertebrata are but a part, and to whose type, the type of the Vertebrata is subordinate. In like manner, structures subordinate to the type of the Vertebrata, cannot manifest themselves until after a modified appearance of the *general type*, of which they are but partial metamorphoses. More and more special forms are thus in succession reached, until the one most special is at length attained. ‖

* There is, however, another cause why individuals, even of the same birth, should differ: viz. the different periods, at which the maternal portion of the germs may have been first secreted in the Ovary: for, though continually renewed, they must have, in consequence, a more or less peculiar state of being.

† Von Bär, l. c. ‡ Burmeister, l. c.

§ The necessary appearance, first, of a structure common to *animals* generally, affords indeed a principal reason for *supposing that there is essentially but one fundamental form.*

‖ *Valentin*, an excellent German author, already quoted, says, "the development of the animal kingdom, and of the individual animal, are in the original idea, throughout, one and the same; but in the realization of single beings, perfectly different, and elaborated in different directions." The latter he conceives to take place in obedience to "metamorphoses" (a becoming more and more special) "of the original idea." Whether such is the case, we need not now inquire; but it is due to him, to acknowledge, that if there

To the law, requiring that a more fundamental type shall uniformly manifest itself before the appearance of one more subordinate, is perhaps referrible, the formation of parts that seem to answer no other purpose than the fulfilment of this law; viz. parts that either continue rudimentary through life, or not being used, disappear.

An example of the first, occurs in the appendix vermiformis of the caput cœcum coli, in the human subject; of the second, in the embryonal gills of land and air-vertebrata, which latter, having at no period an aquatic respiration, can never use gills.* Development proceeds to a certain point—though this point may differ in different animals—in obedience to the law, requiring that a more fundamental type shall uniformly manifest itself, before the appearance of one more subordinate; so that the special purpose to create Birds, Quadrupeds, and even Man himself, is, as it were, subordinate to the more general purpose, to create a Vertebrated animal. This explanation will perhaps apply to all parts present in a rudimentary state alone. †

any thing like probability in what we have proposed as an explanation of the re-appearance of general characters in individual development, it has, in some degree, resulted from reflection on the contents of his admirable work. —See the last 100 pages of his "Entwickelungsgeschichte," entitled, "Fragmente zu einer künftigen Gesetzlehre der individuellen Entwickelung."

* *Rathke* (Meckel's Archiv, 1827, p. 556.) and *Von Bär*, have described gills, in embryos of Mammals and of Man; *Huschke* (Oken's Isis, 1828, Heft I. p. 2.) in very small embryos of Birds.

† There are, however, certain parts of structure, that arise and disappear, not rudimentarily, for the fulfilment of this law; but to serve purposes required by the temporary relations of germinal and embryonal life. Such are the yolk, and umbilical vesicle, the amnion, chorion, and placenta, or corresponding parts; the gills, fins, and tail in the tadpole, or fœtus of the frog; to which examples, there might be added a host of others.

The metamorphosis of insects, furnishes a beautiful instance of the temporary presence of certain parts of structure, during embryonal life. Instead of an appended yolk, over which the Mucous or Vegetative layer, of the Germinal Membrane, is spread, to imbibe nourishment; that layer, in the larval state, becomes speedily a huge intestine, into which food is taken in prodigious quantity by the mouth. The vegetative process is, in this condition, the main object. But, as the pupal state is gradually attained, growth yields to transformation; and, as Burmeister has well shewn,* the intestine is, in part, metamorphosed into generative organs; which, in the Imago, or perfect insect, give origin to germs, destined to undergo like changes.

* l. c.

It has thus been shewn,

1*stly*, That a heterogeneous or special structure, arises only out of one more homogeneous or general, and this by a *gradual* change.

2*dly*, That the *manner* of the change, is probably the same throughout the animal kingdom, however much

3*dly*, The *direction* (or *type*) and *degree* of development may differ, and thus produce variety in structure; which however, there is good reason to believe, is

4*thly*, In essential character, *fundamentally the same.*

5*thly*, That no two individuals can have precisely the same innate susceptibilities of structure, or plastic properties; and therefore,

6*thly*, That though all the individuals of a *species*, may take, in their development, the same *general* direction,—there is a *particular* direction in development,—and, therefore, a *particular* structure,—proper to each *individual.*

7*thly*, That structures common to a whole Class must, in a modified form, re-appear in individual development; and,

Lastly, That they can re-appear in a certain order only; viz. in the order of their generality in the animal kingdom.

It has been our endeavour, throughout this paper, to limit the idea of fundamental unity of structure, to *essential* character alone; specific, and even individual peculiarities,—however inappreciable,—forbidding more. Each germ, even when presenting the merely *animal* type, must do so in a modified and peculiar form; on which the nature of its future metamorphoses depends: and if in the course of embryonal life, there occur resemblances in certain parts of structure, to corresponding parts in other animals, they are no more than *resemblances;* since individualities cannot be laid aside.

There is a danger in the present day, of generalizing too freely;* of carrying transcendental speculation much too far; of being so captivated by "the idea of a subjective unity, that real variety may be lost sight of;—as bright sunbeams veil myriads of worlds, that might shew to mortal man, what they are, compared with his world, and how little he is in the latter." †

* See an excellent chapter on the "Unity of Design" by *Dr Roget:* Bridgewater Treatise; vol. ii. p. 625.

† *Valentin,* Fragmente zu einer Künftigen Gesetzlehre der individuellen Entwickelung, in his Entwickelungsgeschichte, &c. S. 566,