An inaugural dissertation on organogeny : submitted to the dean and faculty of the Medical College of the State of South-Carolina for the degree of M.D., and recommended by the medical committee for publication / by Myddelton Michel.

Michel (M)

AN

INAUGURAL DISSERTATION

ON

ORGANOGENY,

SUBMITTED TO THE

DEAN AND FACULTY OF THE MEDICAL COLLEGE OF THE STATE OF SOUTH-CAROLINA,

FOR THE DEGREE OF M. D.,

BY

MYDDELTON MICHEL,

AND RECOMMENDED BY THE MEDICAL COMMITTEE FOR PUBLICATION.

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The tendency of the mind to search for the proximate cause of the origin of all things, has, on some occasions, seduced the physiologist from the province of his empirical science, to wander through the intricate and mysterious theories of a psychological philosophy.

Convinced that he must content himself with but an imperfect knowledge of those organic operations which constitute the phenomena of life, unless he be acquainted with that occult force, which, under favorable conditions, destroys the "static" equilibrium of matter, endowing it potentially with its ultimate and specific form; he has, by his misdirected endeavors to rob nature of one of her greatest secrets inadvertently retarded the progress of his captivating science.

In those inquiries which have been instituted with the view of determining the relations between the vital force and the soul—the *vis animæ*, the former has been so nearly allied to the latter, that the hypothetical speculations inherent to the nature of the research have too often been substituted for that more logical and inductive method originating in an attentive observation of facts.

In so difficult a problem, both terms of the comparison being unknown, it has almost been impossible not to enlist in the cosmological system of the philosophers of old, and the doctrine of

* This essay was presented to the Faculty of the Medical College of the State of South-Carolina, and obtained the prize, awarded by a committee of medical gentlemen, appointed for the purpose of selecting, from among the theses offered for the degree of M. D., that most worthy of publication.

pantheism, towering up like a barrier between the dictates of conscience and the operations of reason, has accordingly often been revived to transport us over a chasm inaccessible to man.

It seems to have been forgotten, by those who are disinclined to admit any identity in the vital and mental principles, that we must first determine the nature of the one which is the more accessible to our means of investigation, so as to possess a term by which we may look in the comparison for their identity or non-identity; and either adopt a doctrine detrimental to the very principles of the science of physiology, or discovering the difference refer the one to that presentiment which recognizes its essence, while we submit the other to the crucible of experimental research. It is only, then, since the tenor of research has been directed to the proper channel, that the first steps have been taken towards the determination of this interesting inquiry.

From the desultory facts thus obtained, have originated the most curious investigations given the physiologist to pursue; and by the discoveries and indefatigable labors of Prof. Coste in the assemblage of these facts, and in the demonstration of their reciprocal bearing with one another, this part of physiology has truly been elevated to the dignity of a science.

The name Organogeny* or the science of organization has been assigned to this subject. The great and thrilling interest which it is now exciting finds its explanation in the truths which it is destined to reveal, and the position it must subsequently occupy with reference to the study of physiology.

Where, indeed, can we better search for the mysterious operations of that principle called the vital force, than where they are first awakened in matter; impressing an amorphous fluid with the primitive trace of organization, and converting it into the permanent *substratum* of life? By the happy application of the sciences to the arts, our means of research have been so benefited, that by the use of the microscope, science is now able to extend the limits of her dominion, and to discover in matter about to individualize itself, the first steps of organization. It is then in the wonderful phenomenon of reproduction; in the evolution of the ovum; that we find the realization of that abstract principle—a creative force, upon which rests the entire science of life. Here, under the testimony of occular demonstration, do we discard those theories which once perplexed and encumbered the history of generation, and which, at the end of the seventeenth century, we learn amounted to no fewer than three hundred. The doctrines of "pre-formation," "metamorpho-

* This word is derived from ὀργανον, an organ, and γεινομαι, to produce. A knowledge of the manner in which the organs of the embryo are produced.

sis," "syngenesis," etc., as so many modifications of the theory of "emboitement," have all been reduced to their just value, in presence of the beautiful laws which now so liken this function to other processes of the economy,—nutrition for example; while the discovery of an ovum in Mammalia and the human species has established the absolute contact of the semen and ovum, the procreative elements, as the predicate of fecundation.

Now before we detail those principles, which we will endeavor to show, render legitimate our regarding them as the essential features of a growing science, it will be instructive to trace our predecessors through the rugged path which conduced to such truths, when we will be then better able to judge to what further inferences they lead.

It was long the subject of disputation whether the old adage of *omne vivum ex ovo* was not rather the expression of a preconception, than the literal announcement of the law of creation. The spiritual nature of man appeared *à priori* to suffer in the event of an origin so material as this, and the denial of the existence of an ovum in the human species and other classes of mammalia, seemed the natural inference which the premise evolved.

It was towards the end of the seventeenth century, that Regnerus de Graaf, in his dissertation "*De Mulierum Organis generationi Inservientibus*," first announced the presence of an ovum in quadrupeds and in man ;* but the vehement resistance he encountered in the angry debates with Swammerdam exemplifies the uncertainty that still invested a truth which his experiments had already divulged in one of its phases.

Having detected, in the uterus of rabbits, ova, which had acquired considerable development, De Graaf was led to infer from their great resemblance to the transparent vesicles of the ovaries, that these latter were the eggs themselves, in accordance with which belief these follicles obtained the name they long bore of *ova graafiana*. But the intuitive evidence of this belief was questioned in no frivolous manner by his contemporary Swammerdam. In his opinion, a cogent argument militated against this view; for at no period was it possible to discover the large ovarian vesicles in their transit through the tubes; and, moreover, it was difficult to conceive of their passage through so capillary a duct. While De Graaf supposed it possible for the tubes to dilate so as to afford them a ready passage, just as the uterus dilates to receive the product of con-

* De Graaf believing the vesicles of the ovary to be the ova, and finding them in all animals, says: "Ova in omni animalium genere reperiri confidenter asserimus; quandoquidem ea non tantùm in avibus, piscibus tam oviparis quàm viviparis; sed etiam in quadrupedibus ac homine ipso evidentissimè conspiciantur. De Mulier: Org: Cap. XII. p. 229.

ception; he could not but feel the argument alleged against their constant absence in the tubes, and was driven to presume that the vesicles only eliminated their contents, leaving us to infer that the ovum (if such it could be called) possessed an indissoluble continuity with the organ producing it. Now, as this was contrary to the analogy drawn from the other classes, where the egg is separated from, and not in continuity with the parent organism, science was yet, with regard to this mystery, *in statu quo.*

Indeed, subsequent researches rendered the accuracy of these statements still more equivocal; for, when it was the good chance of Cruikshanks* first to discover ova in the uterine extremity of the tubes, three days after fecundation, not being in that advanced stage in which Graaf had seen them in the uterus, their extremely small size precluded the possibility of regarding them as identical with the vesicles of the ovary, which were much larger. However, the existence of an ovum in the ovarian vesicles might have been inferred had not the frustrated labors of many refused the belief. Haller† had experimented with this view on some hundred different animals, and Kirchdorff actually published his misgivings as to the ovarious origin of mammalia under the title of "*Dubia de generatione viviparorum ex ovo.*" At a latter period science was much indebted to Prevost and Dumas for their investigations on this subject, in dogs particularly; and though they twice met with a corpuscule from the graafian vesicle, which by inconceivable negligence was refused the attention it worthily deserved, and the important discovery of the long-sought-for ovum was referred to a latter period, yet their labors in this field will always hold the rank to which they have so legitimate a claim.‡ Great doubt still reigned over this impenetrable mystery, for it was yet a question whether the egg was not of ulterior formation: produced by the fluid contents ot the vesicle in its passage through the tubes.

Such was the faithful condition of the science until within the last twenty years, when Baer in 1827, apprized us of the

* De Graaf mentions having found an ovum in the tube; but, with Bischoff I regard the nature ot this body he describes as equivocal. Cruikshanks' experiments are found in Philos. Trans. p. 200. 1797. 23d to 28th exp.

† Elementa Physiologiæ, p. 44, vol. 8.

‡ We read the following lines in the "Troisième Mémoire of Messrs. Prevost and Dumas, headed: "De la génération dans les Mammifères, et des premiers indices du développement de l'Embryon" . . . . . "très probablement les vésicules ou les œufs de l'ovaire, contiennent dans leur intérieur, les petits ovules des cornes, qui s'y trouvent environnés d'un liquide destiné peut-être à faciliter leur arrivèe dans l'utérus. Il nous est survenu deux fois, en ouvrant des vésicules très-avancées, de rencontrer dans leur intérieur un petit corps sphérique d'un millimètre de diametre. Mais ils différait des ovules que nous observions dans les cornes par sa transparence qui était beaucoup moindre."

success which had rewarded his assiduous researches. The corpuscule, encountered two years previously by Prevost and Dumas, was now shown to be identical with the ovum found in the tubes. But here the truth was not, as we might have supposed, irrevocably consigned to the annals of science in all its perspicuity; the strange interpretation which it suffered in his hands, consecrated an error that masked the principles it unfolded; divided the laurels which its discoverer alone should have gathered, and bore that complicated abstruseness which revealed the metaphysical doctrines of the school to which it belonged, while, it was divested of that pleasing simplicity and *rational analogy* it should always wear.

Baer, unable to disengage himself from an idea so prevalent that the graafian vesicles were the ova, only saw in this discovery a confirmation of the belief; and at once endeavored to establish the analogy which was supposed to exist between them and the ova of ovipara. In this erroneous comparison, the tunics of the graafian vesicle were likened to the protective envelopes of the bird's egg; the fluid contents represented the vitellus; the granular layer, and what we term the *cumulus granulosus*, (*tunica granulosa* of Barry,) were the granular membrane and *discus proligerus*;—while, according to this view, the ovum itself, situated within the disk, was supposed to be analogous to the germinal vesicle in birds. But this survey ruffled the knowledge entertained of the function of the constituent parts of the bird's egg, which was so well known; for while in the one the germinal vesicle resolved itself into the formation of the cicatricula,—in the other it was eliminated, and in itself realized the evolution of all subsequent development; in the one the vitellus was incorporated, and essential to the ovum,—in the other it was external to it, and inservient to no purpose. These contradictions were either lost sight of, or were reconciled by an effort of imagination, which, however we may admire its ingenuity, we must condemn its extravagance.

In presence of the high rank man holds in the scale of animated creation, Baer perhaps conceived the possibility of a similar superiority ab initio; and in the unrecognised ovum, its characteristics forcing themselves upon consideration, though only as an element of the graafian vesicle, itself supposed to be *the* ovum, by a singular interpretation of facts, he regarded the condition to be that of an "*egg within an egg*," or "*an ovum raised to the second power*" as he termed it, and carrying out the equation, (if I be allowed this expression,) the formula of the corollary was: as the egg is in the egg, so is the animal within the animal, or the fœtal within the parent organism.

This was another signal illustration of the ready conversion of results to the subserviency of entertained views, and of the in-

fluence of prevailing sentiments upon the determination of a question.

As we have already observed, the error did not alone consist in the doubt which this ambiguity of diction conveyed, but the theory incurred the forfeiture of that principle which was to constitute the corner-stone of the science in contemplation. It led us from the discovery of the apparent identity of the ovum in this and other classes, to a premise utterly fallacious,—and when, I ask, could the subsequent analogies or differences of development in the animal series have been detected, while the initial processes were regarded as essentially different. The great unity in the phenomenon was unknown—the deductions unsought for—and the exposition of the entire catenation of changes, which linked together in regular succession, establishes the character of a philosophical science, was reserved as the fruits of an important and recent discovery. This honor was bequeathed to the learned professor already mentioned in the preliminary. Professor Coste, in quest of what may be regarded the measure of truth—analogy—devoted himself to the examination of the corpuscule of the graafian vesicle, with that undissipated attention which insured success, and after much labor and numerous failures, discovered in an ovule just received from the ovary of a rabbit, a transparent globule or vesicle situated towards the periphery of the central* opacity. But fearful of some mistake, another ovule was immediately resorted to, and then a third, when, the same result being always attained, this newly discovered object was recognized to be analogous to the purkinjean vesicle of birds, he then termed it the germinal vesicle. Now the nature of the corpuscule from the ovarian vesicle, as being literally and emphatically the ovum, demanded only a careful examination of its elements. The translucid ring which surrounds the ovule, when examined beneath the microscope, had been termed *zona pellucida* by Baer, but its character as a thick transparent membrane was now exhibited; and as it enveloped the central mass which Prof. Coste showed to be the vitellus, it also received its proper name of vitellary membrane, *membrana vitelli.* The perfect analogy of this product of the graafian follicle with the ova of other classes was definitively established. It consisted like them of a vitellary membrane; vitellus, and germanial vesicle. No one now questioned the character of the graafian follicle, with its *granular layer and disk.* Analogy alone would have induced the belief of its apparent identity with the calyx in the racemiferous ovaries of birds; and such the able professor showed it to be. It was no farther in relation to the ovum than is the calyx to the bird's egg,—it is

* Recherches sur la génération des Mammiferès, 1834, p. 29.

its domicile—the *receptaculum ovi ;* and contributes, after the exit of the egg, to the formation of the *corpus luteum ;* while its granular layer and cumulus, (the *discus proligerus* of Baer,) is inservient to the wise purpose of placing and retaining the microscopic ovula in relation with the most prominent part of the vesicle, which secured its ready entrance into the tubes upon the dehiscence of the latter.

We might dwell more discursively on the further analogies of these parts, but enough has been said to exhibit the importance of a discovery so essential to the destiny of the science of organization.

As the professor, whose name is so blended with this science, was instrumental in assigning it its character, we are not surprised at the interest it has particularly excited in France, where, he has been called to a chair created for him at the "Collège de France," for the better dissemination of the principles it inculcates.

That this subject subserved a yet greater result than the mere assemblage of those operations, which realize the complete development of an organism, is now to be shown.

To establish its legitimateness to the character of a science, Organogeny had, besides co-ordinating the data obtained from the animal series, and displaying their mutual concordance, a still very important feature to develop, in exhibiting its relation to those sciences around it, so that it might then constitute a link in that great chain of philosophical enquiries further conducive to the verity of their harmonious succession.

Therefore, as Organogeny has for its object a careful examination of the successive evolution of each individual part of the embryo, it is, if I may so speak, the veritable synthesis of creation, and must be readily admitted to furnish the supplement so necessary to a science as analytical as descriptive and comparative anatomy, since both conduce to the determination of the same end. Therefore, ranked by the side of these sister-studies, it received that support which sanctions the position it has already I may say, been admitted to in the great cyclopedia of science.

If, enthusiastic of a subject which I have had for sometime under experimental investigation, I venture, under the authority of names like Cuvier, De Blainville, Muller and Coste, to arrogate for it almost a supersedure over comparative anatomy, I hope the charge of extravagance will be deferred, in my pronouncing it, if not the more logical of the two, at least, its indispensable accompaniment.

By the learned Carus we find comparative anatomy defined : "the history of the gradual perfections of animal organization, and a description and comparison of the peculiarities which the

intimate structure of the most important animals present."* This is indeed that science reduced to its truest expression; but the completion of this plan can never be attained by a purely analytical system. It is from the initial processes of development that we must create that synthetical method, which combined with analysis, then, affords the most irrefragable proofs of the position that an organism should hold in the animal series.

Man, in the one science, taken for the type or unit to which all other beings are compared, is examined with them in the image or perfect state, after passing through those complicated transformations, which the consummation of the design has concealed so as never more to be retraced; a comparison, therefore, evidently the more difficult and the more imperfect as the being is lower in the scale. Here we proceed from complicated to simple phenomena, whereas the reverse would surely lead to more categorical results. In the science which we have just termed the synthesis of creation, histological geniture precedes comparative zootomy;—the most simple forms of creation are brought into view, and in that sphere where all forms are alike—the egg. From hence we build up the various organisms; follow the construction of the edifice in detail; and accompanying these successive transitions where they continue in one while they are suspended, as it were, in another, we establish—relatively—the perfection or imperfection of the entities of the scale; and are able in the survey, as from a commanding eminence, to take that encompassing view of creation which extols the wonders of nature and proclaims the great unity of purpose.

That we may more readily perceive the comparative merits of these modes of inquiry, let us, aided by two or three examples, follow the ratiocination pursued by the comparative anatomist, and the embryogenist in the elucidation of the same views.

It is true that it has been by comparisons that anatomy has received those transcendental bearings which give that high valuation to its rank among sciences; and more particularly to comparative anatomy do we owe those sought for similitudes in parts of apparent dissimilarity. But though genius has often displayed her powers in arriving at truths which were the more beautiful and the more to be admired perhaps on account of their being the results of her unaided reflections, yet a candid observer, in many of these far-fetched comparisons, can only perceive that sum of probabilities which may amount to a certitude, but is forced to confess that the proof is frequently want-

* La Zootomie Comparée doit faire l'histoire des perfectionnemens graduels de l'organisation animale, décrire et comparer les particularités que pressente la structure intime des créatures animales les plus importantes. Carus, Anat. Comp. vol. i, p. 5, 1835.

ing. For example, in the adult the strongest resemblances are supposed to exist between the external genital parts in the two sexes; so much so, that, in the clitoris composed of its corpora cavernosa and urethra slightly separated from them on the under side, is wont to be recognized a striking resemblance to the penis of the male; and in the labia also the scrotum is seen to exist in a modified condition; while in the ovaries we see that repetition of the testicles in man, which caused even the anatomists of old to term them the *testes mulierum.*

Rational as these comparisons may be, they want that stamp of verity so requisite in making them acceptable to the mind of every investigator, and the comparative anatomist is truly at a loss to impart his conviction to all. When, however, the morphological changes of embryonic life are examined, in accordance with that well established law in virtue of which an organism passes through transitions the permanent conditions of other beings, there must necessarily be a period (let it be of however short a duration) in which all conditions are identic, and the process of development exactly coincides in the two sexes. Now let the Embryogenist direct his attention to the inquiry before us; let him, I say, direct his observation to the genital organs, and he will encounter that moment of their development in which it is morally impossible for him to determine to which sex the animal belongs; the being is neither male nor female; the sex is wanting or rather is neuter—nature as it were, has scarcely sketched their ultimate condition, and he then, for the first time, discovers that identity in the parts, when an excess of development may change the balance and convert the being definitively either into the male or female. Here the Embryogenist furnishes the proof,—he commands the verisimilitude of a comparison, which the anatomist only solicited.

Let us now take another example.

The spirit of comparison which has instituted a likeness between the abdominal and thoracic limbs, has also suggested one which was far less accessible to the ordinary means of examination; this was: regarding the upper and inferior maxillary bones as constituting appendages, to a certain extent similar to the members, though modified in that adaptation to purpose that is exemplified in other parts of the economy, where, for example, we see the tail of some of the quadrumana and the proboscis of the elephant converted into prehensile organs. This opinion has been made plausible by comparing these parts to the mandibles, maxillæ and palpi of insects.

By a complaisant effort of the mind, we might indeed perceive some distant analogy of the kind; and in the symmetric halves of the superior maxilla, might detect something comparable to the mandibles of insects, while the inter-maxillary of some animals

and the inferior maxilla might simulate the palpi and maxilla of insects. The frame-work of the buccal cavity may henceforth be regarded as appendages similar to those of insects, where the palpi are tactile organs, and the mandibles take the part of prehensile appendages.

We must confess, however, that the comparison required the genius of him who conceived it, for its intuitive exactitude was much to be questioned; but it has received that evidence from the science before us, which raises it to the level of certainty. And, indeed, if sufficiently favored in examining a human embryo at the early period of twenty-five days, we will really find that disintegrated condition of the elements of the buccal orifice, which exemplifies in an astonishing manner the accuracy of this comparison.

In presence of such examples, we are nevertheless disposed to question the necessity of the intervention of the organogenist, when anatomy, with comparatively imperfect resources, has arrived at the discoveries of such truths. None are more willing than ourselves to admit the undisputed superiority of that science, or more inclined to admire the transcendental nature of those researches which have assigned it its lofty position, but the same candor invites us to observe that many of its inductions need that veri-similitude so necessary to recommend them as well averred facts. But we are ready to go still further, in asserting that, unaided by the science we advocate, comparative anatomy may even be inadequate in pronouncing in some cases; and the example which occurs to our mind is of too pertinent an application to be passed unnoticed; it is the os hyoides.

Were it required of the comparative anatomist in the capacity of an ichthyologist to demonstrate the relationship of the *os hyoides* to a corresponding part in the fish, I apprehend he would find it extremely difficult to discover in any part of that animal the remotest feature of semblance to the bone in question, and would be under the necessity of admitting the insufficiency of his method. But not so if we adopt the synthetical mode of inquiry, for as we then contemplate both organisms at the convergency towards that common point—the ovum—where, congruously to the law above mentioned, they must be alike, we find a ready and easy solution of the problem, which we never could have obtained in viewing them separated as they are at the sinus of the imaginary angle.

The accusation of irrelevancy will not be alleged if we enter upon some preliminary details to illustrate this.

At a very early period of embryonic formation, shortly after the blastoderma has realized the structures of the axis of the embryo, the area germinative or "*tache embryonaire*" of Prof. Coste, which at first presented the shape of a lyre, by a folding

over of its accurately defined borders, assumes the figure of a slipper, the extremities of which supposed to turn upwards would represent what have been called the vagina capitis and vagina caudœ, (capuchons cephalique and caudale of the French,) while the lateral borders of the slipper rising up and curving over to meet on the messial line constitute the visceral plates—*laminæ abdominales* or *vaginæ laterales.* These visceral plates so called in contra-distinction to the dorsal plates, extend from the cephalic to the caudal extremity of the embryo, but at that portion of their extent, which corresponds to the region of the neck, they are interrupted in their continuity, splitting into four processes, on either side of the neck. These quadrified divisions, consistent with the general direction of the structures which produced them, also converge towards the median line, affecting the appearance of so many arches, termed visceral, or more correctly branchial arches, while the breach of continuity they intercept, are the branchial clefts. This arrangement, in accordance with the general plan of organization, is found to obtain in all the vertebrata; and a structural peculiarity constituting a permanent condition in fishes, is actually met with, though of evanescent duration, during the morphological transitions of the human embryo. This is beautifully illustrated in a plate of my own, drawn from a human embryo of twenty-five days, in which we may distinguish these several arches and clefts, and the disintegrated structures of the mouth already referred to.

If, after these explanatory remarks necessary to appreciate what follows, we accompany the respective embryos in their development from this apparent condition of identity, attending particularly to what transpires in the branchial arches, we will detect a most striking metamorphosis of parts. Unlike what is presently to be seen in the human embryo, these arches in the fish acquire an increased development. As they are dependences of the external, serous, or animal layer of the blastoderma, they soon transform into the tissue, that structure is destined to evolve, and are converted into osseo-cartilaginous arches. From the convex surface of these, a series of lamillæ arise, which affect a pectinated disposition, and while these amplifications are continuing in the branchial appendages, corresponding changes in the vascular arrangement of the parts are also observable; the four aortic arches, running along each branchial arch, become of much larger caliber, and from their convexity give off an artery for each lamellæ, terminating in a recurrent vein, thus forming a series of vascular loops, the office of which is to furnish a larger surface for the aeration of blood.

Such are the operations which realize the future branchiæ or gills of the fish. What now becomes of the corresponding arches in the human embryo?

In it, the separated elements of the mouth combine so as to construct the upper and lower jaws: the "*bourgeons incisives*" or what may be termed the incisive gemmæ coalesce on the messial line to form part of the upper jaw, while the first visceral arch produces the remainder with the inferior maxilla and the ossicula auditûs; but the three branchial arches, properly speaking, instead of acquiring a degree of complication, such as we observed in the fish, suffer a notable reduction of size; indeed the two anterior becoming atrophied eventually disappear, as well as the aortic divisions accompanying them, while the *blastema* of the third branchial arch, uniting with its congener of the opposite side, degenerates into a ligamento-osseous loop, extending from one side to the other of the neck, and, still attached to the visceral plates which go to form the sides of the face, ultimately produces the *processus styloideus*, *ligamentum stylo hyoideum* and *os hyoides*.

We now recognize in the os hyoides a metamorphosed gill of a fish.

Studied in this manner, this beautiful succession of phenomena enables us to detect those modified relics of embryonic structure which, becoming in the adult subservient to other purposes, present no claim of analogy to parts in other animals with which they once were identical. So that we here arrive at deductions as logical as they are perfectly independent of any other channel of inquiry. Such should be the character of every anatomical analogy, for, as Geoffroy St. Hillaire justly remarks, true comparisons do not consist in the grouping together of organs, which, in different animals may deviate in form, function and even in structure; but rather in the study of the constituent materials which subsequently produce them.

Another and interesting phase of this science is its practical bearing on pathological anatomy, as most of those anomalies we are wont to regard as caprices of nature may here receive a rigorous interpretation. To illustrate which, we may briefly observe that: by an arrest of development should the incisive gemmæ not unite with the first visceral arches; or the funiculus umbilicus close before the ductus omphalo-mesentericus, becoming impervious, is entirely separated from the intestinal loop; or again, should the lamellæ abdominales unite before the urachus be cut off from the allantois, we may have successively produced either: congenital hare-lip; umbilical hernia; or that unfortunate calamity in which the bladder opens above the symphysis pubis occasioning a congenital urinary fistula.*

* Ascherson, in his Diss. de fistulis congenitis colli, mentions an arrest of development in the branchial arches of the human subject which produced a congenital fistule in the neck.

Before such examples then it must be inferred, and my sanguine expectations encourage the belief, that Organogeny will furnish to the pathologist much light, but to the comparative anatomist the criterion of all future zoological inquiries.

These remarks, already protracted to an unusual length, should perhaps end here; but we would consider our plan defective were we to omit recognizing the greatest achievement which this science has effected. A motive of interest possibly induces me to enter upon these further considerations, as in my researches on the evolution of the ovum in some of the mammalia, I have kept this feature always in view; and though it be not my intention to anticipate the contents of a forthcoming publication, we will dwell with pleasing satisfaction on a subject which is now the theme of European debate. We allude to the histological theories of development.

Pursuing the train of thought which determined the foregoing facts, we may almost anticipate the result which further inquiries have attained.

When the morphological conditions of embryonic life were ascertained, the very law which they established involved an inference which in its turn has disclosed the most remarkable phenomenon hitherto observed, inasmuch as it has given the physiologist the key of his science with which he may lock up the apparent unconnected operations of vitality under one great principle, or open to view that law which reveals their mutual dependency upon each other. Müller observes that physiology had progressed to a surprising extent by the concurrent labors of many, but states that the fundamental principle was yet entirely wanting upon which these extended and finished researches should rest, and with this physiologist we regard a discovery of this peculiar kind as of more general importance to the study of physiology than any hitherto made.

The parallelism in the transitory stages of various embryos was such, that the common origin, which once established, served to detect them, was no longer considered sufficient to explain them. That all beings originated from an ovum, and that this was of seeming identity through the entire animal series, led to deductions the full import of which we have carefully examined, but that nature, with different ends in view, should systematically pursue a parallelism in her operations of striking sameness, was a phenomenon that could not but excite curiosity, and it was imagined that the formative process of development was possibly the same throughout the animal kingdom. To Schwann appertains the discovery which confirmed this. He clearly demonstrated the primitive trace of animal organization to be a *cell;* basing thereon, 1. A complete theory of development; 2. A law of histogenesis or mode of formation of the cell. Our

previous knowledge of such an operation among vegetables at once combined these two vast kingdoms—animal and vegetable, under a sort of unity of composition, which was most appropriate in explaining the similarity of function and structure observable in beings occupying their confines, and which occasions such contrariety of sentiment in determining the respective provinces to which they belong. A knowledge of these facts has become so essential as to induce us to give a lucid exposition of them.

The French will be found here to have made the first steps, and these were furnished us by the vegetable physiologist Duhamel.

Among many experiments which this observer instituted upon plants, one in particular was remarkably curious with reference to its signification; it consisted in inverting a tree, in such a manner, that its branches were introduced in and buried by the earth, whilst the roots stood exposed in the air; the former shooting through the earth were changed into the roots, and the roots themselves expanding into the atmosphere became the branches and altered their functions. The inquiry which such a result solicited was directed to the structural peculiarities of the parts which could so readily supply the offices of one another, when it was observed that they, as well as the entire plant were composed of a series of cells. When the vegetable was recognized as an aggregate of cells, each of which presented not only an element of the plant, but the plant itself, it was easy to conceive an explanation of the phenomenon. For, indeed, the being was not to be viewed as a single being, but as a multitude of beings—a multitude of cells, whose mutual dependency being only recognized in the concrete—in their united state; only constituting an essential part of the whole while removed from those conditions necessary to reveal their individuality, were found endowed with a reproductive power, (in circumstances favorable for such manifestations,) which could reproduce the entire organism of which they were once a part. This structure, exposing the general principle of vegetation, has furnished to the science of phytology what it since disclosed to the animal physiologist—the fundamental principle of vital operations—a cell. But the next examination was the formation of the cell itself, and in this research M. de Mirbel among the French, and Schleiden among the Germans, have become particularly distinguished. The former in excising a part of a plant, observed, between the utricular arrangement, the presence of a liquid which was known to exist, but had received no exact office in the economy of the plant. To this fluid, turning his attention, he finally remarked a number of organic molecules, apparently the effect of coagulation or a concentration of the particles of this amorphous fluid,

in which there had previously existed no sign of structure. Within the centre of these corpuscules a small cavity soon appeared, which at first very small, continued to enlarge at the expense of the substance of the body, without increasing its bulk, until the coagulable matter more and more attenuated, enveloped the cavity on all sides, producing a closed vesicle which was the cell.

Such was the *modus operandi* by which matter became invested in the simplest form of individuality. Schwann detecting a similar structure in the formation of animal tissues, produced a theory of development which it is foreign to my plan to examine; it will be sufficient to state, that by it the various textures of the body are supposed to exist in modified conditions of the primitive cell—the origin of them all: thus, a number of cells may become enlarged and elongated, and so combine as to form muscular fasciculi; or their parietes and cavities may so coalesce as to constitute tubes, and in this manner form the vascular apparatus. These views, however correct, demand further research to perfectly establish them; but what we will here consider, the more particularly as it is not very clearly exposed in the writings of Schwann, is the mode of formation of the cell according to this author.

Schwann, examining the *chorda dorsalis* in the embryo, the cellular nature of which had already been announced by Müller, described the formation of the cell here and in cartilages by a process which he applied as the law regulating its existence in every other development. In that homogeneous formative mass which he termed "*cytoblastema*," which was to evolve the future structures in all their complexities, he observed molecules of matter more like mucous than organic corpuscules, though they sometimes assumed a granular aspect. These particles, or "nucleoli," as they are termed, were observed to exert an attractive influence upon the surrounding liquid, causing a condensation of its substance around them, in such a manner, as to encompass each nucleolus in a delicate pellicle, which, distending by the endosmosis of the ambient liquid, acquired the form of a transparent vesicle, in which the nucleolus was still visible. From these vesicles, as from a seed, the future cell was ultimately to spring, and therefore considered the germ of the cell, received the name of "*cytoblasts*," or nuclei. A further deposite of coagulable substance afterwards invested greater part of the surface of the nucleus, thus formed, and by its condensation, was also converted into a transparent membrane. This membrane rose off from the surface of the nucleus, which it but partially covered, so as to resemble the segment of a greater sphere than that represented by the nucleus. By a continued deposition of matter, and accumulation of fluid between it and the nucleus, the

rising vesicle increased in size without further encroaching upon its surface, until the nucleus evolved a perfect cell in whose parietes it,—the nucleus,—was enclosed.

From this rapid sketch, it is obvious that this elementary structure of animal development passes through four stages: 1. A structureless formative fluid—"*cytoblastema :*" 2. A nucleolus: 3. A cytoblast or nucleus: 4. The perfect cell. It is equally evident that while the nucleoli or molecules of Brown are pre-existent to any organic process, the cytoblast and cell are of subsequent formation; while, again, the mode of their realization is different. For the cytoblast is the immediate effect of a concentration of fluid around the nucleolus, which either disappears after the birth of the nucleus, or bears but a slight relation to the size of that body, which, so to speak, acquires its natural dimensions at once in virtue of the very mode of its formation. But no accumulation of matter entirely surrounding the cytoblast is recognizable in the production of the cell; on the contrary, it is only from a limited portion of its surface that the cell originates, by a gradual augmentation, which infers that the size of the cell, in relation to the nucleus, is in direct ratio to the age of the former; the younger the cell, the smaller its size in comparison to the nucleus.

These several remarks consonant with the theory of Schwann, should have their general application in the history of development; and moreover, we should consider the marked difference by which nature, according to these views, accomplishes the same end in the two kingdoms. In the vegetable the process is one; in the animal it is essentially another.

Now while M. de Mirbel inclines to the belief that what he has so clearly seen and described may not be the only means used in the construction of the vegetable cell, I myself am disposed to question the universal tenability of Schwann's theory. That such a process obtains in certain tissues—cartilages, for example, is evident; but that every cellular evolution is accompanied by the precise and uniform steps which he has advanced, I am not afraid to deny.

In confining my attention to the first birth of cells in the impregnated ova of rabbits, I have been led to entertain great misgivings on this subject. I am aware that I am in opposition here to an observer from whose writings every embryologist has received much light, and from whose private correspondence I must acknowledge much instruction; I refer to Dr. Martin Barry. In his extensive researches, (the most regularly continued series which have yet been made,) he has seen an exact confirmation of the opinions of Schwann, as from the very macula germinativa to the fabrication of the blastoderma, a regular evolution of cells from nucleoli and nuclei is described. I have in all my

observations been disposed to regard Dr. Barry's opinion as almost the offspring of an imagination which endeavoring to generalize a principle with uncertain facts, has sought to establish as true what they appeared only to infer. I have on some hundred impregnated ova found at different distances in the tubes, and even in the infundibular extremity 9 hours post coitum, carefully watched the first manifestations of cell formation, and feel assured that the process is totally different from that announced by Schwann or Dr. Barry. Never have I been able to detect a nucleolus becoming by regular gradations surrounded first by its cytoblast, then by its cell; the operation seemed far more rapid than this.

In the ovum which I had the good fortune to discover nine hours after fecundation, bathed with spermatozoa, the granular vitellus had only become condensed so as no longer entirely to fill the cavity of the vitellary membrane, and its granular nature was very obvious; but no cell was discernible, though granules appeared agglomerated more thickly in some than in other spots. But that these were no commencement of nucleoli or nuclei, was clearly established in a number of ova which I examined from 11 to 10 hours after fecundation. For in those in which there was but an incipient division of the vitellus into two, (the stage immediately following that of 9 to 10 hours), I already discovered two cells perfectly formed, appearing as transparent central vesicles with a nucleus, while the agglomerated granules were still visible over the surface of the vitellus, though they should also have formed as many cells, had they really been nuclei. Consequently, at a period of the evolution of the ovum immediately succeeding that in which no trace of a cell was to be seen, two are already visible, and that even before the first division of the vitellus is completely effected, yet they have appeared without the possibility of tracing them to any such regular process as described by Schwann.

We may find a repetition of this mode of generation of cells in following the dichotomous segmentation of the vitellus until it had reached that multiple state of division which Dr. Barry terms the "mulberry body." In the centre of each segment of the yolk, but a single cell comes into view, as it were, by a rarefaction of the centre of the sphere, appearing at once as a vesicle or cell. So that where the vitellus has become divided into two or four segments, we have produced two or four cells: which fact allows of our examining an ovum whose segmentation presenting the degree beyond that of the last which we might have had under notice, affords us the certitude of no possible intervening stage of development; when, nevertheless, we invariably discover the already formed cell, admitting per-

haps of but one further perfection, which is: an enlargement, and a more accurately determined contour.

Such is the process even unto the most extreme divisions and subdivisions of the vitellus; when each minute organic sphere, being then only large enough to contain the cell which it is to produce, is itself transformed into that cell; and these coalescing in the order of a tesselated pavement, ultimately produce the blastoderma.

This is not the place to discuss the nature of the facts that have led me on to the subject of histogenesis to an opinion different from Schwann, Coste, Bischoff, Bergmann, Reichert.

These views are here only traced out, as it were; to what extent they liken the process to that transpiring among vegetables will be detailed hereafter.

We may conclude, however, from what has been said, that, let the process be what it may, the production of a cell is the first manifestation of vitality discoverable in an unorganized fluid; which fact, (though it does not arrogate the pretension of having divested the mystery of life of that obscurity in which it is involved), must at all events be regarded as pregnant with deep instruction to the physiologist, and replete with interest to the general inquirer. We see in this cell the simplest form of life unfolding the intricate complexities of more perfect developments, whose very growth and reproduction is but a repetition of the act to which they owe their own existence; for if, like some, we regard the ovum to be itself a cell; recognizing in the germinal spot—a nucleolus; in the germinal vesicle—a nucleus; and in the vitellary membrane—an envelop to the cell, we may, in its elimination from the ovary itself a mass of cells, retrace a curious similarity to the phenomenon of nutrition; or acknowledging this separation of a cell from an aggregate of cells, compare the reproductive act in man to a modified process of that generation by fissiparity observed in the inferior classes and in plants; where the being, as a compound organism of individual organisms, each multiples of the germ from whence it sprung, possesses "actually" in diffusion the reproductive principle; the only difference being, that this diffusion, found for example in plants (and in the hydra among animals) to be universal, is in the higher compound systems, concentrated, as it were, in one part—the ovaries.

In conclusion, it is not incongruous to reason to observe, that in investigations of such material nature, even before the *commonness* of origin, and the similarity of Nature's operations through the animal, nay, even the vegetable kingdoms, there is yet nothing which entitles us to infer life to be the sole effect of material forces, or to consider these observations as involving a doctrine pernicious to the very progress of the science of life. This un-

deviating operation towards the attainment of totally different ends; the result which it gives rise to,—of transitions through regular stages, the permanent conditions of other existences, all imply an ordinative principle,—a sentient, intelligent force, directing the progress of an unintelligible, (and in that sense) impotent property, which compels matter to terminate,—now at this,—now at that end; and the ovum to accomplish the development either of a fish or an amphibia, a bird or a man. The doctrine of chances is here in no requisition. The materialist is denied the premise he wishes to assume; for life, which he regards as the effect of those forces inherent to matter, exists, so to speak, in the germ before those effects are even in play; in other words, the germ possesses "potentially," the specific form of the being, in virtue of a creative and intelligent power which is to realize it,—but this force cannot be inherent to matter, for the reality would remain accomplished,—hence it is external,—but if external is also independent of matter,—whence then its power over matter? unless in essence an ordinative principle, superior to the active powers it gives rise to,—infinite therefore in wisdom,—ordaining all things,—in essence a God. Before these facts the materialist must shrink to his natural dimensions, let him not extend beyond his sphere, where, it is true, he may explain the modality of certain vital phenomena, but can in nowise reveal their concordant relations towards a determinate end.