Further observations on the unity of structure in the animal kingdom, and on congenital anomalies, including 'hermaphrodites' : with some remarks on embryology, as facilitating animal nomenclature, classification, and the study of comparative anatomy / by Martin Barry.

FURTHER OBSERVATIONS

ON THE

UNITY OF STRUCTURE IN THE ANIMAL KINGDOM,

AND ON

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WITH SOME REMARKS ON

EMBRYOLOGY,

AS FACILITATING

ANIMAL NOMENCLATURE, CLASSIFICATION, AND THE STUDY OF COMPARATIVE ANATOMY.

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

From the Edinburgh New Philosophical Journal for April 1837.

FURTHER OBSERVATIONS, &c.

In a former memoir on this subject,* certain conclusions were arrived at, which, to save reference, it may be proper to repeat, viz.

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.* Yet,

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.

These conclusions, especially the two last, with the reasoning from which they are derived, sufficiently explain why, in the embryonal life of the more elaborate animals, there occur temporary resemblances in certain parts of structure, to the permanent states of corresponding parts, in animals less wrought out.

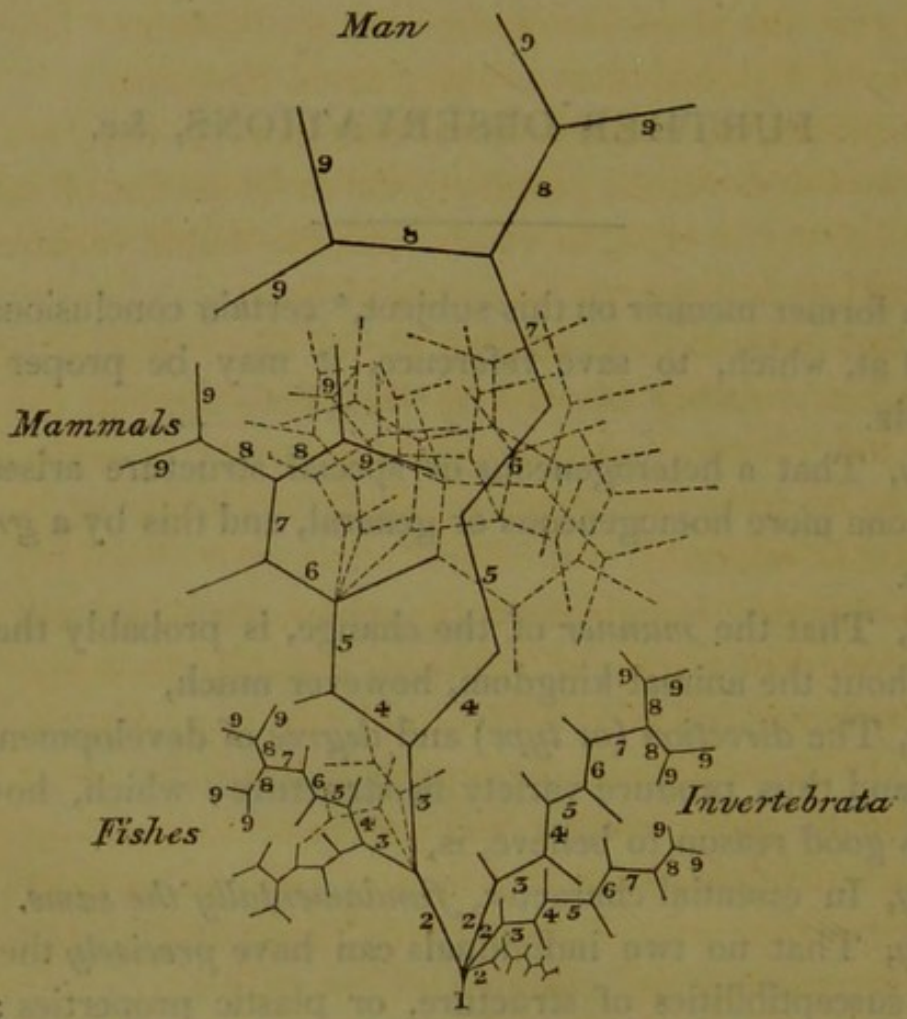
A Diagram will serve to illustrate some of these conclusions.

* See also the Edinburgh New Phil. Journ. for January 1837.

The Tree of Animal Development ;

Shewing fundamental Unity in Structure, and the causes of variety ; the latter consisting in *Direction* and *Degree* of development.

Fig. 12.



The whole figure represents the development of the entire Animal Kingdom. *

Any one of the primary divisions may rudely illustrate the development of a single organism, viz.—

Explanation—to be read from below upwards.

9. The *Individual* character in its most special form.
8. The *Sexual* character obvious, but the *Individual* character obscure.
7. The *Variety* obvious, but) *Sexual* difference scarcely apparent.
6. The *Species* manifest, but (the *Variety* unpronounced.
5. The *Genus* obvious, but not the *Species.*
4. The *Family* manifest, but the *Genus* not known.
3. The *Order* obvious, but not the *Family.*
2. The *Class* manifest, but the *Order* not distinguishable.
1. No *appreciable* difference in the Germs of all *animals* (Fundamental Unity ?)

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* The lower *dotted* branches, indicate directions for the development of Birds and Reptiles ; the following out of which, would have rendered the diagram complicated and obscure.

To avoid complication, only binary divisions have beenused ; but *dotted* branches (the *upper* ones) are introduced, to shew that *all* the *remote* divisions admit of such addition, except those that indicate the development of sex.

The distance between the root and the extremities of the last twigs, shews the degree of aggregate elaboration or development.

(Slightly modified, the diagram might perhaps represent the development of the entire *vegetable* kingdom,—or any one of its primary divisions, the development of a single *vegetable* organism; for the above conclusions are probably not less applicable to the *Vegetable* than to the Animal Kingdom.)

This illustration is but a coarse one, since it does not shew the *particular* direction, proper to the development of each individual germ; in order to which, each line would require to be separated into a divergent fasciculus of lines.

It is not unusual, however, to hear of the "higher" animals *repeating* or *passing through* in their development, the structure of the "lower:" and though this is said in reference, of course, to no more than single organs, it is a mode of speaking calculated to mislead.

Such expressions might not be improper, did there exist in the animal kingdom a scale of structure differing in *degree* alone. But there is no such scale. We must "distinguish between the degree of elaboration and the type of structure."* Each class, order, family, genus, species, and variety of animals,—each sex and each individual,—has a structure peculiar to itself; nay, every organ also, must, from the first, be constituted with reference to the most special structure it is destined to attain. "The Blastema (germ) of the new being, must be already peculiarly organized, to produce, under requisite, favouring circumstances, this or that individual. A formless material, as the foundation of, and susceptible of constituting, any individuality you please, is merely an abstract notion of the mind, and exists nowhere in Nature; where there are only concrete realities,—more or less characteristic individualities, contained in a higher whole."†

Strictly speaking, therefore, no animal absolutely *repeats* in its development, the structure of any part of any other animal; and not only is the human embryo at all periods of its existence a human embryo, but the human heart and brain, closely as they resemble corresponding organs in other Vertebrata at certain periods of development, are never any thing else than the heart and brain of Man. If the young frog, the tadpole, resem-

* Von Bär.

† Valentin, Fragmente zu einer Künftigen Gesetzlehre der individuellen Entwickelung, in his Entwickelungsgeschichte des Menschen, &c. S. 591.

bles in some respects a fish, and spends a portion of its existence in the water, is it to be said that the tadpole *is* a fish? Would a highly developed fish constitute a frog? Besides, as said by Valentin,* a passage by the embryo of the so-called "higher" animals through the "lower" grades, would imply the possibility of an individual, at certain periods, laying down its individuality, and assuming that of another animal; which would abolish its existence as a determinate concrete reality.

No structure peculiarly *characterizing* any one set of animals in the perfect state, makes its appearance even in the embryonal life of any other.† Thus the perfect gills of fishes, and the air-sacs distributed through the body and the bones of birds, relating as these organs do, to the elements respectively, in which fishes and birds have their abode, are found in them alone, which could not be the case, did the so-called "higher" animals pass through the perfect states of those said to be "lower."

Besides which, as Von Bär has truly said,‡ were it a law of nature, that individual development should *consist* in passing through permanent but less elaborate forms, there is not a feature in embryonal life, nor a part then present, that we should not expect to find, somewhere at least, in the animal kingdom. Yet in what direction are we to look for an animal carrying about its food, as the embryo the yolk, or a pendant portion of intestine, like the vesicula umbilicalis? In Mammals, the incisors are the teeth which first appear; but no animals have permanently fore-teeth alone.

The same author has well remarked, that inasmuch as embryonal relations produce forms that are present in no grown animal, such as the pendant intestinal sac, just mentioned; it is also impossible that any embryo can repeat the state of many groups of animals. All embryos are surrounded with fluid; and consequently incapable of immediately respiring air. The real character of insects, therefore,—a lively relation to the air,—can never be repeated in an embryo. For the same reason, the embryo of mammals can never resemble perfect birds.§

* l. c. p. 592.

† Valentin, l. c. p. 596.

‡ Ueber Entwickelungsgeschichte der Thiere, Beobachtung und Reflexion. Königsberg, 1828. S. 204.

§ l. c. p. 204.

Besides these arguments, there are others; but it is by no means needful to bring forward more. We briefly recapitulate those now advanced.

1*stly*, There does not exist a scale of structure, differing in *degree* alone.

2*dly*, Individualities cannot be laid aside.

3*dly*, There exist permanent structures among the so-called "lower" animals, not met with in the embryonal phases of any of the "higher."

4*thly*, There are many phases of the "higher" animals, corresponding to which, we do not find any permanent structures among the "lower."

4*thly*, No structure peculiarly characterizing any one set of animals in the perfect state, makes its appearance even in the embryonal life of any other.

Lastly, The sum of the innate susceptibilities of structure is not the same in any two germs.

It has been said,* that "the assertion is nothing more than that Man, as Man, has once in the progress of his development, been upon that grade upon which the several classes beneath him remain stationary in the progressive development of the entire animal kingdom." But even thus qualified, it is by no means true. Man, in the progress of his development, is not upon that grade on which any other animals remain stationary, unless the latter belong to the same *type* as man†: and even then the resemblance would relate to certain parts only, because each order, family, genus, species, variety, sex, and individual, has its own peculiarities, which are repeated in the structure of no other animal.

When the great Meckel said, "the higher animal in its development, passes through *essentially* the lower and permanent grades; by which periodical differences, and differences between classes, may be brought together;"‡ he evidently meant no more, than that there occurred in the development of a single

* Burmeister's Entomology, translated by Shuckard, 8vo, 1836, p. 419.

† We admit, indeed, that the whole animal kingdom has essentially the same fundamental or merely *animal* form; but from this there is an immediate *divergence*. (See Fig. 12, p. 4.)

‡ System der Vergleichenden Anatomie; erster Theil, S. 396. Halle, 1821.

organism, a *modified* reappearance of structures common to other animals; and further, that he did not intend to say that *all* the structures of *all* "lower" animals reappear in the development of each of the "higher,"—is evident from a remark he uses in reply to one of the objections made by Feiler;* on which occasion, Meckel says, "It is perfectly indifferent, whether the human embryo passes through all, or only some of the grades of formation; if certainly ascertained facts demonstrate that it passes through *many*,—that it *always* passes through them,—and therefore that the analogies in question are not accidental."†

It may not be improper, by a few of the facts on which Meckel's proposition appears to have been grounded, to exemplify some of the conclusions at which we arrived when last on this subject; and by quoting which, we commenced the present paper.

The uniform appearance first, in the osseous system of the Vertebrata, of what are called the arches of the vertebræ, is referrible at once to the law determining the *order* in which structures essentially the same in a whole class of animals, manifest themselves in individual development; and to the law of uniformity in the *manner* of development. If in the Cephalopoda, there is permanently no more than the trace of a spinal column, corresponding to the arches of the vertebræ,‡ it shews that the last degree of development in these animals, is sufficient to produce no more than an approximation to the Vertebrata; but that, so far as they do go, they proceed, in this respect at least, by nearly the same road.

If the ilium is the first pelvic bone that becomes ossified in animals possessing a pelvis,§ and if there be an animal in which this is the only portion of the pelvis present; this shews undeviating fulfilment of the same laws, though but a rudimental structure be produced.

The absence of the sternum and the costal cartilages in most

* Ueber angeborne menschliche Misbildungen im Allgemeinen und Hermaphroditen insbesondere. Landshut, 1820.

† L. c. p. 411, 412.

‡ Meckel, l. c. p. 399.

§ Meckel, l. c. p. 400.

Fishes and the "lower" Reptiles,* proves that these parts are not necessary to the general type of the Vertebrata; further evidence of which, is given in the late acquirement of them by those animals in which they are present.

In Man the encephalon is small in comparison with the spinal cord and the rest of the nervous system; the cerebellum is small compared with the medulla oblongata; and the corpora quadrigemina are enormous in proportion to all the other parts of the encephalon.† Corresponding states are found through life in many animals. Now, this is just what we should expect. For certain parts of the cerebro-spinal axis, such as the spinal cord, the medulla oblongata, and corpora quadrigemina, must, in fulfilment of the law determining the *order* in which structures common, essentially, to a whole class, reappear modified in the development of an individual organism, precede, in their appearance, those that are of a more specific character, such as the large volume of the hemispheres in Man.

Having seen why, in corresponding stages of development, parts of the human organism should resemble, in their structure, corresponding parts in many perfect but less elaborate animals; it is obvious, that if human development be arrested in any of those stages, the resemblances become permanent. Hence malformations of *defect*. But sometimes the development of certain parts proceeds beyond the normal limits; and hence malformations of *excess*.‡

Examples occur especially in the vascular system. Thus, the human heart with a single cavity, is somewhat analogous, in its simplicity, to the heart of the Insecta, Crustacea, and Brachiopoda. A single auricle and a single ventricle, affords some resemblance to what we find the normal state in most molluscous animals and Fishes. The Batrachians have two auricles and a ventricle; the incomplete state of the interventricular septum, being analogous to what is regular in the more elaborate

* Meckel, l. c. p. 400. † Ibid. p. 401.

‡ J. F. Meckel was the first who satisfactorily explained congenital anomalies. Handbuch der Pathologischen Anatomie. Leipzig, 1812.

Reptiles. Anomalies in the pulmonary artery and the aorta, afford examples of the same kind of resemblance; as do also the subclavian, brachial, cœliac, and renal arteries; and the inferior cava vein. Malformations occur also, though less frequently, in the nervous system. Many are afforded by the osseous system, as well as by the digestive, respiratory, urinary, and generative organs, the organs of sense, &c.

Meckel attributes the greater tendency in certain parts of the body to malformation, than other parts, to the circumstance, that parts in the "animal series" corresponding to the former, present normally more numerous varieties than others.* Thus for example, the anterior or superior extremities are more liable to deviations than the posterior or inferior. This explanation is no doubt the true one. We would add to it only, a reference to the law determining the *order* in which structures common to a whole class reappear modified in individual development; for in proportion to the generality of the latter in the animal kingdom, will their individual reappearance be early and established, and *vice versa*. As a further proof of this, it may be added, also, that the liability of parts to malformation, is in the direct ratio of their lateness in appearing.†

The nervous system, as said before, is subject to fewer anomalies than the vascular, and also than the digestive, generative, and urinary organs; corresponding to the relative degree of normal variety in these parts in the animal kingdom. This affords a further illustration of the foregoing; and it may be added, as a proof of the greater universality of the same essential structure in the nervous system of the Vertebrata, that its development is much more pronounced than that of other parts, at an early period of development.‡

The coincidence between the presence of ovaria or testes, on

* l. c. p. 427.

† Hence if a fundamental and early-formed part be not developed, parts dependent on, and subordinate to it, do not appear. Thus, if the vertebræ be not developed, the ribs do not appear; and if the ribs are not formed, the sternum also is wanting. Again the lateral portions of the vertebræ appear before their spines; therefore the latter are never present without the former.

‡ See the third paragraph of page 15, in our former paper (p. 139 of the Journal).

the one hand, and of a certain habitus, as well as other circumstances in various parts of the body, on the other, is sufficiently well ascertained. It is known too, that castration has the effect of neutralizing this genital influence; rendering males, in general circumstance, less masculine, females less feminine; that is to say, it brings the sexes nearer to a mean state. Age, or the natural termination of the reproductive faculty, produces in degree the same effect. This is observable in the human species as well as in other animals.*

The fact, that malformations of the genitals occur most frequently in the organs of excitation and copulation,†—parts of subordinate importance, and not formed until a comparatively late period,—affords an example of the fulfilment of the law, determining the *order* in which innate formative properties are manifested. The co-existence of testes, on the one hand, and of ovaria on the other, with a male or female habitus,—formed, as those organs are, long before the external, less important, genitals,—such co-existence is recognisable in the fact observed by Sömmering, that the sexes may be distinguished in general appearance, before a difference in the external genitals themselves proclaims them. ‡ In cases, too, of malformed genitals, it rarely happens that the real sex is not decidedly pronounced in the general habitus; shewing further, the early operation of the latter law.

Another proposition of J. F. Meckel is as follows, viz. "That sexual differences, at least according to their origin, and periodical differences, may likewise be brought together;"§ in other words, that sexual differences may be compared to differences caused by the phases of life. It is not easy to suppose that Meckel intended to represent the sexes as differing in *degree* alone; and yet it is added afterwards, that "the inferior animals are purely females."‖

* Old female birds acquire a plumage more or less similar to those of males; as well as spurs, combs, and even in degree, male instincts also.—Meckel, l. c. p. 446.

† Meckel, l. c. p. 447.

‡ Valentin, l. c. p. 595.

§ L. c. p. 396.

‖ L. c. p. 425.

The circumstance, that what are called "neuter" Hymenoptera, particularly bees—those born for workers—by being conditioned in a certain way, may be converted into females or queen bees, leads obviously to the conclusion, that the so-called "neuter" bees, *are* really females, in an imperfectly developed state. But does it warrant the conclusion, which Meckel seems to draw, that females are scarcely more than imperfectly developed males? Female bees may rest in an imperfect stage, so that their sex is not obvious: by treatment, they become proclaimed as females: but, we ask, would any further treatment make them *males?*

Yet it is not easy to conceive that Meckel intended the expressions used, for literal acceptation. Perhaps this proposition is to be regarded as not less susceptible of a modified application, than the one alluded to before.

Sexual characters bespeak properties that are innate; though, from being nearly the last that make their appearance in development, they are among the least established, and *therefore* very liable to vary. The sexual character has been said to stand between the character of the species, and the special or particular character of the individual being.* This is true, in as far as specific characters *manifest* themselves prior to those of sex, and those of sex prior to the last touches, stamping the individual character; yet it must not be forgotten, that throughout development, *all innate properties*, from those common to animals in general, down to those distinguishing the species and the sex, are modified in their individual reappearance by individuality.

Now, just as parts of structure common to the *class* are, in essential character, fundamentally the same; so are those common to an *order*, *family*, *genus*, and *species*.† The *sexual* organs, also, are in both the sexes of a species, in essential character fundamentally the same;‡ just as *vertebræ* are fundamentally the same in all the Vertebrata. Male and female organs

* Valentin, l. c. p. 594.

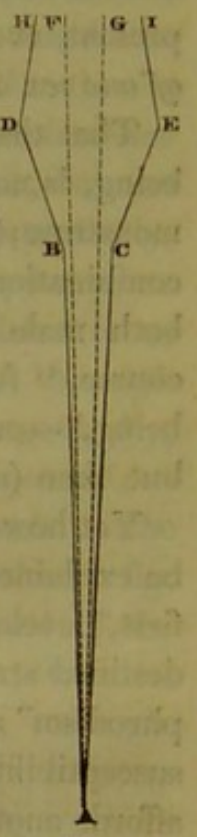
† It is only *individual* peculiarities, that are shared with no other being.

‡ An interesting proof of this occurs in the Order Marsupialia. Males have not, of course, a marsupium or pouch, unless in a rudimental form; but

have a common origin as processes, and take the same *general* direction, out of corresponding laminæ of the germinal membrane or tubes, and they have the same *manner* of development; but, just as parts of structure, at first common essentially to the *class*, become afterwards transformed, so do the *sexual* organs, which, essentially, are at first common to the *species;* and a difference in function follows. But from the first, as said before, development proceeds according to the *sum* of the innate formative properties, *sexual* properties being included in this sum; though their influence on development be not at first appreciable.

Let the point A, Fig. 13, represent the supposed fundamental form, essentially the same in all animals, so long as a merely *animal* structure is manifested. Two germs belonging to the same species, but of different sexes, start in their developement from this point A. Their divergence in developement is small, because occasioned by two influences only; one of which is sex, the other, individuality. At the points B, C, sexual peculiarities,—local as well as general,—exercise more sensibly their sway; and further developement takes them, respectively, to the points D, E. Here, if castration terminate the reproductive faculty in both, the result is,—not indeed the attainment of, for that is now impossible, but,—an approximation to, the mean state, F, G, which these individuals, respectively would have reached, had developement been influenced,—not by sex, but,—by individuality alone; the points H, I, being now attained. This we conceive may serve rudely to illustrate, what really takes place in nature.

Fig. 13.



It follows from the above, that we cannot adopt the theory

they have the marsupial bones. We need not, however, go for illustrations beyond the human race; in which the males have rudimental mammæ.

These examples will serve further to illustrate an explanation offered in the former memoir, regarding another branch of our subject (p. 25; or p. 140 of the Journal), viz. that rudimental structures seem to answer no other purpose than the fulfilment of the law, requiring that a fundamental or general type shall uniformly manifest itself before the appearance of one subordinate thereto, and special.

proposed in the Edinburgh Journal of Science for 1829–30;—that "there are, fundamentally, male and female organs in the same being, or originally in all embryos, elementary yet distinct parts, out of which both sets of organs may be formed by development." It is the *sum* of the innate susceptibilities of structure, that determines the direction taken in the development of every germ. Development must therefore from the first, have reference to the sex, as well as to the variety, species, genus, family, order, and class: nay more, development must from the first, have reference to the *individual* structure,—more special still than that of sex. Since, therefore, no properties can exist in an absolutely latent state,—*i. e.* without exercising their influence on development,—both male and female organs cannot be present, even in an elementary state, in the same being, *if those of one sex only, are to be developed.**

That the presence of both male and female organs in the same being, is not *incompatible*, most plants and certain animals demonstrate;† where normal and true hermaphrodism exhibits a combination of parts, for the performance in an individual, of both male and female functions. In such cases, there are of course, "fundamentally male and female organs in the same being,"—or at least there is the susceptibility of acquiring them; but then (and herein consists the difference) *both are developed.*

Yet how then, is *anomalous* "hermaphrodism" (so called) to be explained? To be consistent, we must admit that from the first, development has, here as elsewhere, reference to a certain destined structure; ergo, that in cases of anomalous "hermaphrodism" at least, there are fundamentally the elements, or the susceptibilities, out of which it has arisen.‡ Be it so; this but affords another proof of what has been so much insisted on al-

* Supposing the organs of both sexes present in the germ, and those of one sex only, to be developed;—what becomes of the other set? Because, occasionally, parts similar to those in other animals, have appeared in the human structure, may it not as well be said, that, fundamentally, there are the rudiments of *all other animals* in man? (!)

† Helix pomatia,—the garden snail,—affords a well-known example of the latter.

‡ Into the subject of casualties, happening during embryonal life, we do not enter.

ready; that in development, *general* structures must precede in their appearance, the more *special.* In an organism, the younger the embryo, the more alike,--because the less concentrated,—are its several parts or organs. In the animal kingdom, the younger any two embryos, the more alike are they, for the same reason. But, as already said, there is no *appreciable* difference between male and female organs in fundamental structure, as well in the animal kingdom at large, as in two individuals of the same species: though this by no means amounts to the assertion, that *either* male or female organs may be formed out of the same elements. Now, certain of the sexual organs, because of *deficiency* in their elements, or in susceptibility of structure, may advance *less* than is normal, towards concentration: certain of them, because of a *surplus* in their elements, or in susceptibility, may advance *further* than is normal: certain of them may take in development a *male* direction, certain others may proclaim themselves as *female*, because the male and female elements (or susceptibilities), respectively, *of these parts*, existed in the same germ. If the *surplus* relate to the chief organs and to the system generally, there is an *excessive* development of the sexual character: if the *deficiency* relate to the chief organs and to the system generally, males are *less* masculine, females *less* feminine, than is normal;—in other words, there is, in the latter case, an approach to the mean state spoken of before. (See at p. 13 the remarks on fig. 13.) What we have said of surplus or deficiency, and of the presence of both male and female elements or susceptibilities, may relate to one side of the body, or to both sides; to single organs on one side, or on both sides; all of which varieties are known.* The innate *cause* of such anomalies, we may perhaps never know; but the *manner* of their development, it does not seem difficult to understand.

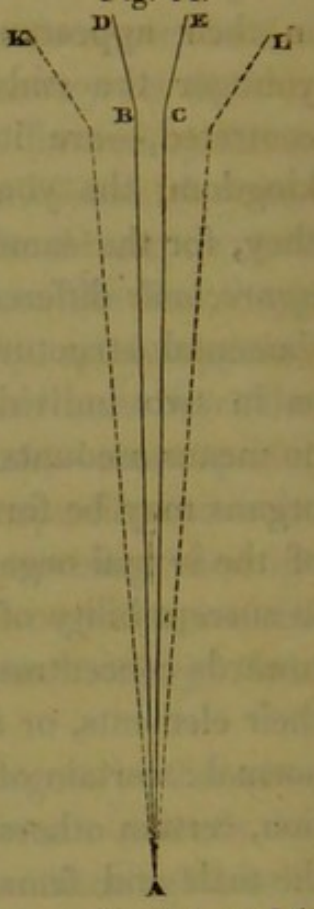
In further proof of the justness of this reasoning, may be adduced the fact mentioned by Meckel,† that hermaphrodism is frequent and complete, in proportion as the genital organs are simple, and in proportion as they resemble each other in the

* For an account of "hermaphrodites" in detail, see the late work of Isidore Geoffroy St Hilaire. 8vo, 1836.

† l. c. p. 457.

normal state; of which Fishes afford the best example. Now this is just what we should expect.

Fig. 14.



For, with a modification of the last figure (13),—let D, E (Fig. 14), represent, respectively, the points reached in the development of a male and female of a species, in which the sexual organs are very simple, and in which, therefore, the sexual difference is very small. It is plain, that a deviation here, would be more appreciable,—because relatively greater,—than if development had produced complicated structures, and carried the sexes further apart,—as, for example, to the points K, L: in other words —the less the angle of divergence, the more appreciable is a deviation, and therefore the more "*complete*" is the hermaphrodism.

But, "in proportion as the genital organs are simple, and in proportion as they resemble each other in the normal state," when perfect,—the less pronounced must be the reference to them throughout development; the later therefore do they manifest themselves. Now, as already said, the liability of parts to malformation, is in the direct ratio of their lateness in development. Hence, in such cases, the more "*frequent*" is hermaphrodism.

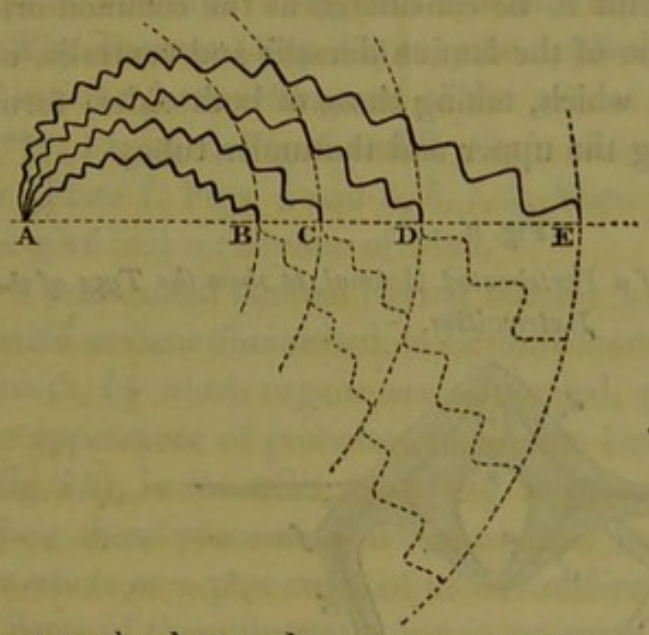
We conclude, then, that the explanation before offered, regarding the necessity of a modified re-appearance in individual development, of structures common to a whole class of animals, and regarding the *order* of such re-appearance, is applicable to all congenital anomalies, including those called "hermaphrodites."

It remains to notice unity of plan, as obvious in organs of the same organism; various parts appearing like modified copies of each other. Organs of the same organism that admit of such

comparison, being among those that originate in the same lamina of the germinal membrane or tube, analogies appear referable, 1*stly*, to a common origin,—and therefore 2*dly*, to a common fundamental and general form,—some resemblance, 3*dly*, being preserved in proceeding towards the special.

A diagram used in our former memoir being required here, we again introduce it, to save reference.* Let the point A, Fig. 11, represent the common origin,—the homogeneous nature,—and therefore the coincidence, essentially, in fundamental form,—of various parts arising out of the serous lamina of the germinal membrane of Man (Plate I, Fig. 3, **):† and *firstly*, of those parts proceeding, respectively, from the laminæ dorsales and ventrales; constituting as the latter do, an *upper* and an *under* tube, (Plate I, Fig. 6, *a. b. c.*)

Fig. 11.



The curves, differing in *direction* and in *length*, may illustrate differences in *direction* and in *degree* of development of the vertebræ; including as well the development of those constituting the coccyx,—curve A B,—as that of those which, vastly more wrought out, enter into the formation of the cranial bones,—curve A E; the development of the intermediate vertebræ being represented by the intervening curves. ‡

* For a more detailed application of the elements of this diagram, see pages 19, 20, of the former memoir (pp. 135, 136, of the Journal).

† The Plate here referred to, is contained in the former memoir.

‡ In our former paper, p. 20, (p. 135 of the Journal) we stated the applicability of the above diagram, in a comparison of systems of organs or single organs in different animals. Thus to apply it here; the curve A E, representing the development of the cranial bones in Man,—A C, and A D, may illustrate coresponding parts in osseous Fishes or other Vertebrata, less removed from vertebræ both in direction and degree.

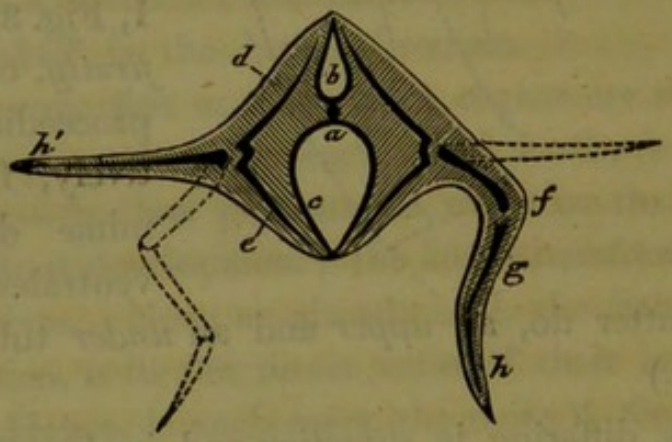
The development of the ribs being exhibited by one curve, that of the hyoid bone, lower jaw, &c. may be shewn by others.

If the curve A B, represent the development of the spinal cord,—A E may serve to shew that of the most elaborate portion of the hemispheres; and the intervening curves, the development of intermediate parts of the cerebro-spinal axis.* All the nerves connected with the latter, may be illustrated in the same manner;—they seem, as it were, rude copies of each other,—differing only in direction and degree.

Secondly, Let the point A be considered as the common origin, in the fleshy portion of the lamina dorsalis and ventralis, of a series of osseous arcs, which, taking those of both sides, form an *outer* tube, including the upper and the under tube.

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.†)

* Referring to the preceding note, we have again an instance in which the curves A C and A D, may illustrate the development of the hemispheres in animals whose brains are less removed from their primitive simplicity than the brain of Man.

† This figure also, was exhibited in our last paper. Its re-appearance is needful for the reason before given regarding Fig. 11.

The curves may now illustrate the development of the radical portion of either an extremity, viz. of the scapula and clavicle, on the one hand, and of the outer portion of the os innominatum,* on the other, or that part of the base of the cranium, which,—formed by one of those osseous arcs, and having coalesced with the cranial vertebræ,—serves to articulate the upper jaw.†

Again, if A represent a point near the middle of each arc, the curves shew the development of a process originating there, now into an arm or leg, and now into an upper jaw.‡

The diagram (Fig. 11) may be applied also in a comparison of various parts arising out of the mucus (Plate I. Figs. 3 and 4***, Fig. 5, *l*, Fig. 6 and 7, *f*), in close union with the vascular (Plate I. Figs. 4 and 5, *h*, *i*, *k*, Figs. 6 and 7, *e*) lamina of the germinal membrane of Man.

These united laminæ having become a tube, there occurs in certain sections diminished, in certain others increased growth, by which organs are originated, presenting the appearance of processes, in the one case *towards* (Fig. 15), in the other *from* (Fig. 16) the axis of the tube; these processes having, as their base, either the whole or a part only, of its circumference.

Fig. 15.

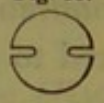


Fig. 16.

Some of these processes are in no small degree analogous to each other, and, as is the case with all other organs of a series,—with all animals indeed,—the more alike, the nearer to the period of their origin we view them.

Thus the lungs have been compared to the urinary organs,

* The inner portion of this bone being probably, as Von Bär supposes, analogous to ribs, derived from the under tube, and coalescing with a section of the outer, to constitute the pelvis.

† Von Bär.

‡ Or in some of the Vertebrata, into a wing, a fin, &c.

In Fig. 10, p. 16 of the former memoir, (p. 131 of the Journal), there was given an ideal transverse section, shewing the structures formed out of the serous lamina of the germinal membrane in the Arthrozoa. There is a remarkable tendency to repetition in the segments of their dermo-skeleton, including that portion of the latter that enters into the formation of the head; and in certain of them the legs insensibly pass into maxillæ. No doubt the same tendency to repetition is universal in the animal kingdom.

and the genitals to portions of the alimentary canal.* But having proposed to enter upon general considerations only, we cannot go into the details of comparison.

With this common origin, and therefore coincidence in fundamental and general form, it is not surprising that organs should present analogies. Besides which, there seems, however, unity of plan in proceeding from the general to the special,—a tendency, as said before, to repetition of parts in the several sections of the same tube. Development appears to take the same *general* direction in the several sections, with various *particular* directions, according to various particular and proper functions, in their subdivisions.

It appears, then, that unity of plan, which we have seen to direct *general* structure in the animal kingdom as a whole, extends to the *general* structure of an individual organism. Thus, particular organs originating in the same lamina of the germinal membrane or tube, of the same organism, may perhaps be compared to individuals of different sexes in the same species.

A great deal of labour seems to have been lost, in endeavouring to find out corresponding parts,—as well in different organisms as in the same organism,—because directed to the examination of *perfect* structures. How much of this labour,—perhaps, too, some octavos,—might have been spared, had due regard been paid to the *fundamental similarity* in structure, and to the identity that exists in the *manner* of development, of two germinal membranes. To a few general and easily understood principles, are referable all analogies,—whether in the same organism, or in different organisms,—as well as all congenital anomalies.

The same remarks are applicable to Classification; which, as already said,† can have no sure basis in structure, as met with in the *perfect* state; when *different* functions, performed by *corresponding* parts of structure, tend to embarrass and mislead. Nomenclature also, depending thus on data that are uncertain, must be fraught with error.

* The resemblance is very striking in animals of simple structure, as well, indeed, as in many of the Vertebrata; in which, for example, the oviducts are scarcely distinguishable from parts of the intestine.

† Page 22 of the former paper (p. 136 of the Journal).

The fact is, that naturalists have begun, just where they should have ended. They have attended to details, but neglected general principles. Instead of analyzing, their process has been one of synthesis. Their attention has been directed to the grouping of the *twigs*,—as if thus they were to find their natural connections, without even looking for assistance towards the branches, or the trunk that gave them forth. But the simile is inadequate; the labour lost, has been greater than even this supposes. For in the *grown tree* of *animal* structure, parts, once essentially the same, not only have diverged in their development, and become elaborated into very different forms,—but, as said before, perform *very different functions* also. Hence a *positive*, in addition to a negative source of error.

But what other course *could* naturalists have taken? Truly none: their "circumstance" allowed no other. It is only now that a way is beginning to be opened, by which it may by and by be possible to proceed in an opposite direction; viz. from trunk to branches and to twigs.

This, if ever accomplished, must be by means of the *History of Development* or *Embryology*, both human and comparative; a science almost new, and regarding which, there prevails in this country the profoundest ignorance and indifference. The French are in advance of us; but it is to *German* enterprise, industry, and perseverance, that we are indebted for almost every fact known to us on this subject; at least of those brought to light in recent times.* It is to be hoped, however, that ere long this science will begin to obtain, even among ourselves, some degree of the attention which its importance claims.†

* When St Hilaire proclaimed in France the principle, that zoological research can have no solid basis but in *anatomy*,—and that it is not the organs of the functions in their totality, but the materials constituting these organs, between which, resemblances are to be sought for,—he advanced a most essential step: yet there was still wanting, more regard to *Embryology*.

† Dr Allen Thomson's excellent paper (see vol. ix. and x. of the Ed. New Phil. Journal) we have already noticed.

The recent appearance, too, of a "Sketch of the Comparative Anatomy of the Nervous System, with Remarks on its Development in the Human Embryo"—by John Anderson, M.E.S., 4to, 1837,—shews that there are grounds for such an expectation as is expressed above. We have only just glanced the volume through, but seen enough to say, that it contains many valuable and well-arranged facts, admirably calculated to illustrate the doctrines of the great Meckel and others, published in Germany so many years ago. Had we read this essay before writing the present memoir, some of the facts it contains might have been adduced by way of illustration.

If these remarks are not uncalled for, in reference to nomenclature and classification,—they will not perhaps be deemed unworthy of consideration, when applied to a science, in the study of which, nomenclature and classification are but *means*. But independently of these, does it require much penetration to discern, whether it is easier, in the study of *any* science, first to commit to memory isolated facts, and then proceed to arrange them ;—or, having first become acquainted with general principles, to trace their applications? In other words, having first studied structure in its unity,* to follow it out in development, and find the causes of variety to be resolvable into *direction* and *degree*? If the latter method be the easier, *Embryology would incalculably facilitate the study of Comparative Anatomy.*

* It is not intended that *human* structure should be thus first learned: an acquaintance with it, obtained in the usual manner, is here presupposed.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