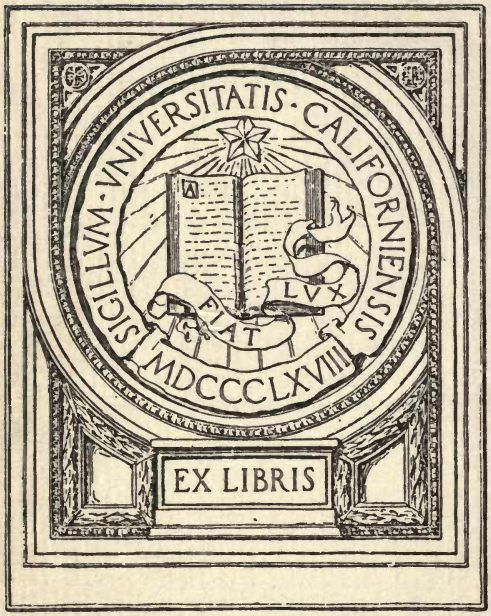

THE RECAPITULATION THEORY AND HUMAN INFANCY

BY

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SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY, IN THE FACULTY OF PHILOSOPHY, COLUMBIA UNIVERSITY

PUBLISHED BY

Teachers College, Columbia University

NEW YORK CITY

1914

ACKNOWLEDGMENTS

This paper was presented to the Division of Philosophy of Columbia University as a doctoral dissertation. It was written under the direction of Professor John Angus MacVannel, of Teachers College, to whom is made grateful acknowledgment of kind encouragement and valued suggestions. The writer welcomes the opportunity of expressing his sense of an indebtedness of a fundamental character to the teachings and generosity of Professor John Dewey. Thanks are due also to Professor J. Perrin Smith, of the Department of Geology in Stanford Unversity, for his courtesy in reading the manuscript.

P. E. D.

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THE RECAPITULATION THEORY AND HUMAN INFANCY

CHAPTER I

INTRODUCTION

The strong interest in its biological and anthropological setting which attended the beginnings of the systematic study of childhood in this country has somewhat abated. Among other things practical considerations have drawn attention away to urgent matters of institutional management, while newer and more exact methods, borrowed from the nearby sciences, have been enthusiastically resorted to in the hope of a more immediately serviceable knowledge of childhood than any search into its history could reasonably be expected to yield.

Doubtless this change of emphasis is a wholesome one. Education has still to find its most advantageous methods, if indeed it has not yet to delimit its field. It is only right, then, that all the methods which have done excellent work in the sciences should be tested and evaluated for their usefulness in its service. It would be a mistake, however, to regard this departure from biology and anthropology as a final one, and to conclude that education has nothing to learn from these sources. Man's animal heritage is too intimate a part of him, and his historical career too significant of his make-up, ever to justify a neglect of these things on the part of those who propose to mould his present condition and in some measure to direct his future.

It may be, too, that some sense of disappointment has figured in this willingness of students of childhood to turn in new directions. Fruitful as it was in suggestion, the older genetic line of approach could not, in the nature of the case, lead to

a scientific basis for a practical educational program. This could come only with the aid of an exact and faithful interpretation of childhood as it exists in modern societies. Educational schemes based upon historical inferences were therefore necessarily precarious and could easily be found unsound when fairly tested. More especially has the older genetic method of study suffered from the discredit into which some of its guiding principles have fallen. One of these principles was embodied in the theory of recapitulation, the idea that the child in its development rehearses the history of its ancestry, and that in consequence its nature may be inferred from the probable course of human evolution. Taken bodily from embryology, this idea was projected upon the field of mental genesis, where it became a commonplace. More recently disquieting rumors from the source of its origin have been heard to the effect that the principle was formulated without sufficient warrant, and that it cannot be depended upon even as a helpful hypothesis. Its prestige has in consequence been seriously damaged and there is plainly evident great uncertainty as to the degree of truth it may contain.

This uncertainty with regard to a principle with important implications for the theory of infancy and psychogenesis, is hardly excusable or necessary. For recourse to the science from which the principle was derived is open, and no obvious reason exists why its real standing there should not be known. If education is to be spared the humiliation which comes inevitably from building on the sand, it must earnestly endeavor solidly to ground its doctrine. Especially is this true when this doctrine is drawn from the pure sciences, for a thorough knowledge of these on the part of outsiders is not easy of attainment and a little knowledge is a dangerous thing. Moreover, the position of education is peculiarly difficult, for as an art its practice is not only dependent upon science as such; more than one science is implicated. Education is none the less in duty bound either to acquaint itself with the true value of these borrowed principles or to leave them alone.

This paper represents an effort to discover something of the status of recapitulation in biology and to note its implications for the period of infancy. It makes no pretensions to scholarly exhaustiveness. Its justification is the lack of any accessible

account of the history and present position of the idea to which students of psychogenesis may refer, and its one merit is that it stands for a conscientious attempt to understand and report some of the more obvious aspects of the discussion. At some future time someone with the requisite knowledge of biology, anthropology, and psychology will do full justice to the topic and supply us with an authoritative account of the matter. Meanwhile we can at least clear away the superficial obstacles and prepare ourselves for the more complete statement.

No one can justly object to a desire on the part of students of childhood to know its biological history and its nature in consequence. It is at least a legitimate object of curiosity. More than this, no situation ever failed to become more intelligible, and so more amenable, in the perspective yielded by its history. On the side of possible cultural homologies in infancy and childhood there is the chance of a more direct usefulness. Some years ago Professor Dewey inquired pointedly as to what good could come from a knowledge of the historical genetic order, when an argument from it directly to the proper treatment of growth is not warranted. And it must be admitted that there are positive limits to the use of principles derived from this source. Education must be based primarily upon a knowledge of the ontogenetic order itself. But it appears already that the ontogenetic order is not easy of discovery. Although childish and youthful performances can be objectively described and in many cases measured, the true inward significance of these performances is determined with the greatest difficulty, because it is ultimately a matter of interpretation. Is it not possible, then, that a knowledge of historical processes may have something to offer, not as principles upon which action shall be based, but as cues and hypotheses with which to approach the exceedingly intricate phenomena of individual psychogenesis? Historical processes expressed themselves slowly. They were made with difficulty and became registered step by step in objective products which lie open the world over for sympathetic inspection. If a warrant can be found in general terms for some degree of correspondence between individual psychogenesis and social or historical development, it seems not impossible that a close study of the latter order may yield suggestions of real value with which to approach

the difficulties of the first. At least the possibility should not be denied in advance of a fair trial. Obviously the resources of child psychology would be immensely amplified if they might include those of comparative psychology and ethnology. This hope may stand as some justification for the present effort to clear away some part of the obscurity which gathers about the relations of the child and the race. If this should be insufficient there still remains the interest which attaches to a knowledge of the net result of one phase of a significant pioneer movement in the study of childhood.

CHAPTER II

THE RECAPITULATION THEORY IN BIOLOGY: A SKETCH OF ITS HISTORY

1. Other Names for the Theory.

"This has been named by Hatschek the 'morphogenetic theory,' by Hyatt the 'law of morphogenesis,' by Haeckel the 'biogenetic law,' by Cope the 'doctrine of parallelism,' and by Morgan the 'repetition theory.' Sometimes it has been alluded to as the 'law of von Baer,' but incorrectly, for von Baer was its severest critic."[1]

2. Anticipations of the Recapitulation Idea.

The idea that embryos of higher forms pass through the adult stages of the lower animals is a very old one and no one name is associated with its origin. The first clear reference to it appeared at the end of the eighteenth and the beginning of the nineteenth centuries. The system of classification then in vogue was that of Linnaeus, which placed the various groups one above the other in a single scale or series from the lowest to the highest. In this scale the worms held the lowest rank, and then in order, the insects, fishes, amphibia, birds, mammals. The allusions to the animal series in the extracts which follow are therefore to this uniserial system.

In these early expressions embryonic or developmental stages were naturally found to resemble the mature forms of *existing* lower animals, evolution as yet being a conception of a very few prophetic minds. One of the earliest of these expressions, however, was that of such a prophetic mind. Lorenzo Oken, a speculative evolutionist and a popularizer of the science of the time, wrote in 1805,

"Each animal 'metamorphoses itself' through all animal forms. The frog appears first under the form of a mollusk in order to pass from this stage to a higher one. The tadpole

[1] Montgomery, Analysis of Racial Descent in Animals, 1906, p. 177.

stage is a true snail; it has gills which hang free at the sides of the body as is the case in *Unio pictorum.* It has even a byssus, as in Mytilus, in order to cling to the grass. The tail is nothing else than the foot of the snail. The metamorphosis of an insect is a repetition of the whole class, scolopendra, oniscus, julus, spider, crab."[2]

Later, in 1883, Oken wrote, in reference to the same matter,

"There is no doubt that we have here a striking resemblance, and one that justifies us in thinking that the development in the ovum is merely a repetition of the story of the creation of the animal groups."[3]

Here, plainly enough, is a statement in crude form of the idea of recapitulation which was to have clear definition with the advent of the doctrine of descent, and which was destined to play so important a role in the history of that doctrine.

The other early references to be noted make comparisons of development with the *rank of existing* animals. Thus, Walther, in 1808, said,

"The human foetus passes through its metamorphosis in the cavity of the uterus in such a way that it repeats all classes of animals, but, remaining permanently in none, develops more and more into the innate human form. First the embryo has the form of a worm. It reaches the insect stage just before its metamorphosis. The origin of the liver, the appearance of the different secretions, etc., show clearly an advance from the class of the worm into that of the mollusk."[4]

The embryologist Meckel, in 1808, 1811, and 1821, gave greater definiteness to these comparisons:

"He held that the embryo of higher forms, before reaching its complete development, passes through many stages that correspond to those at which the lower animals appeared to be checked through their whole life. In fact the embryos of higher animals, the mammals, and especially man, correspond in the form of their organs, in their number, position, and proportionate size, to those of the animals standing below them. The skin is at first, and for a considerable period of embryonic life, soft, smooth, hairless, as in the zoophytes, medusae, many worms, mollusks, fishes, and even in the lower amphibians."[5]

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[2] Quoted by Morgan, Evolution and Adaptation, 1903, p. 59.

[3] Quoted by Bolsche, Haeckel, His Life and Works, translated by J. McCabe, p. 227.

[4] Quoted by Morgan, *loc. cit.*, p. 59.

[5] *Ibid.*

Many other instances were given by Meckel, some fantastic and absurd, others still to be found in the text-books on embryology. It was this conception that met with the opposition of von Baer, writing in 1828. Von Baer refers to

"The accepted idea, that the embryo in higher animals passes through the permanent forms of the lower. . . . This idea, which was born in a time when, besides Malpighi and Wolff, no connected investigations had been undertaken upon the early periods of the embryology of any animal, and was especially carried out by a man who possessed perhaps the most knowledge upon the embryology of the higher organisms, could not help but arouse great support, because it was based upon a multitude of special proofs. . . . Some supporters were so zealous that they spoke no longer of similarity, but of complete identity, and acted as though the correspondence were proven universally and in each particular. We read a short time ago, in a paper upon the blood circulation of the embryo, that the human embryo does not omit a single animal form."[6]

"That," remarks Montgomery, "must indeed have been the luscious Springtime of the theory!"

Von Baer urged against the prevailing view of recapitulation

"(1) that no adult animal ever has a yolk sac, or (2) is surrounded by embryonic fluids; (3) that it is not the case that an embryo of a higher animal in each embryonic stage corresponds in every point with an adult of a lower species, or (4) that in the ontogeny of a lower form structural relations do not occur which are found in the adult of a higher; (5) that it is equally not the case that parts which are characteristic of only the highest forms appear latest in the ontogeny."[7]

3. The "Theory of Types."

Recapitulation in its next phase became intimately involved in that scientific theory of the natural world which preceded the evolutionary or Darwinian conception now current, and which stubbornly contested the claims of the latter until overwhelmed by an incontrovertible array of fact. It is known as the "theory of types," and is associated especially with the names of Georges Cuvier, Louis Agassiz, Johannes Mueller, and Richard Owen. The conception has been analyzed and traced to various sources by Merz in his "History of European

[6] Quoted by Montgomery, *loc. cit.*, p. 177.
[7] *Ibid*, p. 176.

Thought in the Nineteenth Century."[8] Only its more general character need be noted here. It was, in brief, the logical culmination of the progress of descriptive science following the Revival of Learning. From independent beginnings, embryology and physiology, comparative anatomy, geology and geography, and botany, had by degrees and in unrelated ways accumulated a vast amount of unorganized knowledge which by the first quarter of the nineteenth century invited a general and unified formulation. The outcome was a conception constituted in part of inductions and analogies derived from the observation of nature, in part of the literal biblical interpretation of the overshadowing Puritanism of the time.[9]

In this theory the plan of arranging the animal groups in a single scale or series gave way to a system in which the species were regarded as modifications of four main "types" or "embranchements," independent and equivalent "plans of structure," namely, the vertebrate, articulate, radiate, and molluscan. The species representing these great types were "fixed," in the sense that they had been separately created as they were found to be, and were in no wise genetically related. The study of fossils and geological formations led to the additional idea that species had suffered extinction coincident with colossal revolutions or catastrophes in the life of the planet, succeeded by the creation of new types. Only by the intervention of such episodes could be explained the succession of life forms so unequivocally indicated in these phenomena.

4. Von Baer's Law: "The Law of Embryonic Resemblance."

Von Baer was identified with the theory of types; in fact he seems to have had some share in its formulation, although he did not go to the extremes of its chief exponents. His views of the significance of embryonic development are therefore to be understood with this theory as a background. For von Baer did not merely criticize the prevailing ideas of Meckel and others on this subject. A distinguished embryologist, he held original and striking ideas of his own, which had a large place in the subsequent history of the discussion. Von Baer's position is represented by the following laws, which he formulated:

[8] Vol. II, Chap. IX.
[9] Poulton, Essays on Evolution, pp. 56, 57.

"(1) That the general of a large animal group expresses itself earlier in the embryo than the special. (2) Out of the most general of the structural relations evolves the less general, and so forth until finally the most special appears. (3) Each embryo of a particular animal form instead of passing through the other particular forms, separates itself rather from them. (4) In reality accordingly the embryo of a higher form is never like to another animal form, but only to its embryo."[10]

Morgan illustrates these laws as follows:

"For example two similar species of pigeons will follow the same method of development up to almost the last stage of their formation. The embryos of these two forms will be practically identical until each produces the special characters of its own species. On the other hand two animals belonging to different families of the same phylum will have only the earlier stages in common. Thus, a bird and a mammal will have the first stages similar, or identical, and then diverge, the mammal adding the higher characters of its group. The resemblance is between corresponding embryonic stages and not between the embryo of the mammal and the adult form of a lower group.

"Von Baer was also careful to compare embryos of the same phylum with each other, and states explicitly that there are no grounds for comparison between embryos of different groups. . . . In one place von Baer raises the question whether the egg may not be a form common to all the phyla."[11]

The phyla alluded to are, of course, the four great groups or types. It is important to remember that von Baer had reference in his statements to likenesses among existing animals, and not to ancestral relationships. Von Baer did not accept evolution although the issue between the two theories had been well drawn before his death. Later Herbert Spencer pointed out that a thoroughgoing application of von Baer's law in filial and ancestral relationships implied the recapitulation of Oken, that is, the idea that the embryogeny "repeated the story of the creation of the animal groups."

5. *The Correspondence Stated as between Developmental Stages of Existing Animals and the Succession of Adult Forms of Extinct Representatives. Agassiz.*

Von Baer's significant contribution to the discussion did not exert an immediate influence. It was Louis Agassiz, a pupil of Cuvier, the principal originator of the type theory, who made

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[11] *Loc. cit.*, p. 61.

recapitulation an integral element in this theory and gave it its new form. Early in his life Agassiz entered upon elaborate studies of living and fossil fishes and so came upon resemblances between developmental phases of living animals and the adult forms of their extinct representatives. As his interest broadened to include the systematic classification of the whole animal world, Agassiz relied more and more upon the facts of embryology to make good the deficiencies of fossil remains and to prevent the confusion, inevitable as he believed, from an examination of anatomical differences alone. In 1857 he wrote, "I satisfied myself long ago that embryology furnishes the most trustworthy standard to determine the relative rank among animals."

In the system ultimately evolved by Agassiz, descriptive of what he believed to be the natural order, there were four great parallelisms, or systems of relationship. These were (1) a parallelism between the geological succession of animals and their relative standing or structural gradation; (2) a parallelism between the geological succession of animals and the individual development of their living representatives; (3) a parallelism between the relative rank or gradation of animals and their individual development; and (4) these several series were again related to geographical distribution. Thus

"the phenomena of animal life correspond to one another, whether we compare their rank as determined by structural complication with the phases of their growth, or with their succession in past geological ages; whether we compare this succession with their embryonic growth, or all these different relations with each other and with the geographical distribution of animals upon earth. The same series everywhere!"[12]

This interlocking system of relationship constituted the groundwork of the "plan of creation" Agassiz's "Essay on Classification" was meant to delineate, a plan very satisfying to his own religious sentiments, if indeed it was not inspired by them. "Shall we," he exclaims, "by any false argumentation, allow ourselves to deny the intervention of a Supreme Intellect in calling into existence combinations in nature by the side of which all human conceptions are child's play?"[13]

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[12] Essay on Classification, 1857, p. 196.
[13] *Ibid.*, p. 197.

It was the second parallelism, that between the succession in geological time and the embryonic stages of living representatives, that constituted the new phase in the history of recapitulation. Of this he said more particularly,

"These relations, now they are satisfactorily known, may also be considered as exemplifying, as it were, in the diversity of animals of an earlier period, the pattern upon which the phases of the development of other animals of a later period were to be established. They appear now, like a prophecy in those earlier times, of an order of things not possible with the earlier combinations then prevailing in the animal kingdom, but exhibiting in a later period, in a striking manner, the antecedent considerations of every step in the gradation of animals."[14]

There is here suggested Agassiz's well known concept of "prophetic types," the facts for which, as well as for his "synthetic" and "progressive" types, were so significant to other minds of a genetic relationship he himself refused to acknowledge.

6. Embryology and Darwinism.

This correspondence between embryonic stages and the geological succession of animal forms was destined to play an important part with the advent of Darwinism ("Origin of Species," 1859). It will be well to indicate at once the three allied uses to which the facts of embryology were put in the development of this theory. They became, in the first place, one main support to the doctrine of descent itself. This was naturally the value attached to them chiefly by Darwin. Once the doctrine was accepted, embryology was employed with all degrees of assurance to determine the affinities of living animals in the interests of a classification based upon genetic relationship. Fritz Müller was one of the first of a long line of students to demonstrate their usefulness from this viewpoint. Finally, as this classification became elaborated, it made possible the tracing back of genealogies, phylogenies, or racial histories, and this was introduced systematically by Haeckel.

7. Darwin.

By the time of the sixth edition of the "Origin of Species" in 1872, the two applications of the facts of embryology just mentioned had been made and had received the sympathetic notice

[14] Essay on Classification, 1857, p. 156.

of Darwin. The contribution of Fritz Müller to the classification of the Crustacea, largely by the aid of embryology, had been of particular interest to him, and Haeckel's work with phylogenies was alluded to with approval.[15]

Darwin's treatment of the facts under discussion is found in Chapter XIV of the sixth edition where he deals with the mutual affinities of organic beings. Referring to the efforts of the "special creationists" to arrange a "natural system" in accordance with the divine plan, he urges that such a plan is meaningless unless it relates to time and place and has a specific content, and that all the rules, aids, and difficulties in the then current efforts at classification are well explained by a view of a natural system founded on descent with modification. In support of this contention he proceeds to submit to scrutiny the several kinds of recognized affinities among animals, those of embryology among them. After a citation of facts, including some of von Baer and a direct reference to his law of embryonic resemblance, Darwin asks,

"How then can we explain these several facts in embryology, —namely, the very general, though not universal, difference in structure between the embryo and the adult;—the various parts in the same individual embryo, which ultimately become very unlike and serve for diverse purposes, being at an early period of growth alike;—the common, but not invariable, resemblance between the embryos or larvae of the most distinct species in the same class;—the embryo often retaining whilst within the egg or womb, structures which are of no service to it, either at that or at a later period of life; on the other hand larvae, which have to provide for their own wants, being perfectly adapted to the surrounding conditions;—and lastly the fact of certain larvae standing higher in the scale of organization than the mature animal into which they are developed?"

The explanation is contained in the two principles, viz., " . . . that slight variations generally appear at a not very early period of life and are inherited at a corresponding not early period." Darwin's illustration helps to make his meaning plain,

"Now let us apply these two principles to species in a state of nature. Let us take a group of birds, descended from some ancient form and modified through natural selection for differ-

[15] Origin of Species, American ed., p. 231.

ent habits. Then, from the many slight successive variations having supervened in the several species at a not early age, and having been inherited at a corresponding age, the young will have been but little modified, and they will still resemble each other much more closely than do the adults,—just as we have seen with the breeds of pigeons."[16]

For Darwin did not fail to verify his statements by carefully measuring young and old dogs, horses, and pigeons. Accordingly,

"It is highly probable that with many animals the embryonic or larval stages show us, more or less completely, the condition of the progenitor of the whole group in its adult state."

Furthermore, "we can see why ancient and extinct forms so often resemble in their adult state the embryos of existing species of the same class. Agassiz believes this to be a universal law of nature; and we may hope hereafter to see the law proved true. It can, however, be proved true only in those cases in which the ancient state of the progenitor of the group has not been wholly obliterated, either by successive variations having supervened at a very early period of growth, or by such variations having been inherited at an earlier stage than that at which they first appeared. It should also be borne in mind that the law may be true, but yet, owing to the geological record not extending far enough back in time, may remain for a long period, or forever, incapable of demonstration. The law will not strictly hold good in those cases in which an ancient form became adapted in its larval state to some special line of life, and transmitted the same larval state to a whole group of descendants; for such larvae will not resemble any still more ancient form in its adult state."[17]

These passages have a peculiar interest in the light of the later history of the discussion. There is every intention evident of doing full justice to the complexity of the facts and a plain acknowledgment of a variety of cases. Nevertheless, one detects an unmistakable leaning in the direction of a general statement favorable to recapitulation, and in the allusion to Agassiz an expressed sympathy for a "universal law of nature." With the great authority of Darwin offering this much justification, one cannot be surprised if in the hands of less careful students the facts should be found to warrant a much more sweeping statement.

[16] Origion of Species, American ed., pp. 245, 247, 249.
[17] *Ibid.*, pp. 252, 254.

8. The Developmental-Ancestral Correspondence Clearly Enunciated: Fritz Müller.

It has been noted that Darwin had profited by the contribution to his theory made by Müller in his book, "Für Darwin," published in 1864. Torn between the claims of the rival theories, Müller determined rigidly to apply the principles of Darwin to one group, the Crustacea, in order to discover whether lines of descent and a genetic classification could in this manner be determined within it. In concluding his study Müller generalized upon the facts of resemblance between the developmental history of descendants and the adult state of ancestors in a more precise manner than Darwin had in his first edition. His conclusions are as follows:

"Descendants, therefore, reach a new goal, either by deviating sooner or later whilst still on the way towards the form of their parents, or by passing along this course without deviation, but then, instead of standing still, advance still further.

"In the second case the entire development of the progenitors is also passed through by the descendants, and, therefore, so far as the production of a species depends upon this second mode of progress, the historical development of the species will be mirrored in its developmental history.

"The historical record preserved in developmental history is gradually *effaced* as the development strikes into a constantly straighter course from the egg to the perfect animal, and it is frequently *sophisticated* by the struggle for existence which the free-living larvae have to undergo.

"Which of the different modes of development at present occurring in a class of animals may claim to be that approaching most nearly to the original one, is easy to judge from the above statements."[18]

9. "Ontogeny is a Short and Rapid Recapitulation of Phylogeny:" Haeckel.

In the statement of principles quoted above from Fritz Müller it will be observed that there is no disposition to weight the cases of recapitulation in very great disproportion to those of embryonic or larval deviation. Two possible courses of development are shown, recapitulation being the second. And there is little disposition, if any, to make the second class of cases the more prevalent or the more characteristic in any fundamental way.

[18] Facts and Arguments for Darwin, pp. 111, 112, 114.

It was noticed, too, that Darwin hesitated to formulate a generalization distinctly in favor of recapitulation, whatever may have been his inclination. It remained for Haeckel to raise Müller's second class of cases into very great prominence at the expense of the first, to assume that this represents the more general, and indeed in some fashion a necessary order, and to throw together all the cases of the first class as mere subsidiary disturbances of the order represented by the second. Thus the "law of recapitulation" took the form in which it is best known. It is interesting to consider the consequences if by chance the emphasis had been placed the other way round. Then the "law" would have read somewhat as follows: Ontogeny records the adaptations the life history of descendants has made in its evolution and is indicative of its phylogeny in those cases only in which embryonic or larval deviation has not occurred.

Haeckel's great popularity as a writer gave his statement very wide currency, in fact, made it dominant. It has happened in consequence that the whole succeeding history of the discussion, including its application to mental growth, has turned largely upon either the possible substantiation of his "biogenetic law," or upon its possible refutation. It may be said with justice that much of the mischief that has resulted from a careless use of his formula has been due to the particular form in which the facts were thus summarized.

Haeckel was a young man beginning his career at Jena when Darwin's great book appeared. The circumstances of his training had been such as to prepare his mind for the new doctrine and he became its most ardent advocate and disseminator in Germany. Haeckel was not content to limit himself to a study of the causes of descent. At once speculative and intrepid, he carried the doctrine in every direction his system-loving mind pointed, and ultimately built a complete natural philosophy upon it. He would not demonstrate the kinships within one class only, as had Fritz Müller. Nothing less than a genealogical tree of the entire animal world became his object. Haeckel was particularly interested in the two extremes of descent concerning which Darwin had been less explicit, that of the ancestry common to the great phyla among the lowest forms, and that of man. His original investigations were consequently directed upon the lowest orders and he was able to suggest a succession of

steps by which the Metazoa had evolved from the simplest form of living matter. This he in turn derived from the inanimate. Haeckel was equally consistent in applying the doctrine of descent to mankind. The groundwork of his entire system was laid in the "Generelle Morphologie," published in 1866, his numerous later publications being practically extensions of this work.

In this book Haeckel recurs to the threefold parallelism of Agassiz between the order represented by the classification of existing animals and those of palaeontology and of individual development.[19] But in place of the mystic bond of connection between the three of Agassiz, Haeckel substitutes a "close casual nexus" derived from the theory of descent in the two factors of heredity and adaptation. This primary conception assists in the understanding of his attitude toward recapitulation, for it is the keynote to his whole system.

When one considers the situation in 1866 and the nature of his general purpose, it is not surprising that Haeckel should have reverted to this threefold parallelism. To his mind Darwin had shown conclusively the truth of the doctrine of descent with modification. Obviously the hierarchy of living forms, from the lowest one-cell condition through the several grades of complication to the highest, was a result of descent, and was at least suggestive of what the historical order had been. It would therefore correspond with the actual historical order so far as this was indicated by the succession of fossils in the earth's formations. The gradual progression through development from the ovum to the complicated adult was again suggestive of this order in its broad outlines at least. All three of these had served Darwin as foundations for his theory, and the least plausible, that of development, had received a certain warrant in fact in the writings of Darwin and Fritz Müller, besides having had a respectable history prior to the descent theory. Development, indeed, presented in the concrete the only available picture of what the idealized evolution of animals through geological time presupposed. This suggestiveness of development has often been alluded to since Haeckel, and still is, by biological students. If one is content wtih exceedingly broad

[19] ". . . die Stufenleiter des natürlichen Systems mit den parallen Stufenleitern der individuellen und der paläontologischen Entwickelung in dem engsten mechanischen Causalnexus steht." Gen. Morph. II, XIX.

outlines one may still hold with justice for the truth of this threefold parallelism.[20] Its recurrence with Haeckel was consequently the obvious thing on the part of one who desired to present a panoramic view of the natural world after the manner of Humboldt and Agassiz. The imperfections of the parallelism would naturally appear subsequent to its original formulation.

It may have been the prestige of this parallelism in his mind, together with the fact that he was for the time primarily a morphologist, as the title of his book implies, that led Haeckel to over-simplify the effects of heredity and adaptation throughout descent, and to neglect somewhat the question of what was required of these two factors to substantially support the parallelism. This had been a matter of primary concern to Darwin and Müller, as has been noted. Throughout his works the ontogenetic-phylogenetic parallelism is associated especially with the "laws" of hereditary transmission at corresponding ages and in corresponding place relations, and with that of abbreviated heredity suggested by Müller.[21] The effect of the first two was to repeat the parental order; the effect of the last was to simplify and shorten this order perhaps, but not to destroy it. This is essentially the situation in the fifth edition of the "Evolution of Man,"[22] where the symbolic representation of the two series indicates omission of ancestral stages, and some modification of them in ontogeny without obscuring their identity.

The appearance of novelty, or variation, was identified by Haeckel with adaptation, or the direct modifying effect of environment. This again would explain in part his over-emphasis of the conservative influence of heredity, for the ever-recurring changes induced by germinal variations regardless

[20] "It is indisputable, if we only consider the most general features, that the history of the development of an individual is a kind of rapid recapitulation of the slow phases of the evolution of the species and of the branch." Depéret, Transformations of the Animal World, trans. 1909, p. 254.

[21] "Der Parallelismus zwischen der phyletischen (paläontologischen) und der biontischen (individuellen) Entwickelung erklärt sich einfach mechanisch aus den Vererbungs-Gesetzen und insbesondere aus den Gesetzen der gleichzeitlichen, der gleichörtlichen und der abgekürtzen Vererbung. Alle Erscheinungen, welche die individuelle Entwiekelung begleiten, erklären sich lediglich, soweit sie nicht unmittlebares Resultat der Anpassung an neue Existenz-Bedingungen sind, aus der paläontologischen Entwickelung der Vorfahren des Individuums." Gen. Morph. II, p. 372.

[22] Trans., 1910, p. 4.

of adaptation would be eliminated at one stroke. Adaptation would effect embryonic and larval structures, as he clearly points out, but presumably its principal effect would be to extend the ontogeny in a linear way corresponding to a similar linear extension of the phylogeny through geological time. However this may be, one misses in the accounts of Haeckel the detailed consideration of the effects of heredity, variation, and adaptation in the life-histories of succeeding generations, so noticeable in the treatment of Darwin and Müller. This, perhaps, is what reasonably might have happened from a preoccupation with the parallelism he presupposed. The upshot of the matter is that Haeckel greatly overestimated the conserving force of heredity operating through descent. This renders intelligible his concluding formula: "Phylogeny is the mechanical cause of ontogeny," a true statement when the parents and immediate ancestors are considered, only true with respect to the remote ancestors in a phylogeny on the assumption that the force of heredity has been fairly constant throughout.

It would, however, be unfair to Haeckel to rest an interpretation of his biogenetic law upon his formal summaries alone. A consideration of the actual use to which the law was put in elaborating phylogenies presents a somewhat different aspect. For instance, in developing the phylogeny of man the argument invariably proceeds from a comparison of *embryonic resemblances* to a discovery of the palingenetic, or racially older, features by an elimination of the cenogenic, or more recent additions. Once these older features are determined the biogenetic law is invoked and the ancestral reference made. In the earlier stages the ancestral reference is to hypothetical ancestral adult forms, as from the gastrula to the Gastraea, or from the coelomula to the hypothetical Coelomaea, and a sequence of such forms results, in keeping with recapitulation in the ordinary sense of a chronological series. But in the later and higher stages the ancestral reference is not to specific ancestral adult characters, but to ancestors having an embryogeny with similar features. This last may be illustrated "We see," he says, "that man entirely resembles the higher Mammals, and most of all the apes, in embryonic development as well as in anatomic structure. And if we seek to understand

this ontogenetic agreement, in the light of the biogenetic law, we find that it proves clearly and necessarily the descent of man, from a series of other Mammals, and proximately from the Primates."[23] From ontogenetic resemblances a common ancestry is argued. Clearly this is not recapitulation in the strict sense. But Haeckel is applying the biogenetic law as he understands it, wherefore it must be that he means by recapitulation in this application only that an ontogeny presents in its racially older features evidence of value regarding its proximate or less remote ancestors. Haeckel's formal generalizations and their actual use thus do not appear wholly in agreement, and if the meaning of principles lies more especially in the work they do, it must be admitted that the common opinion of Haeckel's conception requires some modification. It should be noted that the notion of recapitulation conveyed by the practice just referred to brings Haeckel close to the position of some of the most radical critics of his theory.

Whatever the case may be in these particulars, the general effect of Haeckel's formal statements of the biogenetic law was to imply a sequence in embryonic development such *in general* that it was broadly descriptive of a similar sequence in phylogeny. His qualifications of the law still did not have the force of robbing the principal statement in the formula of first-rate descriptive value. Moreover his language was such as to suggest some fundamental tendency toward or necessity for recapitulation, which might be obstructed partially so as to "falsify" or "confuse" or "distort" this order. All this is declared to be misleading in its implications. Ontogeny is subject to many factors, of which those favoring recapitulation are but of equal value, or even much less than equal value, with the rest. And they are no more natural or to be expected or primary than those with which they associate.[24]

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[23] Evolution of Man, trans., 1910, p. 307.

[24] Compare this statement from Miall:

"I diverge from him [Haeckel] when he says that each animal is compelled to discover its parentage in its own development. . . . I admit no sort of necessity for the recapitulation of the events of the phylogeny in the development of the individual. . . . I am on my guard when he talks of *laws*, for the term is misleading, and ascribes to what is a mere general statement of observed facts the force of a command. The so-called laws of nature (a phrase to be avoided) may indeed enable us to predict what will happen in a few cases, but only when the conditions are uniform and simple—a thing which is common in Physics, but very rare in Biol-

10. Herbert Spencer.

It is interesting to compare with the views of Haeckel the position of another great systematist whose book appeared in the same year with the "Generelle Morphologie." This book is the "Principles of Biology" of Herbert Spencer. Spencer makes his starting point von Baer's law and does not widely depart from it throughout the account of his first edition. He however cautions his reader against accepting the generalization as exact. The resemblances among related embryos noted by von Baer "are not precise but approximate. Only leading characteristics are the same: not all the details . . . . each kind of organism, though having a general direction of development like that of the others it is for a time traveling with, shows from the first a tendency to leave the general route—a tendency which presently becomes strongly marked." Still as an average truth the generalization may be regarded as beyond question. But, "the generalization must not be confounded with an erroneous semblance of it that has obtained considerable currency. An impression has been given by those who have popularized the statements of embryologists, that during development each higher organism passes through stages in which it resembles the adult forms of lower organisms. . . This is not the fact." Thus Spencer repudiates recapitulation in the form it was taking with Haeckel.[25]

In a later chapter where he presents with the others the embryological arguments for evolution, Spencer is occupied in showing that evolution explains not only the resemblances of embryos but the lack of such resemblances as well. This is due to the very unlike life conditions and consequent unlike adaptations made by different groups in their evolution subsequent to their departure from the common ancestor, adap-

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ogy." Report of the British Association for the Advancement of Science, 1897, p. 682. Compare also the following from Hyatt:

"The use of terms indicating that Nature has confused or destroyed its own ontogenetic records of the transmission of characters in certain cases assumes (1) that these are exceptional cases, (2) that caenogenesis is not the normal mode of transmission in certain types in which it occurs, (3) that both of these modes of transmission are not affected by tachygenesis, all these implications being erroneous. . . . "destruction," "confusion," or "falsification" are subjective terms inapplicable to the objective character of the phenomena . . . entirely out of place in natural science." Phylogeny of an Acquired Characteristic, p. 401, footnote.

[25] Vol. 1, 1st American ed., 1898, pp. 143, 144.

tations which are reflected in embryonic changes. As a result, "the embryological parallelism is qualified by irregularities that are mostly small, in many cases considerable, and occasionally great."[26]

The irregularities in the law noted by Spencer may be briefly enumerated: (1) The *substitution of organs* and the *suppression of organs* in certain embryos as compared with others, the first illustrated by the succession of changes in the aërating appliances of the mammalian embryo, the second by the suppression of the foetal teeth of whales; (2) retrograde development, as in the loss of limbs and senses in adult parasites; (3) substituted modes of development, the two typical modes being *direct* and *indirect.* In the former case the development of the animal proceeds from the egg to the adult condition without intermediate stages. In the latter a circuitous route is to be noted involving often many metamorphoses. The latter mode is that of the higher or more complicated animals because it reflects the many changes incident to the embryo from the long succession of unlike conditions through which the group has passed. The direct mode is therefore the substituted mode among the higher animals, the cause being a prolonged constancy of conditions inducing finally an adjustment of all parts of the animal to the settled condition of its life as a whole. Similar facts are to be noted among particular organs as such.

Subsequent to the publication of the first edition of the "Principles of Biology" Spencer's views suffered a change of emphasis. In later editions the condemnatory sentences regarding recapitulation are missing. He has found, in fact, that von Baer's law, when carried out consistently in evolutionary terms, implies recapitulation.[27]

"This conception," says Spencer, "of a tree, symbolizing the relationships of types and a species derived from the same root, has a concomitant conception. The implication is that each organism, setting out from the simple nucleated cell, must in the course of its development follow the line of the trunk, some main branch, some sub-branch, some sub-sub-branch, etc., of this embryological tree; and so on till it reaches the ultimate

[26] Vol. 1, 1st American ed., 1898, p. 368.
[27] See the first two laws of von Baer, p. 9.

twig representing the species of which it is a member. It must in a general way go through the particular line of forms which preceded it in all past times: there must be what has been aptly called a "recapitulation" of the successive ancestral structures. This, at least, is the conclusion necessitated by the generalization we are considering under its original crude form."[28]

Thus in any unfolding embryo there are two sets of energies at work, one tending toward the type of the primitive ancestors, the other toward the evolved terminal type, the intermediate structures being influenced by their conflict. Still other factors intervene to affect the character of development. One is economy. A premium is placed upon any animal in a series which can mature at a saving in vital energy. This tends to shorten the process. Economy again explains the entire disappearance of intermediate forms in some cases. Economy explains, once more, "preadaptation," in the earlier preparation of structures and functions of increasing size and importance in the life of the evolving animal. A demand for more time in the upbuilding of increasingly complicated organs may also bring about preadaptations. Finally the lack of uniformity in the decrease and disappearance of organs may be explained in several ways: large organs will suffer more than small ones from the principle of economy; decrease in unused organs may not coincide with the evolution of more important ones; ancestral features may become embodied as parts of new organs; and some disused organs may entail evil by being in the way of the modes of living.[29]

Spencer's views are interesting in that while they arrive at an acceptance of the chronological idea of recapitulation, they do so by inferences directly from the law of von Baer. But recapitulation is true only to the extent that von Baer's law holds, and Spencer is very well aware of the variations from the law. His statements thus escape the extreme form given to those of Haeckel by the latter's presupposition of a biogenetic fundamental law. Spencer's position is representative of an acceptance of recapitulation more just to the complexities of the facts, and more nearly in accord with the views of Darwin and Müller.

[28] *Loc. cit.*, p. 453.
[29] *Ibid.*, p. 458, *et seq.*

11. The Laws of Acceleration and Retardation.

A notable series of investigations in which recapitulation figured largely was inaugurated by Alpheus Hyatt in Boston in the year 1866. Hyatt's original study was made upon fossil shells of certain mollusks, but his method has been used by his pupils and followers with various groups of mollusks and other invertebrates, and even with the vertebrates. This school of investigators has derived so much assistance from recapitulation that they are now to be regarded as its chief defenders. Indeed, one member of the school has declared that "If the embryologists had not forestalled them, the paleontologists would have had to invent the theory." "This," observes Cumings, "may be considered as a fair sample of the general attitude of paleontologists of the Hyatt school. . ."[30]

It was suggested by Hyatt that the conditions for making comparisons between development and the "phylocycle" by means of fossil shells are exceptionally favorable. The shell and its parts are highly significant of the structure of the animal, and display in a unique way the important phases of its growth from the later embryonic stages to old age. Moreover, the procession through geological time is abundantly shown in the successive geological formations not only for the adult forms but for the corresponding immature stages in every youthful phase as well.[31] It is therefore possible for students of these shells to compare immature stages directly with their own adult condition and with the immature and adult conditions of their predecessors and descendants. These favorable circumstances make the conclusions of this group of investigators of peculiar value within the limits of their field of study.

In making these comparisons Hyatt found certain relations prevailing between the development of the individual and the ancestral series, and summarized them by means of a restatement of recapitulation, along with an induction original with him, since known as the *law of acceleration.* His own words for these two generalizations are:

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[30] For a valuable summary of the work of this school, with bibliographies, see an article by this writer, Paleontology and the Recapitulation Theory, in Proceedings of the Indiana Academy of Sciences, 1908–09: pp. 305–340.

[31] Phylogeny of an Acquired Characteristic, Proceedings American Philosophical Society, 1893: p. 350.

"We have endeavored to demonstrate that a natural classification can be made by means of a system of analysis in which the individual is the unit of comparison, because its life in all its phases, morphological and physiological, embryo, larva, adolescent, adult, and old (ontogeny), correlates with the morphological and physiological history of the group to which it belongs (phylogeny).

"All modifications and variations in progressive series tend to appear first in the adolescent stages of growth, and then to be inherited in successive descendants at earlier and earlier stages according to the law of acceleration, until they either become embryonic or are crowded out of the organization and replaced in the development by characteristics of later origin."[32]

The term acceleration is not to be understood as implying necessarily a quicker development. On the contrary, "an animal having accelerated development of characteristics does not necessarily have a quick development, but may grow, so far as time is concerned, even more slowly than others of its own group."[33] The accelerated characteristic merely takes a new relative position in the whole ontogeny by reason of the omission or suppression of the earliest or older stages and the addition of adaptive phases at the adult end.

The evolutionary explanation of the law is as follows:

"We can fully understand the phenomena of acceleration in development only when we begin by assuming that the characteristics last introduced in the history of any type were more suitable to the new conditions of life on the horizon of occurrence of the species than those which characterized the same stock in preceding horizons. These characters would then necessarily, on account of their greater usefulness and superior adaptability, interfere with the development of the less useful ancestral stages, and thus tend to replace them."[34]

Two important additions to this law of acceleration were made by the distinguished American naturalist, Cope, who presented an independent formulation of the law itself in the year 1866[35]—a year significant for recapitulation, for as has been noted, it gave expression to three original statements of the law, namely, those of Haeckel, Hyatt, and Cope. One of

[32] Genesis of the Arietidae, Smithsonian Contributions to Knowledge, 1890, preface

[33] *Ibid.*, p. 40, footnote.

[34] *Ibid.*, pp. 44, 45.

[35] Primary Factors of Evolution, 1896, p. 9.

these added ideas was that of unequal acceleration, concerning which Cope makes this statement:

"The acceleration in the assumption of a character, progressing more rapidly than the same in another character, must soon produce, in a type whose stages were once the exact parallel of a permanent lower form, the condition of *inexact parallelism*. As all the more comprehensive groups present this relation to each other, we are compelled to believe that *acceleration* has been the principle of their successive evolution during the long ages of geological time."[36]

Two other extracts from another writer will show more fully the meaning of this principle:

"A character useful to the immature form will have a tendency to be inherited at an earlier age than those useful only to the adult, and so by unequal acceleration of development the parallel between ontogeny and phylogeny is broken";

and this unequal acceleration is especially to be expected

"in the larval and adolescent periods where the shortness of the time of development causes throwing together of characters that were not contemporaneous in the ancestors, and where the small size and general habits prevent differentiation of organs that in the correlative adult forms were highly developed..."[37]

The other idea added to the law of acceleration was named by Cope "retardation."

"Where characters which appear latest in embryonic history are lost, we have simple retardation, that is, the animal in successive generations fails to grow up to the highest point of completion, falling further and further back, thus presenting an increasingly slower growth in the special direction in question."[38]

This gives rise to retrogressive series in evolving forms in contrast with progressive series resulting from the effect of acceleration.

The bearing of these principles of acceleration, unequal acceleration, and retardation upon the theory of recapitulation has now to be indicated. If acceleration should operate uniformly upon lines of descent without obstruction, plainly the

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[36] Origin of the Fittest, p. 142.
[37] J. P. Smith, *Journ. of Geology*, Vol. 8, 1900, p. 417.
[38] Origin of the Fittest, p. 13.

ontogeny of a descendant would be a perfectly repeated sequence of the succession of its adult ancestors, except where the most ancient forms would have been suppressed or omitted from the earliest corresponding embryonic period. This is Cope's "exact parallelism." It would also have the effect of condensing stages without confusing the ancestral order in certain portions of the ontogeny. In case of simple retardation the ontogeny would fail to repeat the most ancient forms, would repeat faithfully the later forms up to the point where the retardation left off, and would then fail to repeat stages which the ancestry had recently lost by retardation or successive failure to complete its life cycle. Unequal acceleration would have the effect of "telescoping," or bringing together, stages in ontogeny which had been successive in phylogeny, and to locate later phylogenetic stages before earlier ones. It is obvious that, theoretically, this last could confuse the phylogenetic order hopelessly or could even reverse it.

The relative importance of these several principles, and the validity of recapitulation, becomes therefore a matter of fact. On this point we can but quote competent authority:

"... there are so many species and genera in the various groups of invertebrates whose ontogeny is simple, progressive, and fairly complete, and whose stages of growth are almost exact repetitions of successive antecedent genera, that it would be impossible to find a student of morphogeny of the brachiopods, the marine mollusks, or the lower crustaceans, that does not believe implicitly in the value of larval stages of these groups as records of their family history."[39]

"In the Cephalapoda, Pelecypoda, Gastropoda, Brachiopoda, Trilobita, Bryozoa, Graptolites, Echinoderms, and Corals, examples are pointed out in which there is clear and unmistakable evidence of recapitulation."[40]

Hyatt and Cope adduced certain illustrations of acceleration and retardation with man and other vertebrates, but since the more recent writers do not emphasize these, it may be assumed that the case for recapitulation rests for the group of students here referred to chiefly upon the examples among the invertebrates.

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[39] J. P. Smith, *loc. cit.*, p. 422.
[40] Cumings, *loc. cit.*, p. 337.

A point of importance emphasized by Cumings deserves notice here:

"....the Hyatt school of paleontologists have based their phylogenies on epembryonic [i. e., larval] rather than embryonic stages....since in the nature of the case the true embryonic stages are scarcely ever accessible to the student of fossils.... There arises here a question of definition, does the biogenetic law mean that the *ontogeny* is a recapitulation of the phylogeny, or does it mean that the *embryogeny* is a recapitulation of the phylogeny?" "In most of these cases [those listed in the second paragraph above] it is the epembryonic and not the embryonic stages that are the basis of comparison."[41]

In concluding this report of the bearing of acceleration and retardation upon recapitulation, it will be well to refer to a significant caution contained in Cope's discussion of "inexact parallelism." It has been noted that Cope used this expression in part to refer to a lack of correspondence between any ontogeny and its own restricted line of descent. But he used it also to cover a lack of correspondence between an ontogeny of one line of descent and forms in parallel lines of greater or less kinship by reason of ancestors at different points of remoteness in the past. Thus,

"So soon as new subordinate characters are assumed.... the parallelism becomes "inexact," and such is the kind of parallelism usually observed. And it is the more inexact the more widely removed in relationship are the forms compared. Thus the parallelism between the embryo man with five branchial slits, and the adult shark, it is very inexact; but that between a true fish and a shark is much less inexact. That between a higher and a lower shark is still more exact, and so on." "As we compare species which are more and more different the more necessarily must we confine the assertion of parallelism to single parts of the animals and less to the whole animal."[42]

It appears, therefore, that in the cases of perfect acceleration we have just those conditions required by the logic of the theory of recapitulation in its extreme form. They illustrate nicely the modifications "at a not early age" that Darwin saw were needed for a genetic explanation of von Baer's law, and they fall into Fritz Müller's second class of cases. The evidence

[41] *Loc. cit.*, pp. 306, 337.
[42] Primary Factors in Evolution, 1896, pp. 200, 207.

and the authority of the writers quoted in this section leave no question of the actuality of many examples of more or less close recapitulation among the invertebrates, at least for shell characteristics as such, and for whole organisms to the extent shells are illustrative of the entire structure of the animal.[43] Just how general this recapitulation is does not appear, probably this can not be known as yet. The gist of the contentions of the writers in this field seems to be nothing more than that recapitulation constitutes a working principle for genetic classification of very genuine usefulness. There is no disposition to make of it, at the present time at least, a principle of universal application. It is plain that generalizations carried over from this rather circumscribed field of fact to the vertebrate or human territory, and more especially to the human nervous system or mind, can be the sheerest hypothetical possibilities, in view of the complexity of the facts upon this field of their clearest embodiment and of the possible and probable very unlike conditions that have surrounded the evolution of the higher vertebrate forms.

12. The Facts of Recapitulation.

The sketch of the history of the idea of recapitulation thus far drawn shows that speculation and deduction have had no small part in its formulation. The purpose of the present section is to refer somewhat independently to the facts that have been adduced in its support at different times and by various writers. These facts are found to fall into three classes: (a) those derived from a comparison of known ontogenetic and palaeontological data; (b) those of embryonic resemblance among existing types; (c) those of stages or features in ontogeny showing resemblance to stages or features so common to lower allied *living* groups as to raise the question of an ancestral relationship. The facts of the first group are unequivocal in their significance. Either the parallel exists or does not exist when ontogeny and phylogeny are known and accurately compared. The other two types of fact are open to alternative explanations, and give ground for controversy, as we shall see.

[43] "The Mollusks would seem, at first sight, bound to supply us with exact phylogenetic documents by reason of the abundance of their *calcerous shells* in all geological strata. But . . . the shell is a morphological organ of little importance." Depéret, *loc. cit.*, p. 48.

(*a*) *The Facts of Palaeontology.*

In the discussion of the views of Darwin reference was made to his expressed sympathy for the belief of Agassiz in the embryonic character of extinct forms. As late as the year 1872 Darwin said, "We may hope hereafter to see this law proved true." Commenting on this point an eminent English embryologist, Sedgwick, says, "But as Huxley has shown and as the whole course of palaeontological investigation has demonstrated, no such statement can be made. The extinct forms of life are very similar to those now existing and there is nothing specially embryonic about them. So that the facts, as we know them, lend no support to theory."[44] The reference to Huxley in this quotation is made to papers written in the years 1855 and 1862. In the second paper Huxley wrote "An impartial survey of positively ascertained truth then negatives the common doctrines of progressive modification, or a necessary progress from more or less embryonic forms . . . . it either shows us no evidence of any such modification or demonstrates it to have been very slight."[45]

Passing the question as to whether Huxley's views may have undergone a change of emphasis later with the accession of new facts, we may compare with the statement of Sedgwick the opinions of a distinguished German palaeontologist. Zittel, writing on Palaeontology and the Biogenetic Law, in 1895, says, after referring to the immense advantages that would accrue to palaeontology if this law could be strictly used,

"If we consult palaeontology, it shows that these surmises are by no means confirmed. There are, indeed, a great number of fossil genera which retain throughout life the embryonic, or, rather, the youthful characters of their existing allies, but it is only among the mammals, and to some extent among the reptiles, that I could name a complete series of forms following one another in time and belonging to the same line of development. The Eocene, Oligocene, and, in part also, even the Miocene Mammalia stand to their now existing allies, for the most part, in the relation of youthful forms, while they, almost without exception, exhibit at least some characters which are quickly passed through by their geologically younger successors in the embryonic or youthful stage. The ontogeny of organisms now

[44] In Darwin and Modern Science, 1909, p. 174.
[45] Scientific Memoirs, Vol. II, p. 528.

living would, for the rest, afford but an unsafe basis for the reconstruction of ancient faunas and floras, since experience teaches that the biogenetic law is frequently veiled or completely obscured owing to various causes."

Concluding a series of illustrations of the absurdities to follow from an unchecked use of the law this authority remarks that these few instances "may suffice to show how trivial are the discoveries concerning existence in earlier periods of earth-history that can follow from ontogenetic researches alone."[46]

Cope and others were interested in collecting particular instances of recapitulation and these appear in the text-books. They are conveniently presented by Woodward in the following paragraph:

"There is no doubt, for example, that in the course of the individual development the homocercal tail of a modern bony fish passes through the same stages as those successively exhibited by the majority of the adult fishes at the different geological epochs. It is also evident that the family of deer (Cervidae) has gradually acquired complex antlers in precisely the same manner as every modern stag acquires them during the course of its individual life. Again the "cloven foot" of the existing ruminant appears in the embryo with separated metapodial bones, like those of the adult ancestral ruminants. It is also tolerably certain (though fossils have not yet provided absolute demonstration) that the rudimentary teeth and hind limbs of the existing whale bone whales (Mystacoceti) are inherited from functionally toothed quadrupedal ancestors."[47]

In Osborn's "Evolution of Mammalian Molar Teeth" this example of recapitulation is to be found,

"In the lower molar teeth the order of calcification is precisely the order of evolution.....So we find that the order of embryonic development exactly repeats the order of historical development ....But this....is not exactly the case in the upper molars. Nevertheless, out of eight cusps in the upper and lower molars considered together, *six* cusps calcify in the order in which they were successively added to the single reptilian cone."[48]

And from the same authority—this note,

"The recent discovery of the modes of origin of the horns in the titanotheres, a perissodactyl group remotely related to

[46] *Natural Science*, Vol. 6, 1895: pp. 308, 309.
[47] Outlines of Vertebrate Palaeontology, 1898, p. xxiii.
[48] p. 65.

horses, tapirs, and rhinoceroses, permits of a comparison of phylogenesis with the ontogenesis of the horns in bovine mammals—the conclusion is that ontogeny closely recapitulates phylogeny, that the genesis is gradual or continuous, that the horns arise definitely and determinately."[49]

As is well known the ancestry of the horse is one of the few vertebrate ancestries that have been reconstructed on palaeontological evidence, and it is therefore of peculiar interest to note the results of a comparison of the embryogeny of the horse with its racial history. This comparison has been made in part by Ewart, who, in the course of his report, raises and answers this question,

"What evidence is afforded by the horse in favour of the recapitulation theory?.....

Evidently if the reservations made on the plea of abbreviation in development, etc., are almost unlimited, a very remote resemblance in an embryo to a supposed ancestor might be considered sufficient evidence of recapitulation....There must, however, be some limit to the use of the word recapitulation.... Recapitulation, if it means anything at all, must be held to mean that, say in the case of the horse, the embryo should after a time not only resemble the unknown embryos of its extinct ancestors, but that it should resemble the fully-developed ancestors. This implies that during its ontogeny the horse should not only advance in a zigzag fashion along the trunk of the animal tree, but also when it reached its own particular branch that it should during its onward course make deflections in the direction of *Hyracotherium*, *Mesohippus*, etc., until having, at a respectful distance, done hurried homage to its ancestors, it at last reaches its final goal, and presents its true characters....It is impossible with any degree of accuracy, either to speak of a *Hyracotherium* or a *Mesohippus* stage, or even of a *Hipparion* stage. If, on the other hand, all that is meant by recapitulation is that the developmental record of any given form is represented by a series of zigzags or curves instead of a straight line, the horse may be claimed as supporting it. As is to be expected in forms that have evidently descended from the same ancestors, there is a certain amount of agreement between horse embryos and the so-called fossil horses; and were it possible to know the development of these extinct forms, the points of agreement would be doubtless increased. Further, as might also have been expected, the points of agreement become more numerous and more evident as Hipparion—a not very ancient form—is reached.

[49] *Science*, Vol. XXXV, 1912, pp. 595, 596.

So much is this the case, now that we know the second and fourth digits are for a time fairly well developed, we might speak of a *Hipparion* stage in the ontogeny of the horse. To admit that the horse, before assuming its own specific characters, makes, as it were, a deflection towards the not very ancient form *Hipparion*, is hardly going far enough to justify the assertion that the horse during its development assumes, one after another, the characters of its ancestors, or, in other words, except in the most limited sense, 'climbs its own ancestral tree.'"[50]

Depéret, in the book to which reference has already been made, not only presents an authoritative appraisement of the embryological method of determining phylogenies, from the viewpoint of palaeontology, but gives also a convenient summary of the amount of correspondence of ontogeny with phylogeny as determined from this same viewpoint:

"Has Palaeontology completely confirmed the conclusions thus drawn from the embryology of existing beings? We may approach this important question by two different methods. The first method, which is the oldest and the one most generally employed, consists in finding in geological strata forms which in the adult state reproduce one of the transitory phases through which the development of an existing animal passes. We give to these fossil forms the name of *Persistent Embryonic types*. Palaeontology is able to furnish us with a fairly large number of examples of this. Thus the Fishes of the Primary epoch, such as the scaly Ganoids, have a soft vertebral column in a state of embryonic tissue or *notocord*, as in the existing Ganoids or Teleosteans.... In the same way the Palaeozoic Amphibians pass, as regards the ossification of the vertebral column, through a series of progressive phases.... These different phases are reproduced in the development of our present Reptiles and Amphibians. In recent and modern Ruminants the bones of the metacarpus and of the metatarsus, separate in the embryo and the young animal, become welded later in the adult into a cannon-bone caused by the fusion of the two metapods. We know among the early Ruminants genera.... in which the metacarpal and the metatarsal bones remain distinct in the adult state.

"We may also quote a few persistent types among the Invertebrates.....

"But it must be clearly stated that these examples of representation in fossil adult species of the embryonic, or more correctly, of the youthful characteristics of existing animals, cannot be

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[50] Ewart, *Journ. Anat. and Phys.*, Vol. XXVIII, 1893–94, pp. 348–350.

generalized, and that they remain up till now in the state of exceptional facts."[51]

The second mode of answering the question is that of studying the development of fossils themselves, and this has been reported in the earlier section dealing with the laws of acceleration and retardation. The evidence for recapitulation there presented belongs in character with that just cited.

With the exception of this last group of facts relating to the shells of invertebrates the authorities quoted are in general agreement. We must conclude that the palaeontological evidence for recapitulation is not impressive. Among certain groups of animals in some part of their history, some forms are embryonic in a broad way, and a considerable number of particular instances of the embryonic or youthful retention of ancestral adult traces are noted. Apparently the conditions favoring recapitulation in fossil shells are peculiar to such characters.

(*b*) *The Facts of Embryonic Resemblance.*

The historical importance of von Baer's law for the present topic has been obvious enough. Darwin, Haeckel, and Spencer either made it the point of departure of their arguments or drew heavily upon it. Spencer showed clearly in the words quoted from him that a consistent evolutionary application of the law is equivalent to recapitulation. But the limitations of the formula were noticed very early. Darwin alluded to the common, but not invariable, resemblance between embryos in the same class. Fritz Müller speaks of "developmental forms now so totally different in the nearest allies, now so surprisingly similar in members of the most distant groups."[52] Spencer regarded the generalization as an average truth only. Haeckel and others found great difficulty in reducing to an order consistent with the law the observed differences between comparable embryonic stages. The following extracts will indicate the attitude of more recent writers toward the facts in question:

"Von Baer's statement appears to be erroneous from a modern point of view in the following respects. We know that in certain large groups some forms develop in a very different way from

[51] pp. 254–256.
[52] For Darwin, p. 97.

that followed by other members of the group....Again, it is entirely arbitrary to assume that the group-characters are the first to appear, and then successively those of the order, family, genus, species. Finally....we do not find early embryos of a group identical, for with a sufficient knowledge of the development it is always possible to distinguish between the embryos of different species, as well as between adults, only it is more difficult to do so, because the embryonic forms are simpler."[53]

In a study made in 1894 Sedgwick put the law to test by making comparisons between embryos of closely allied animals and embryos of animals remotely related. The observed facts did not substantiate the law.[54] Sedgwick's more recent statement is as follows:

"The law asserts that embryos of different species of animals of the same group are more alike than the adults and that, the younger the embryo, the greater are the resemblances. If this law could be established it would undoubtedly be a strong argument in favor of the "recapitulation" explanation of the facts of embryology. But its truth has been seriously disputed. If it were true we should expect to find that the embryos of closely similar species would be indistinguishable from one another, but this is notoriously not the case. It is more difficult to meet the assertion when it is made in the form given above, for here we are dealing with matters of opinion. For instance, no one would deny that the embryo of a dogfish is different from the embryo of a rabbit, but there is room for difference of opinion when it is asserted that the difference is less than the difference between an adult dogfish and an adult rabbit. It would be perfectly true to say that the differences between the embryos concern other organs more than do the differences between the adults, but who is prepared to affirm that the presence of a cephalic coelom and of cranial segments, of external gills, of six gill slits, of the kidney tubes opening into the muscle-plate coelom, of an enormous yolk-sack, of a neurenteric canal, and the absence of any trace of an amnion, of an allantois, and of a primitive streak are not morphological facts of as high an import as those implied by the differences between the adults? The generalization undoubtedly had its origin in the fact that there is what may be called a family resemblance between embryos and larvae, but this resemblance, which is by no means exact, is largely superficial and does not extend to anatomical detail."[55]

From these authoritative statements it appears that the facts of embryonic resemblances fail to support recapitulation

[53] Morgan, *loc. cit.*, pp. 74, 75.
[54] *Quart. Journ. of Micros. Sci.* Vol. 36, N. S., 1894, pp. 35–52.
[55] Darwin and Modern Science, p. 175.

in all three of its main implications. The order of appearance of characters is not uniformly, or even commonly, that required by recapitulation, which is first those representative of the order, and then in succession, of the family, genus, species. In the second place, embryonic resemblance in comparable stages does not vary directly with remoteness of kinship, but shows often very great divergence from this rule, indicating unlike careers in lines of descent in the same group and therefore great diversity in the appearance of variation during development, at any period, and not only at the adolescent or adult end of ontogeny. Finally, where resemblance does exist, it is not identity, nor even close, implying that the effect of variation upon the same ancestral structure has not been the same in allied lines of descent, but has been productive of new structures, suggesting perhaps in broad outlines the ancestral structure, but still variant in every case, and essentially so.

What is left for von Baer's law is the "family resemblance." But family resemblance does not imply recapitulation. It means at most a common ancestor.[56] This common ancestor may have had his ontogeny determined in any way, recapitulatory or other. That this family resemblance may often be striking without implying recapitulation is well shown in a recent statement. The Nauplius larva is common to many Crustacea. "But it is not in the least justifiable to deduce, as some have attempted, that the Nauplius larva represents the adult ancestral form from which the Crustacea as a whole have sprung."[57] The Zoaea larva is similarly characteristic of many widely separated Crustacean groups, nevertheless "it cannot possibly be looked upon as representing the adult ancestral type of these animals."[58]

Again, "A larval form, yet more widely spread than either of the Crustacean larvae mentioned, is the Trochosphere larva, characteristic of Annelids of all kinds and curiously enough of some Mollusks . . . . which in the adult state are entirely

[56] "When we recognize a larval or embryonal form as characteristic for a whole animal group, we may not conclude therefrom that necessarily a similar phylogenetic stage is represented by the same. We are justified only in the conclusion that the ancestral form of this animal group had possessed that characteristic developmental stage." Hatschek, quoted by Montgomery, *loc. cit.*, p. 185.

[57] Smith, Primitive Animals, 1912, p. 64.

[58] *Ibid.*, p. 65.

different in their whole organization from worms of any descriptive. This fact implies that the Trochosphere is an exceedingly ancient type of larva, which must have been possessed at some period by the common ancestor of the Annelids and Mollusks . . . There is however nothing to support the view that the Trochosphere in any way represents the common ancestor of the Annelids and Mollusks. . ."[59]

"We cannot however press the argument too far and say that no larval form ever represents an adult ancestral form. Every case must be judged on its own merits after taking into account all the available evidence to be derived from the comparative study of related forms. Thus it seems indubitable that the so-called Mysis larva, a stage assumed by [many members of a group of Crustaceans] after the Zoaea . . . . does very closely represent an adult ancestral form, the actual existence of which is nearly realized by the primitive *Anaspides* and Schizopod shrimps. Here we are dealing with a late larval form just before the adult structure is attained, and it would appear not to have had time to have been profoundly modified in accordance with larval existence. It would seem, therefore, that we are more likely to meet with actual adult ancestral types in the late larval or developmental stages of fairly closely related animals, which have not had time to be secondarily modified, than in the very early stages of more remotely related forms, although these, in accordance with von Baer's law, may show many points of resemblance which are lost in the adults."[60]

The writer from whom these sentences are taken is able to accept von Baer's law by a loose construction of it: "his [von Baer's] statement was that in any two or more related animals the further back we go in their developmental history from the egg the more do they resemble one another. In this form it must be admitted that von Baer's law holds good with very few exceptions....."[61]

This statement may be compared with those of the authorities already quoted. It appears that even on this loose construction of the meaning of von Baer's formulae there is no settled unanimity of opinion among biologists. These discrepancies, however, do not affect the essential significance of the law for recapitulation, for as to this all the writers quoted agree in that embryonic likenesses do not of themselves imply

[59] Smith, Primitive Animals, 1912, pp. 68, 70.
[60] *Ibid.*, pp. 66-68.
[61] *Ibid.*, p. 58.

a law of recapitulation, but at most only the retention of ancestral forms. Whether these are to be regarded as embryonic or adult forms is a matter for study in each case.

(*c*) *The Facts of Comparative Morphology.*

The third type of evidence for recapitulation, that involving a comparison of ontogenetic stages with forms common to "lower" existing groups, may now be referred to. There are, first, those phases in the very early embryonic development of Metazoa suggestive of a progression from the unicellular condition, and in the development of Chordata, from the simple metazoon form to the chordate and vertebrate condition. The case for recapitulation on these lines is well stated by Dendy in his recent text-book.

"We have already referred....to some of the earlier stages in the development of that primitive fish-like animal Amphioxus. Let us next enquire how these stages may be interpreted in accordance with the recapitulation hypothesis. The unicellular ovum obviously represents the remote protozoon ancestors which were common to the whole animal kingdom, and which are also represented at the present day by independent unicellular organisms such as the Amoeba. The segmentation of the ovum into primitive embryonic cells or blastomeres represents the transition from the condition of the simple protozoon to that of the protozoon colony, in which the individual cells, instead of separating, as in the dividing Amoeba, remain together, but still without undergoing any marked differentiation and division of labor. The arrangement of the blastomeres in the form of a hollow sphere, the blastula or blastosphere, with a single layer of cells surrounding a central cavity, represents the formation of such a protozoon colony as we see in the existing Volvox or Sphaerozoum. The process of gastrulation, whereby the single-layered blastula is converted into a two-layered gastrula, with primitive digestive cavity (enteron) and primitive mouth (blastopore) represents the transition from the protozoon colony to the coelenterate stage of evolution, the latter being still represented at the present day by such forms as Hydra, Obelia, the jelly-fish, the corals, and all their numerous relations, which retain in their organization all the essential features of the gastrula, though generally complicated by the development of tentacles, skeleton, etc. The development of the coelomic pouches as outgrowths of the primitive digestive cavity, and the conversion of these into mesoblastic somites, arranged serially or metamerically down each side of the body, mark the transition from the unsegmented and coelenterate condition to the metamerically

segmented and coelomate condition. The cavities of the coelomic pouches form the coelom or body cavity, which is at first transversely sub-divided into compartments, as it still is in the adult earthworm, while their walls form the third germ-layer or meso-blast, lying between the epiblast which covers the surface of the body and the hypoblast which lines the digestive cavity. Along the mid-dorsal line of the body a strip of epiblast sinks down and becomes folded into the form of a tube, the rudiment of the central nervous system (brain and spinal cord) and beneath this tube a long strip of hypoblast becomes nipped off from the roof of the gut, forming the notocord or axial skeletal rod—the foundation around which in higher types the vertebral column is built up. A little later the front part of the gut becomes pierced by gill-slits for purposes of respiration and the primitive chordate condition is thus fully attained.

Amphioxus does not progress much beyond this stage in its development. . . . Amphioxus is a chordate animal but it is not a true vertebrate. It probably, however, represents fairly closely a stage of evolution through which the ancestors of the vertebrates have passed, though it becomes somewhat modified by secondary features in the later stages of its development."[62]

In the case of man Haeckel carried the series beyond that represented by Amphioxus through three stages, the cyclostoma, the ichthyoda, and the amniote, making ten stages in all representing an ontogenetic-phylogenetic correspondence.[63] But as suggested above in the account of Haeckel's part in the formulation of the theory of recapitulation, the ancestral reference in the higher stages is often to ontogenetic conditions in lower forms, making the adult phylogenetic equivalence in such stages indirect, to say the least.

It is significant, by the way, that the chief exponent of recapitulation is able to present an ontogenetic-phylogenetic correspondence of ten stages only. When it is considered that on the phylogenetic side the sequence occupied millions of years and proceeded through an almost indefinite number of special forms, the limitations of a conception of ontogeny as illustrative of the chronological sequence of ancestors become fairly obvious.

It is almost impossible to report biological opinion as to the significance of the kind of fact now referred to, so various are the views held regarding it. One can merely set the outside

[62] Outlines of Evolutionary Biology, 1912, pp. 265–267.
[63] Evolution of Man (5th ed. trans.), pp. 547–550.

limits within which it ranges. These are represented at one end by the views of Dendy and Haeckel, as indicated, and those of the palaeontologist, Depéret, at the other. The latter refers to Haeckel's hypothetical ancestors as "visions of the mind" because no fossil evidence can be offered for them. It is probably true that most naturalists and embryologists do not wholly discount the phylogenetic significance of the series of early embryonic stages among the Metazoa, and are willing to admit that it may possibly represent in a very generalized fashion what actually happened in the early evolution of organic forms. It may be well, however, to report here a recent conservative statement apparently aimed directly at the type of discussion illustrated in the quotation from Dendy just given:

"....in the present state of knowledge we are able to separate the various components of the animal kingdom into a certain number of divergent groups or phyla; and that within the limits of these phyla, although we are far from knowing even approximately in every case the course evolution has followed, yet we are safe in concluding that all the diverse ramifications have originated in the remote past from one common source, or type. But when we attempt to go behind the phyla and discover their origin and inter-relationships, we leave the firm ground altogether and wander in a slippery and nebulous region of speculation.

It is true that certain hypotheses of a plausible character have been suggested which have satisfied uncritical minds, and which we often hear advanced as a part of ascertained science and accepted in an otiose spirit. We are urged to believe that life "originated" in certain chemical compounds which on attaining a certain degree of complexity began to exhibit the fundamental properties of life; and from these comparatively structureless masses the nucleated cell was evolved and the unicellular animals and plants, the Protozoa and Protophyta, made their appearance; that these gave rise to cell colonies, the Metaphyta on the one hand, and the Metazoa on the other. The Coelenterate type of organization is presented to us as the form in which the early Metazoa had their being, and from this by the addition of the mesoderm we arrive at the Platyhelmia, and from them by the addition of a coelom and of metameric segmentation at the segmented Annelid. And so by the addition and subtraction of their characteristic qualities we may pass in imagination from one fundamental type to another; but what is there of reality in these speculations? They rest not on any objective evidence

but upon the tendency of the mind to pass from the apparently simple to the manifestly complex, and to regard the former as primitive and ancestral and the latter as secondary and derivative."[64]

Another class of facts representing this third type of evidence for recapitulation is made up of certain profound metamorphoses observable in the development of certain groups possessing larvae which recall in a rather striking way the ancient forms from which groups in question are believed to be descended. These facts bear unmistakable evidence to a course of evolution in parts of some lines of descent, in which variations or mutations leading to the higher form have supervened emphatically at the adult end of the ontogeny. Ordinarily these larvae have been adapted in important ways to the special conditions of their life as larvae, but not so seriously as to wholly obscure the ancient structures upon which the adaptations took place. These larval forms are untrue to the ancient pattern also by virtue of the fact that they are transient, constantly progressing in the direction of the adult condition, and their organization is therefore disposed in part with reference to the demands of the future. The customary example is the familiar metamorphosis of the common frog. Similar cases are found among the ascidians, the crustaceans, the insects, the flat fishes. The only way in which the ancestral reference in these cases is denied is by so minimizing the resemblance to the ancient form that the recapitulation is said to be wholly superficial and lacking in real significance. This has been done by a few extreme critics of the recapitulation theory. Currect opinion of this class of facts is reported below.

Finally these are those rudiments and isolated special characters in the embryos of higher vertebrates which recall similar characters and conditions in the adults of lower vertebrate forms. These are referred to by Sedgwick as follows:

". . . .the embryos of the higher vertebrate possess in the structure of the pharynx and of the heart and vascular system certain features—namely, paired pharyngeal apertures, a simple tubular heart, and a single ventral aorta giving off right and left

[64] Smith, Primitive Animals, pp. 14 *et seq.*

For an elaborate hypothesis regarding the evolution of animal forms largely on the type of evidence now under discussion, see Bernard, Some Neglected Factors in Evolut ion, 1911.

a number of branches which pass between the pharyngeal apertures—which permanently characterize these organs in fishes. The skeleton, largely bony in the adult, passes through a stage in which it is entirely without bone, and consists mainly of cartilage—the form which it permanently possesses in certain fishes. Further, the vertebrate embryo possesses for a time a notocord, a segmented muscular system, a continuity between the pericardium and the posterior part of the perivisceral cavity—all features which characterize certain groups of Pisces in the adult state. Instances of this kind might be multiplied for the work of anatomists and embryologists has of late years been largely devoted to adding to them."[65]

There is no disposition evident on the part of biological students to deny the ancestral reference of this class of facts. Opinion differs as to the sense in which they are to be regarded as ancestral. These differences of opinion are reported in the second section following. But it is important to note that such facts coexist with other embryonic conditions for which no ancestral reference is found. For instance,

"Examples of embryonic characters which are not found in the adults of other vertebrates are the following: At a certain stage of development the central nervous system has the form of a groove in the skin, there is a communication at the hind end of the body between the neural and alimentary canals, the mouth aperture at the first has the form of an elongated slit, the growing end of the Wolffian duct is in some groups continuous with the ectoderm, and the retina is at one stage a portion of the wall of the medullary canal. In the embryos of the lower Vertebrates many other instances of the same interesting character might be mentioned."[66]

13. Recapitulation and the Physiology of Development.

The later history of recapitulation has been seriously affected by two lines of thought which combined to unsettle some of its primary assumptions. These followed upon the gradual

[65] Encyclopaedia Britannica, 11th edition, art. Embryology, p. 322.

[66] *Ibid.*,

For a statement of the evidence favorable to recapitulation, see Marshall, Lectures on the Darwinian Theory, 1894, and Biological Lectures and Addresses, 1894, by the same author. Miall's comment on the presentation of Marshall is, "Development tells us something, I admit, and that something is welcome, but it gives no answer at all to most of the questions we put. . . . The best facts of the Recapitulationist are striking and valuable, but they are much rarer than the thoroughgoing Recapitulationist admits; he has picked out all the big strawberries and put them at the top of the basket." Brit. Assoc. for the Adv. of Science, 1897, p. 682.

depreciation of the inheritance of acquired characters which took place in the latter part of the last century, and the application of experimental methods to the facts of growth and development (Experimental Zoology, Experimental Embryology, The Mechanics of Development, Experimental Morphology). The inheritance of acquired characters favored a conception of variation at the adult end of ontogeny in response to the direct action of the environment. It was one of the chief interests of Hyatt to show how these latest acquisitions in development became successively inherited in such fashion that they left in the ontogeny a true record of the changes in descent, and it is well known that the three men whose authority gave the greatest prestige to recapitulation, Darwin,[67] Haeckel, and Spencer, all acknowledged the direct action of the environment as a source of variation.

With the progress of the study of development the complexity of the whole matter of growth and differentiation of structure became apparent, and the implications for the dominant idea of recapitulation were pointed out. Wilhelm His, in 1874, in "Unserer Körperform," gave expression to his dissatisfaction with Haeckel's view of phylogeny as the mechanical cause of ontogeny, and introduced the idea of forces inherent in the process of growth itself to account for its changes of form. His words are as follows:

"In the entire series of forms which a developing organism runs through, each form is the necessary antecedent step of the following. If the embryo is to reach the complicated end-forms, it must pass, step by step, through the simpler ones. Each step of the series is the physiological consequence of the preceding stage and the necessary condition of the following. Jumps, or short cuts, of the development process, are unknown in the physiological process of development. If embryonic forms are the inevitable precedents of the mature forms, because the more complicated forms must pass through the simpler, we can understand the fact that paleontological forms are so often like the embryonic forms of today. The paleontological forms are embryonal, because they have remained at the lower stage of

[67] "Whatever influence long-continued use or disuse may have had in modifying the limbs or other parts of any species, this will chiefly or solely have effected it when nearly mature, when it was compelled to use its full powers to gain its own living; and the effects thus produced will have been transmitted to the offspring at a corresponding nearly mature age." Origin of Species, II, 6th ed., London, 1902, p. 613.

development, and the present embryos must pass also through lower stages in order to reach the higher. But it is by no means necessary for the later, higher forms to pass through embryonal forms because their ancestors have once existed in this condition"[68]

Haeckel's phylogenetic method is therefore "a mere by-path," and is "not necessary at all for the explanation of the facts of embryology."

The implications of the germinal origin of variations were indicated by Hatschek in these sentences:

"When one premises (as Haeckel does) that the modifications which the developed individual inherits directly through outer influences become hereditary in its descendants, then the explanation shapes itself very simply. The new acquisitions of the adults bring about immediately a prolongation, in the single generation very insignificant, in the course of generations increasing, of the ontogenetic row of forms in the descendants. But when one holds fast to the view that only those newly occurring characters become inherited, which have arisen through variation of the reproductive cells. . . . another explanation seems necessary. One must presuppose 'overstepping varieties.' With this name I would call such varieties as consist in a prolongation of the ontogenetic row of forms."[69]

From this conception another seems to follow:

"We must consider it as a general law, derivable from the principle of causality, that with the phylogenetic modification of the animal form (individual cycle) never only the end stage becomes changed, but always the whole row from egg cell to the end stage. Each modification of the end stage necessitates a change of the egg cell itself."[70]

In view of the truth contained in the last sentence, we must believe that through the course of descent from the unicellular condition to the existing higher species, the germ cell has undergone an evolution from simple to complicated conditions, corresponding to the difference in organic complication suggested by a comparison of existing protozoon and highly differentiated adult animals. In what sense, then, can the ovum of a higher vertebrate be said to correspond with the ancestral Amoeboid?

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[68] Quoted by Morgan, Evolution and Adaptation, p. 71.

[69] Quoted by Montgomery, Analysis of Racial Descent, p. 184, from Lehrbuch der Zoologie, 1888.

[70] Quoted by Montgomery, *loc. cit.*

"Our doctrine is, that the species-cell, even as the adult, many-celled representative of the species, has passed through a progressive, and, indeed, in general a corresponding development in the course of phylogeny. This view appears to stand in contradiction to the biogenetic law....We must drop the expression 'repetition of the form of extinct forefathers', and put in its place the repetition of forms which are necessary for organic development, and lead from the simple to the complex... The egg-cell of the present time, and its one-celled predecessor in the phylogenetic history, the amoeba, are only comparable in so far as they fall under the common definition of the cell, but beyond this they are extraordinarily different from each other....Undoubtedly there exists in a certain sense a parallel between the phylogenetic, and the ontogenetic, development.... Ontogenetic studies give us therefore only greatly changed copies of phylogenetic stages. The two correspond not according to their actual contents but only as to their form."[71]

This is the argument and conclusion of the embryologist, O. Hertwig (1898). Hertwig's concluding idea that the embryo repeats the ancestral stage in its form only does not commend itself to Morgan as a model of clear thinking: "Can we be asked to believe for instance that a young chick repeats the ancestral adult fish form but not the contents of the fish?"[72]

Montgomery was so greatly impressed by these physiological considerations that he was compelled to repudiate recapitulation *in toto*.

"....a new racial character is not something, like dead ballast, passively transported by the germ plasm; it is a change in the living processes....The egg of a Mammal is as dissimilar from that of a Fish as their adult stages, no matter whether the differences are as perceptible or not. This was the idea of the great old-master von Baer; the egg is as much a bird as is the hen.....The earlier the ontogenetic stage the more the individual may seem to be like its simple ancestors; but in reality it is just as unlike them in those earlier stages as in its matured condition. For degree of difference must not be adjudged in this case from visible differences alone, but rather equally well from differences in growth energies and ultra-observational structural bases, which, though not perceptible, are nevertheless just as clearly proven to exist....Therefore we can only conclude that the embryogeny does not furnish any

[71] Quoted by Morgan, Evolution and Adaptation, pp. 78, 79, 80, 82.
[72] *Ibid.*, p. 83.

recapitulation of the phylogeny, not even a recapitulation marred at occasional points by secondary change."[73]

According to Cumings the error latent in the views of Montgomery is the confusion of morphology with physiology.

"The confusion arising from this source colors all the argument of Montgomery, in which he endeavors to prove that new specific characters must have some representation in the ovum—a view which we must certainly agree with—and that therefore 'the whole row' of cells from the ovum to the adult must be different. We grant that the 'whole row' *is* different in some way, different in the play of energies; but it may conceivably be morphologically identical up to the very point where the new character is added. It is just as easy to conceive that the energy, or whatever we choose to call it, that is at a certain stage of development to produce a certain rib or spine or color-band on the shell of a gastropod, may be handed through the row of cells reaching up to the given stage, without producing a single recognizable morphological change in the row, as compared with the individual that is not to possess the new character, as it is to conceive the opposite. The argument for the one view is just as *a priori* as the argument for the other view. It is also perfectly conceivable that the morphology of the *individual cells* in the row might differ after the acquisition of the new character (in so far as this assumption is required by recent cytological studies), and yet not a single organ or part of the organism be different up to the stage in ontogeny when the new character appears. Unless, therefore, a change in the energies of the cells *inevitably necessitates* a change in the morphology of all the cells or all the organs which they compose, the argument of Montgomery proves nothing." [74]

The argument between Montgomery and Cumings apparently labors with difficulties of a logical character as well as with issues of fact, and suggests the desirability of clear conceptions of the business of intelligence in the presence of the truly genetic phenomena of development. By carrying back in thought to the germ cell all the derivative complexities of the adult, Montgomery succeeds in imputing to it and to all the intervening stages a correlative complexity out of keeping with the obvious simpler conditions of the earlier ontogenetic stages. By a similar logical extreme Cumings conceives a segregation of the physiological "energies" from the objective morphological

[73] Analysis of Racial Descent, pp. 191, 192.
[74] Indiana Acad. of Science, 1908–09, pp. 310, 311.

changes up to the point in development when the new variation appears, when, presumably, the hitherto unrelated "energies" are suddenly connected up with the morphological sequence of events.

It has been clearly pointed out by the students of genetic logic that in dealing with a genetic series of events the intelligence works under constraints which do not hamper it in non-genetic phenomena. A primary obligation laid upon thought in such circumstances is that it shall deal fairly and accurately with the phenomena of any one stage without reading into it what the stage in question may ultimately lead to or what it has proceeded from, except as evidences of these things are actually exhibited in the phenomena.[75]

With these restrictions in mind we may recur to the facts of development as they have been presented by the experimental students of the subject. It is worthy of notice that one of the many names applied to the experimental study of development is Experimental Morphology, and it seems evident that in so far as the term "energies," in Cumings's usage, is necessitated by the observed facts it is required in explanation of morphological changes, minute and gross, that is, changes of form. A primary dynamic expression, "induction," employed by Driesch, and by Jenkinson after him, is thus defined by the latter: "An 'induction' is simply an effect produced upon the parts that are developing by other parts, or possibly by some factor in the external environment."[76] Perhaps, then, a juster statement of the case would be that inasmuch as latent "energies" are known only as they express themselves in the structure and behavior of cells and their aggregates, resemblances and differences in the latter will be the only available index to the resemblances and differences of the "energies" which lie within. Ontogenetic-phylogenetic resemblances, when they have been truly described, therefore, must be regarded as real and not factitious. Moreover, although it must be admitted that the living substance has been greatly modified and differentiated through descent, does it follow that it has been utterly made over? If homologies do not refer to essential resemblances, to what can they refer?

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[77] See Dewey, Studies in Logical Theory, Ch. I; Baldwin, Development and Evolution, Ch. XIX.

[78] Experimental Embryology, 1909, p. 2.

The question thus becomes one of accurate description, of the greatest difficulty necessarily, in view of the peculiar nature of the facts upon which all inferences as to ontogenetic-ancestral comparisons rest. In the following extract from Minot is presented an illustration of a somewhat closer approach to the comparison than is customary:

"One of the first things which will impress itself upon the student of vertebrate embryology is, that, though he may find at the proper stage in the embryo the organs of the body clearly developed, yet, owing to the fact that they consist of relatively undifferentiated cells, they are incapable in large part, of performing functions which they are ultimately to assume, and the performance of which is the very object of their development. This change in histological structure brings about a marked unlikeness of the embryo to the assumed ancestral type."[77]

The main point of difference between Montgomery and Cumings, is, however, not one of logical form merely, but turns upon a significant question of fact. This has to do with the manner in which the specific differences, which by general consent reside n the germ-cell, affect the subsequent course of development. Do these differences express themselves equally upon all periods of ontogeny, and so disturb "the whole row" of stages, as Montgomery implies, or can they be regarded as relatively unimportant in certain phases and highly important in others, as suggested by Cumings? Does a variation affect the entire ontogeny uniformly, or does it exhibit itself at a given period when the conditions are favorable? In short, how much liberty has any phase of growth to evolve by itself without markedly disturbing other phases?

The facts, as reported by the investigators, seem to favor the suggestion of Cumings. Thus in the language of Driesch,

"....the actual fate of a part need not be identical with its possible fate, at least in many cases;....There are more morphogenetic possibilities contained in each embryonic part than are actually realized in a special morphogenetic case."[78]

That is to say, the fate of a part is determined in some degree in the course of its subsequent history. A complementary thought is embodied in these words of Morgan:

[77] Laboratory Text Book in Embryology, 2d ed., 1910, p. 14.
[78] The Science and Philosophy of the Organism, Vol. 1, 1909, p. 77.

"There is certainly no evidence in favor of the view that the organization of the egg need be anything like the organization of the embryo that comes from the egg, although the organization of the egg may be perfectly definite in its character."[79]

The several "factors" contributing to the differentiation of structure are thus summarized by Jenkinson:

"Experimental investigation, as far as experiment has at present gone, has shown, first, that a certain complexity of the physical and chemical environment is a necessary condition of normal development; that complexity may, it is true, vary within certain limits, but those limits can only be transgressed under pain of abnormality or death. In the second place, it has been demonstrated that the initial structure of the germ, and the mutual interactions of the parts as they develop are both indispensable factors."[80]

We are thus encouraged to believe that development is neither an independent process of self-realization of the germ-cell on the one hand, nor a differentiating effect of a regulative environiment upon a neutral protoplasm on the other, but rather an intricate and puzzling interaction or mutual interrelationship of specific external influences and internal conditions. The authoritative primacy of the germ-cell thus becomes greatly reduced. To recall the usage of von Baer, the egg, the chick, and the hen, the entire ontogeny in fact, is really the bird. The two important ideas for the present discussion of ontogenetic-ancestral resemblances, to be derived from these considerations, are these: the fate of any embryogeny is in part determined in the course of ontogenetic history, and the succession of events in this history permits a new organization in each phase. This conception of development receives empirical support from the circuitous and indirect course taken by many animals from the germ-cell to the terminal or adult condition. If then the caterpillar is found to have certain describable resemblances to a worm, or a tadpole to a fish, the fact that the subsequent

[79] Regeneration, 1901.

[80] Experimental Embryology, 1909, p. 279.

For a summary of the results of experimental study of the effect of environmental differences upon the life cycle, see Morgan, Experimental Zoology, 1910, Chaps. XIX–XXIII.

A recent significant discussion of the effective relationship of environment to organic existence, is to be found in Henderson, Fitness of the Environment, 1913. A summary statement from this book is the following: ". . . . somehow, beneath adaptations, peculiar and unsuspected relationships exist between the properties of matter and the phenomena of life."

development leads to a butterfly or a frog need not necessarily be held to discredit these resemblances, and the force of Cumings' contention receives a certain justification.

That this position has limitations appears from one other aspect of the study of development. Apparently it is possible to over-emphasize the isolation of phases in ontogeny. For although, as Morgan suggests, the organization of one period need not be like the organization of another, still we are told the essential unity of an animal is the central fact of the internal condition of its differentiation of structure, rather than any mere interaction of the parts. This feature of development has led to radical differences of opinion as to its import, and has been interpreted in both vitalistic and mechanical terms. Aside from the matter of interpretation the fact is admitted. The following quotation from Morgan presents the situation as viewed by one student of the facts:

"The central problem for embryology is the determination of what is the cause, or causes of differentiation. Our analysis leads us to answer that it is the outcome of the organization; but what is the organization?"[81]

The organization....is a structure or arrangement of the material basis of the organism, and to it are to be referred all the fundamental changes in form, and perhaps of function as well....We know this organization at present from only a few attributes that we ascribe to it, and are not in a position even to picture to ourselves the arrangement that we suppose to exist."[82]

The whole discussion of the section is thus shown to be full of difficulty. We must conclude that the resemblances between ontogenetic stages and ancestral forms are real and not factitious; still they are resemblances that show themselves among entities in some fashion unique in every case. But this seems to be true of all resemblances among organic beings.

14. Biological Opinion Regarding Recapitulation.

The situation in biology with reference to recapitulation may be summed up as follows:

1. Recapitulation as a record of phylogeny is denied *in toto*.
2. The traditional view is still upheld.

[81] Regeneration, p. 258.
[82] *Ibid.*, p. 288.

3. The facts are regarded as indicating resemblances between present ontogenies and ancestral ontogenies.

4. The third view is held, but cases of recapitulation are admitted.

(1) Montgomery's general denial of recapitulation on physiological grounds has been noted and discussed in the section preceding. In an article written in 1897, Hurst takes an equally radical position.

"....ontogeny is not an epitome, is not a record, either perfect or imperfect, of past history, is not a recapitulation of the course of evolution."

Hurst's argument runs as follows:

"In order that any structure of the adult which varies, and hence ceases to exist as an adult structure at all, may become an ontogenetic record of that adult structure, it is necessary that variation should occur in a way utterly unlike the way in which it does actually occur. The more the adult structure comes to be unlike the adult structure of the ancestors, the more do the late stages of development undergo a modification of the same kind. This is not mere dogma, but is a simple paraphrase of von Baer's law....

"In order to produce a 'record' it is necessary that new chapters be added at the end of the pre-existing record. It is necessary, in fact, that as the adult structure varies in one direction, the late stages in development shall vary in another, so as to become, not more like the new adult structure than they were before, but more like the old ones."[83]

In an article in reply to Hurst, in the same year, Bather makes the following comment upon the former's argument:

"This is hardly a fair statement of the case. It is not correct to say that the late stages of development must vary in *another* direction; for it surely is the case, in any series of parents and offspring, which are varying in a given direction, and which we may denote A1, A2, A3, An, that A6 is nearer to A7 than A5 is. Consequently, if the latest stage of development of the form A7 resembles A6, it is necessarily more like A7 than a stage that resembles A5. That is to say, on the Recapitulation Theory, the stages of development vary in the *same* direction as the adults."[84]

Bather substitutes for Hurst's method of variation that of the Hyatt school, with which we are familiar, and then says,

[83] *Natural Science*, Vol. II, 1893, pp. 197, 198.
[84] *Natural Science*, Vol. II, p. 278.

"Although the adherents of the Recapitulation Theory will doubtless accept the above as, in the main, a correct statement of the method of development, yet not the most sanguine of them will hope to find so perfect an epitome of phylogeny in the majority of cases." It is "truly remarkable that we should get as much recapitulation as we do."[85]

Hurst rested his argument mainly upon von Baer's law and the cases cited in its favor by Darwin, with a few of his own. In his reply Bather refers to cases which point very strongly to an actual retention of adult characters in ontogeny, and questions Hurst's use of von Baer's law. This law was meant to refer to existing groups.

"....there is all the difference in the world between filial and fraternal relationship, and although von Baer's law is undoubtedly true of the latter, there are many objections to supposing that it is equally true of the former."

(2) In the section on acceleration and retardation it was shown that many palaeontologists strongly uphold the theory of recapitulation and present many illustrative cases especially among invertebrate fossils. That recapitulation in practically the form given it by Haeckel still has advocates appears from the following extract of a recent text-book.

"In short, the embryological investigation of both animal and vegetable organisms leaves no doubt as to the general truth of the recapitulation hypothesis, and must convince any unbiased observer that, however much modified it may be by abbreviation and by the superposition of secondary features, the life-history of the individual is essentially a condensed epitome of the ancestral history of the race. The law of recapitulation, indeed, may be regarded simply as a logical extension of the law of heredity, for every organism tends to inherit the characters not only of its immediate progenitors but of all its ancestors, and these characters appear in the individual life-history in the same order as that in which they first appeared in the ancestral history—in other words, ontogeny is a repetition of phylogeny and can only be explained in terms of organic evolution."[86]

Perhaps the following quotation from a recent text-book of embryology is more representative of the views of those who still accept recapitulation. It will be noticed that the histor-

[85] *Natural Science*, Vol. II, p. 278.
[86] Dendy, Outlines of Evolutionary Biology, 1912, p. 281.

ical reference is a general one and not to a series of ancestral forms.

"This repetition is seldom particular. or detailed, never complete, yet so many of the phenomena of development can be satisfactorily interpreted from the historical point of view, seeming to have this historical sign rather than an immediately adaptive relation, that as a *general* statement the law remains fundamentally true."[87]

(3) The view that the facts upon which the traditional theory of recapitulation has been based can be better explained as indicating resemblances between ontogenies of descendants and ontogenies of ancestors has the support of Hurst, Morgan, Sedgwick, Cunningham, Griggs, and others. Of this view Griggs (1909) has this to say:

"The form which has the largest number of adherents is perhaps that proposed by Morgan ('03), who believes that animals in their ontogeny repeat not the adult, but the embryonic stages of their ancestors. . . . Much of the evidence which the zoölogists bring forward in favor of such a modification as against any broader application is so conclusive, one must acknowledge that such is a correct statement of the facts in the particular cases cited, whatever the general law of development may be. . . .

"The evidence presented by the kelps clearly tends to establish the repetition theory of Morgan."[88]

Griggs does, however, find evidence among the kelps of the retention of adult characters, and concludes with a statement favorable to recapitulation.

Hurst's application of von Baer's law to the disparagement of recapitulation has been given above. His constructive statement from the same point of view follows:

"Each transient stage in the development of any individual is a modification of the corresponding stage of development of its ancestors. It is in no case a modification of the adult stage of the ancestor. The adult stage of a bird, and no other, corresponds to the adult stage of the fish-like ancestors (if it ever had such ancestors.)"[89]

Morgan refers to this suggestion of Hurst with approval. His own treatment of the subject under discussion may be

[87] Kellicott, General Embryology, 1913, p. 24.
[88] Kelps and the Recapitulation Theory, *Amer. Naturalist*, Vol. 43, 1909, p. 97.
[89] *Loc. cit.*, p. 199.

summarized. Passing in review the most prominent of the cases that have been offered in support of recapitulation, namely, the gill-clefts of reptiles, birds, and mammals, the notocord in the vertebrate series, the development of the skull, of the kidneys, of the heart, with some others, and noting in some detail in each case the likeness of the ontogenetic formation to the corresponding conditions and functions at different levels in the chordate series, he is impressed by the following facts. Certain differentiations, such as external gills in the tadpole, do not seem to have any representation among adults in the lower groups. Such transformations as those of the tadpole, can only be regarded as at best analogous to ancestral transitions. More especially, the gill-clefts appear as early in the development of the mammal as in the salamander or fish, which seems paradoxical if the appearance in the mammal is a repetition of the adult amphibian stage. The case is not greatly different with the notocord, skull, kidneys, and heart. Again, in the cases of rudimentary teeth in birds, whales, and other animals, it is manifestly absurd to claim that the ancestral adult condition is repeated when rudiments only appear. Finally, the possible complete loss of ancestral stages is shown in the lack of any indication in the ontogeny of the snake of the limbs of its lizard-like ancestors. Cases of the repetition of adult ancestral stages outside the group of vertebrates, he avers, are often doubtful, sometimes little less than fanciful. Moreover, the work of certain students among the invertebrates shows that common embryonic forms are found which could not possibly be regarded as due to the retention of adult ancestral forms.

How, then, are the apparent resemblances between the embryos of higher forms and the adult of lower animals to be explained?

"The answer is that this resemblance is deceptive, and in so far as there is a resemblance it depends on the resemblance of the adult of the lower form to its own embryonic stages with which we can really make a comparison. The gill-slits of the embryo of the chick are to be compared, not with those of the adult fish, but with those of the embryo of the fish....It is only the embryonic stages of the two groups that we are justified in comparing; and their resemblances are explained on the assumption that there has been an ancestral adult form having these embryonic stages in its development and these stages

have been handed down to the divergent lines of its descendants."[90]

In the opinion of Sedgwick the facts implying an ancestral reference have been much exaggerated, but a sufficient number of unequivocal cases do exist to require explanation. His explanation follows:

"A disappearing adult organ is not retained in a relatively greater development by an organism in the earlier stages of its individual growth unless it is of functional importance to the young form. In the cases in which the whole development is embryonic this rarely happens, because the conditions of embryonic life are so different from free life that functional embryonic organs are usually organs *sui generis*, e. g., the placenta, amnion, etc., which cannot be traced to a modification of organs previously present in the adult. It does, however, appear to have happened sometimes, as an instance of it may be mentioned the *ductus arteriosus* of the Sauropsidan and Mammalian embryo. On the other hand, when there is a considerable period of larval life, it does appear that there is a strong case for thinking that organs which have been lost by the adult may be retained and made use of by the larva. The best known example that can be given of this is the tadpole of the frog. Here we find organs, viz., gills and gill-slits, which are universally regarded as having been attributes of all terrestrial Vertebrata in an earlier and aquatic condition, and we also notice that their retention is due to their being useful on account of the supposed ancient conditions of life having been retained. Many other instances, more or less plausible, of a like retention of ancestral features of larvae might be mentioned, and it must be conceded that there are strong reasons for supposing that larvae often retain traces, more or less complete, of ancestral stages of structure. But this admission does not carry with it any obligation to accept the widely prevalent view that larval history can in any way be regarded as a recapitulation of ancestral history. Far from it, for larvae in retaining some ancestral features are in no way different from adults; they differ only from adults in the features which they have retained. Both larvae and adults retain ancestral features, and both have been modified by an adaptation to their respective conditions of life which has ever been becoming more perfect.

The conclusion, then, has been reached, that whereas larvae frequently retain traces of ancestral stages of adult structure, embryos will rarely do so; and we are confronted again with the question, How can we account for the presence in the embryo

[90] Evolution and Adaptation, pp. 73, 83.

of numerous functionless organs which cannot be explained otherwise than as having been inherited from a previous condition in which they were functional? The answer is that the only organs of this kind which have been retained are organs which have been lost by the adult and have become in this way impressed upon development. As an illustration taken from current natural history of the manner in which larval characters are in actual process of becoming embryonic may be mentioned the case of the viviparous salamander (*Salamander atra*), in which the gills, etc., are all developed but never used, the animal being born without them. In other and closely allied species of salamander there is a considerable period of larval life in which the gills and gill-slits are functional, but in this species the larval stage, for the existence of which there was a distinct reason, viz., the entirely aquatic habits of life in the young state, has become at one stroke embryonic by its simple absorption into the embryonic period. The view, then, that embryonic development is essentially a recapitulation of ancestral history must be given up; it contains only a few references to ancestral history, namely, those which have been preserved probably in a much modified form by previous larvae."[91]

This lengthy quotation may be brought to a point by a concrete application. The traces of gill-slits in the human embryo mean that at a certain period in geological time one of the ancestors of man was an animal with a larva possessing functional gills of use to it in the water. Later with the extension of the embryonic period this functional condition was rendered useless by being absorbed, that is, taken into the egg or body of the mother before birth. Its subsequent embryonic history greatly modified it and reduced it to a rudiment.

It appears, therefore, that with reference to ancestral traces among embryos Sedgwick agrees in the main with Hurst and Morgan. These traces are due to the transmission of similar *embryonic* forms through successive generations. But Sedgwick differs from these writers in that he does believe there are a few cases of the embryonic retention of functional adult characters. And he differs radically in the belief that larvae often retain adult characters in continuing in the life conditions of their ancestors. This however does not happen in a way to show recapitulation. Sedgwick goes beyond Morgan in suggesting how the ancestral form originally got the adult char-

[91] Encyclopaedia Britannica, 11th ed., art. Embryology, p. 323.

acter which was carried down through embryogeny in descent. This, it will be recalled, Morgan did not attempt to explain.

This hypothesis of Sedgwick[92] was accepted and applied by two other biologists. Cunningham carried the discussion back to the probable ancestor of the Amniota to which the larval condition may be assigned. It is not likely, he says, that the case of *Salamander atra* is illustrative of the absorption of the branchiate condition among mammals,

"Since viviparity even in Mammals was evidently acquired at a later stage, and the change came about by means of the development of an egg-shell in which the larva was contained and protected during its development." Moreover, "the mere fact that they were functional originally in a free larval condition is probably not the whole explanation of the temporary development of a complete system of gill-arches and gill-slits in the amnoite embryo. Supposing that no functional importance in embryonic life belongs to them, it is to be noted that the embryonic branchial blood vessels are metamorphosed into the vascular system of the adult, as they are in the metamorphosis of the Amphibia, and a very considerable and very important part of them persists in the adult structure. This does not account for the persistence in the embryo of open branchial clefts, but even these do not wholly disappear in development. The first remains as the Eustachian tube, and even the posterior are related to the thymus gland. It seems to be a general fact that a structure which in metamorphosis disappears completely may easily be omitted altogether in embryonic development, while one which is modified into something else continues to pass more or less through its original larval condition. If the aquatic larval condition then was ever an adult ancestral condition it must have been the ancestor of Amphibian forms, and only through these the ancestor of the Amniota."[93]

The *adapted* character of these larval forms which reflect in some degree an ancient adult condition is made clear by Cunningham, and is of special significance for this whole class of recapitulatory cases. From a comparison of the tadpole and the known forms of fishes he concludes that

"The larva of the frog, therefore, instead of recapitulating the ancestral condition has lost nearly everything characteristic of a fish except the pharyngeal branchiae, which it could not

[92] Cunningham notes that the same suggestion was made antecedently by Balfour. See Comparative Embryology, 2d ed., 1885, p. 210.

[93] *Science Progress*, VI, 1897, p. 488.

lose without ceasing altogether to be an aquatic larva. The larva is therefore much more of an adaptation than a recapitulation."[94]

This he finds generally true of flat fish and other animals with such larvae, so that he feels warranted in making the statement that "Recapitulation does not occur.... except when the external condition to which the ancestral structure was adapted continues to act at an early period of life."[95]

Macbride, employing Sedgwick's theory, gives many illustrative cases and compares the conditions of larvae and embryos. Ancestral traces are found in the vast majority of larvae.[96]

(4) We are thus led to the fourth position assumed toward recapitulation. It is close to that of Sedgwick just described. The greater part of the resemblance between descendants and ancestors is, where it exists at all, between their ontogenies. Nevertheless, cases exist, more especially among larvae, of the ontogenetic retention of adult characters. This, it is to be noted, agrees with the results of the Hyatt school of palaeontologists. In their impressive array of facts, as summarized by Cumings, it was the post-embryonic and not the embryonic stages that made the basis of comparison.[97]

Grigg's acceptance of both the view of ontogenetic repetition and that of ontogenetic-adult repetition, has been noted. A sentence from this writer will serve as a fitting conclusion to this report of opinion: "In each case the evidence must be weighed before a conclusion can be reached."

15. Summary and Conclusions.

The history of the recapitulation theory may be briefly reviewed. In the early references to the idea at the beginning of the nineteenth century, when the science of embryology was taking form, the attention of observers was caught by resemblances which evoked the belief that individual develop-

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[94] *Science Progress*, VI, 1897, p. 489.

[95] *Ibid.*, p. 508.

The functional character of embryonic and rudimentary embryonic structures is illustrated and enlarged upon by Peter, *Ueber die biologische Bedeutung embryonaler und rudimentärer Organe*, Arch. für Entwickelungsmechanik, 1910.

[96] Sedgwick's Theory of the Embryonic Phase of Ontogeny, etc., *Quart. Journ. Micros. Sci.*, XXXVII, 1894–95.

[97] See page 27.

ment displayed in succession the forms of animals as they ranged in a single series one above the other. In one instance this was regarded as a rehearsal of the story of creation of these forms (Oken). Von Baer's suggestion that the prevailing idea was an error and that the resemblances were between embryos of the four great types, to be detected among animals, was for the time disregarded, in favor of a conception of Agassiz of a parallelism between the succession of geological forms as indicated by fossils and the succession of stages in development, a parallelism expressive of one feature of the divine plan of creation. With the advent of the theory of descent with modification the facts of the older view were invoked in support of the theory, and Darwin, with the help of Fritz Müller, showed how a genetic classification could be determined in large part with the aid of embryology. Darwin's moderate acceptance of the theory of a developmental rehearsal or recapitulation of racial history, was supplanted by the radical statements of Haeckel, who, by misconceiving the effects of heredity and adaptation through successive generations, formulated a "biogenetic fundamental law," which implied that by necessity ontogenies must preserve an abbreviated and condensed record of phylogeny. Herbert Spencer helped to extend the influence of this view by accepting it in general, while showing in some detail its limitations. Recapitulation derived new warrant from a series of important investigations made by Hyatt and his followers upon fossil shells of some invertebrates, which showed how by the acceleration and retardation of adult characters in ontogeny a record of the phylogeny was preserved. The palaeontologists of this school to-day constitute the chief advocates of the views of recapitulation as supplying a fairly faithful record of phylogeny in many cases. Among the embryologists the ancestral record in ontogeny was acknowledged and employed for a considerable period until absurdities due to its extreme application greatly impaired its prestige. At the present time the weight of authority favors an explanation of established ancestral traces in ontogeny as being due to the transmission of similar embryonic and larval conditions through successive descendants, while admitting the retention of adult characters in ontogeny in some instances. These traces are not such, however, as to present in any real sense a chrono-

logical record or recapitulation of the evolution of the race through descent. Several biologists believe that the origin of embryonic traces of adult ancestral forms is due to an extension of the embryonic period to include characters once functional in larvæ, these characters having been retained by the larvæ when no longer needed by the modified adult. The genuineness of ancestral resemblance has been impugned on physiological grounds, but the justification for this seems questionable when the facts are carefully described.

Conclusions Regarding Recapitulation.

The above account of the biological discussion of recapitulation seems to lead to the following conclusions:

1. Ontogeny denotes the sequence of events in the life-history of the individual beginning with the maturation and fertilization of the egg, and progressing, under the stimulation of the environment and the mutual relation of parts, through a series of structures to senility and death.

2. A proper conception of an animal involves the entire life-history and should not be based upon its adult condition alone. There has been some kind of life-history from the beginning. "Development and life are coextensive."[98]

3. Heredity denotes the persistence of characteristics through descent, whereby the life-history tends to be preserved in its original form.

4. But the several phases or periods of ontogeny (embryonic, larval, adolescent, adult, senile) are all subject to variation, and selection (when they are such as to be affected by biological utility) and have varied in unlike degrees, whether one compares stages in one line of descent or homologous stages in different lines of descent.

5. These variations, whether small or greater, have appeared in, upon, and around old structures, so that any phase of ontogeny undergoing revision tends to preserve *in some degree* the character of the original basic structure. Because of this fact any ontogeny is likely to give some indication of its past, and to this extent constitutes a "record."

6. Resemblances between comparable ontogenetic periods will therefore tend to be closest between descendants and im-

[98] Cf. Sedgwick, in Darwin and Modern Science.

mediate ancestors. They will on the whole decrease with the widening of the interval between the ancestors and descendants compared.

7. The millions of years occupied by any line of descent has given opportunity for every degree of reconstruction of the life-history to the most radical and it is surprising that a later ontogeny should preserve any traces whatever of the life-history of remote ancestors.

8. In many groups there are very few, if any, such traces, the life-history showing from an early period only the features of its present adult condition.

9. In other groups the life-history is not direct but circuitous, and presents forms which require an explanation other than that of adaptation to the environmental conditions of the adult. These forms often have some kind of ancestral reference, and have been retained probably because of some utility either to the larvae in their independent struggle for existence, or as structural bases for higher differentiations in case they are found in embryos. Some are rudiments without utility of any discernible sort.

10. In the majority of cases the ancestral reference of embryonic or larval stages is to embryonic and larval stages of ancestors. These may have originated either as larval or embryonic conditions as such, or as adult structures which have been retained in some fashion in the earlier ontogeny of descendants.

11. In the smaller number of cases where the ancestral reference of early ontogenetic stages is conclusively to adult forms the explanation is as follows: A life-history originally direct may have been modified at a not early age and thus left the earlier part to resemble the adult ancestor. If this should have happened successively so that modifications each time came later than the already acquired modifications, the later stages in the development of descendants would indicate something of the sequence in which the modifications were successively added in the phylogeny. These stages would then "recapitulate" that part of the phylogeny during which the modifications took place in this fashion. If the modifications had been made *uniformly* in this way, then the whole ontogeny would present a "recapitulation" or chronological record of phylogeny, except where suppression, consolidation, unequal acceleration, and retardation had incidentally prevented.

12. It is obvious that recapitulation in the sense of a chronological repetition of a succession of adult forms in phylogeny is very unlikely. It may have happened in the earliest evolution of organic form as suggested by the very general similarity in early ontogenetic development of the Metazoa, a development which has a somewhat general correspondence to what is believed by many to be the evolutionary sequence among existing lower forms. It has happened somewhat conspicuously among many animals with larvae, for a certain part of the life-history, and also with particular characteristics and organs in some degree, more noticeably in shells and bony structures.

13. But where such recapitulation has occurred, there has been coincidently an alteration of the ancient structures, so that the original form of the latter is often made out with great difficulty, the alteration having had the effect of obscuring the older pattern to some degree, often radically. As a consequence life-history has been very much more *altered* than it has been *extended* through descent.

14. If by recapitulation is meant any traces of adult features in early ontogeny, there is considerable evidence for it, although not a large amount comparatively. But this is not recapitulation in the proper meaning of the term. If by recapitulation is meant any ancestral reference whatever in early ontogeny, there is much of this, especially to more recent ancestral life-history, but this is even a farther remove from the meaning of the word. It is practically synonymous with heredity. If ontogeny is a "record" at all, it is more particularly a record of antecedent ontogenies, to the degree these are not effaced by subsequent variational or mutational changes.

CHAPTER III

HUMAN INFANCY AND THE RECAPITULATION THEORY

1. *Human Embryogeny.*

The ancestral significance of the facts of human foetal development was carefully considered by Duckworth in "Morphology and Anthropology" (1904). This author made comparisons with respect to external features, topographical and systematic anatomy, between the human foetus at birth, also at a point about half way through embryonic development, and the human adult and existing primates. His conclusions are briefly as follows. With respect to the external features of the human foetus a small number of simian characters are recognizable in both stages studied, although the younger stage does not show these in any greater frequency. This is practically the result of the comparison based on topographical anatomy. Some of the points of difference from the adult human condition constitute resemblances to conditions obtaining among the primates. No special primate form is indicated. The conclusions regarding systematic anatomy are given in the words of the author. The observations regarding the ninth month foetal stage are arranged with respect to descent in three groups.

"First of all, there are to be noticed characters, such as the relatively large size of the liver, of the hypogastric arteries, or of the fontanelles, which appear to be quite irrelevant; these are in fact, conditions associated with, and determined by the particular and peculiar mode of development in the higher Eutheria, and, therefore, they may be expected to obtain in all these animals alike. Secondly, there are a number of characters, such as the great size of the head and of the cerebrum, which are related to the specific and peculiar characters of the Hominidae, and which might well be expected to be so impressed in their organization as to appear prematurely, so to speak, in his individual development. . . . These two classes constitute a very considerable number of characters which do not bear upon the question of descent and must be carefully eliminated.

" . . . there remains a residue . . which may be collected and associated in a category of pithecoid affinities. The flatness of the nose, the imperfect power of opposition of the pollex (shown by the mode of grasping in the new-born infant), the straighter lumbar column, the flattened sacrum, the imperfectly extensible hip and knee, the proportionately long upperlimb, the incurved feet (and, in the female, the straighter vagina), may be mentioned as features of this kind . . . further . . . there is no reasonable doubt but that the associations are with the Simidae rather than with their lower congeners among the Primates."[1]

The foetus at the fifth month shows a somewhat greater prominence of the features associated with placental development as such, and the specific human characters are asserting themselves. The residue of simian characters is very small, so small indeed, that nothing is indicated of man's ancestry beyond the immediately antecedent Simidae.

It will be seen from this authoritative review of the facts of foetal development that the character of the human foetus is determined chiefly by its particular foetal condition and by its future as an adult human organism. The resemblances to adult existing apes, and presumably to the adult ape-like ancestor, are few and comparatively unimportant, and as far as we can see, are such as might be due to an indirect likeness to this ape-like ancestor by way of the foetus of the latter. This accords with the view of ancestral similarities reported in the preceding chapter as that having the greater weight of authority among biologists. In instituting these comparisons between non-comparable stages, that is, between the human foetus and the adult ape, Duckworth is under the influence of the traditional conception of recapitulation, to which he refers sympathetically in his introductory paragraphs.

In the chapter following (VIII) the author reports the results of a comparison of certain features in the *mode of development* of man and the apes in the earlier stages. As we should now expect when corresponding ontogenetic stages between closely allied forms are compared, a striking resemblance is found. And, as we should also expect, the resemblances, though more often with the embryogeny of the ape, are to a less degree, with other and lower mammals. The closeness of this correspondence between

[1] pp. 188, 190.

ontogenetic stages, together with the comparative lack of it between the human foetus and the adult condition among apes, once more tends to illustrate the fallacy of the traditional view of recapitulation and to yield added support to the substituted conception of ontogenetic correspondence between descendants and immediate ancestors. A study[2] of the degree of likeness of a foetal gorilla to the human foetus made by the same writer seems to agree with this view, although the author is more interested in indicating the distinguishing characteristics. Human traits are quite plainly manifested in early foetal stages.[3]

2. The Theory of Infancy.

The life-history of the higher mammalia, like that of many lower vertebrate and invertebrate groups, is characterized by a period intervening between the close of embryogeny and the full assumption of adult structures and functions. But whereas larval forms are compelled by the necessities of their independent life to provide themselves with food and protection during the progress of their maturing, the corresponding period among the higher mammalia is one in which the processes of growth and increasing maturity are largely freed from such necessities by the care and protection of a parent or parents.

The term *infancy* has been applied to this period and an explanation of it in terms of biological utility has become current, associated especially with the name of the American philosopher and historian, John Fiske. In the address on the subject printed in "Century of Science" Fiske deals reminiscently with the inception of the theory. He recalls that the impression left upon the minds of many from the reading of Darwin's "Descent of Man" in 1871 was in some ways unsatisfying. Although Darwin's work presented an impressive array of instances of similarity between man and the animals, still the method of the transition to an essentially human condition was not clearly elucidated, and there was a consequent confusion as to man's future destiny as determined by the Darwinian factors of species evolution.

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[2] Studies in Anthropology, 1904.

[3] Ontogenetic likeness is affirmed in current statements of an "almost appalling resemblance between man and the ape before birth," a resemblance which is asserted to be much closer than that between adult man and adult ape. See Mitchell, Childhood of Animals, pp. 7-9; von Buttel-Reepen, Man and his Forerunners, trans., 1913, p. 76.

A significant suggestion which was to lead to a better understanding of this transition, had already been made in an essay by Wallace, Darwin's co-discoverer of the descent theory. This essay appeared in 1864,[4] and presented the idea that for a long period in the history of man's immediate ancestors natural selection had been slowly transferring from the body to the mind, so that by the time of the final emergence of the human species man's bodily evolution had been practically completed for all time, his future evolution being destined to take place along intellectual and moral lines. That is to say, the transition from the ape-like to the human condition had been chiefly in the region of mind and the nervous system.

It is in this connection that Fiske's theory of infancy became prominent. Fiske's thought in this direction was taking form as early as the year 1873, as we learn from a paper published in the *North American Review* for that year. A more complete statement appeared in the *Cosmic Philosophy* of 1875, an independent and constructive presentation of the Spencerian philosophy for American readers. Fiske's views were reiterated with insignificant modifications in his later writings.[5]

The argument of the theory runs as follows. There is an increase in the amount of nerve tissue of the cephalic ganglia, and in the convolutions of the cerebral surface, paralleled by an increase in the higher psychical powers, in the vertebrate scale from lower to higher forms. These higher powers are associated with the compounding and co-ordinating of already compounded nerve connections in the lower centers. Whereas among the lower vertebrates the uniformity and repetition of identical responses to environment brings about a fixed and determined reflex and instinctive organization of nerve tracts in the individual, which are transmitted to descendants, the responses of higher vertebrates are so complex, so lacking in uniformity, that repetition of any specific mode is insufficient to fasten upon the individual and his descendants fixed modes of action. There arises accordingly among such animals a plastic condition of the higher nerve connections which requires time in the early years of life

[4] Reprinted in Natural Selection and Tropical Nature, chap. VIII.

[5] Vol. II, Chap. XVI and XXII. For later statements, see Excursions of an Evolutionist, Chap. XII; Destiny of Man, 35-76. Anticipations of Fiske's idea have been pointed out by Butler, Armstrong, and others. See *Phil. Rev.*, Vol. 15, p. 59.

for their exercise and adult determination, and brings with it coincidently a corresponding amount of helplessness on the part of the young, demanding parental care and protection. Consciousness is especially associated with these complex and intricate connections of the higher ganglia, and very little or not at all with the mechanical reactions of the lower centers. Thus arises conscious intelligence with its differentiation in emotion, memory, perception and reasoning, and volition. In the case of man this whole evolution has reached its acme, so that brain tissues are largest, convolutions of the cerebral surface are most noticeable, the highest psychic powers are manifested, the period of infancy is longest, and parental solicitude most intense. The process has been continued from savagery to civilization. Parental care first provided by the mother alone, is later assumed by the father also, and as the succession of maturing young prolongs the period of conjugal association, with its incidental fostering of family sympathy and feelings of attachment, the family is born, its elaboration giving rise to social as contrasted with merely gregarious relationships. Thus the omission in Darwin's account of the descent of man is made good, as Fiske believed, and the helpless babe is shown to be the instrument of man's peculiarly social and humane endowment.

Fiske's later statements added little to the original one, but other students have illustrated and elaborated certain features of the theory, while certain contributions must be regarded as positive additions to it. The American naturalist, Marsh, had found from a study of fossil remains evidence of a marked increase in cerebral substance in recent mammals as compared with their relatives of the lower tertiary epochs. Eocene brains were small, hardly larger than those of the reptiles in some cases. There was a gradual increase in the size of the mammalian brain through the tertiary period, generally in the cerebral hemispheres. The same law holds good for birds and reptiles from the Jurassic to the present. The brain of a vigorous progressing race was relatively large, that of a declining race relatively small. The brain size of young was found to be proportionately greater than that of adult. This brain increase was regarded by Marsh as an important element in survival.[6]

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[6] *Amer. Journ. of Sci.*, Vol. VIII, 1874; abstract in *Nature*, Vol. XXXII, p. 562.

Lankester regards the conclusions of Marsh as illustrating a general truth, to which the case of Homo and his pithecoid relations is no exception. This authority further considers this progression to be one from action based on instinct to action based on "educability." Educability is transmitted by heredity but its products are not. Instinct and educability are to a large extent in opposition, the loss of the first making an opportunity for the appearance of the latter. Lewis and Romanes are fundamentally wrong in imputing instinct to "lapsed intelligence." There is no community between the two. One can grow only as the other diminishes.[7]

In a study of the causes of extinction of mammalia, Osborn assigns to brain capacity, among a variety of causes, a primary importance. The identification of educability with brain size in surviving mammal forms appears clearly in the following:

> " . . . the chief advantages of brain capacity are undoubtedly in relation to adaptability of habit, resourcefulness in times of exposure, alertness in avoiding new dangers to which the young may be exposed, enterprise in seeking new habitat . . ."[8]

The early insistence upon the cruelty of the natural order as described by Darwinism, and especially the conflict between the state of nature and that of art and humanity, so vigorously urged by Huxley in his "Evolution and Ethics," brought out a series of replies calling attention to the facts of parental care and mutual aid among animals and men. These facts had been alluded to by naturalists incidentally but were made the principal theme of two very widely read authors. These were Henry Drummond in the "Ascent of Man" (1894) and P. Kropotkin in a series of articles[9] in which the facts illustrative of co-operation among animal and savage societies were brought together.

In 1898, Sutherland, in the early chapters of the "Origin and Growth of the Moral Instinct," summarized the facts of parental care among the principal vertebrate groups in terms indicative of its historical evolution. The high fertility, rapid hatching, and early maturity by means of which the species of the lower groups were maintained is shown to yield to the biologically

[7] *Nature*, Vol. LXI, 1900, p. 624.
[8] *Amer. Naturalist*, Vol. XL, 1906, p. 857.
[9] Reprinted in Mutual Aid as a Factor in Evolution, 1902.

more advantageous plan, incidental with the lower groups but characteristic of the higher, in which parental care in some form is involved. In its early organic and unconscious expressions parental care was manifested in the safeguarding of germ-cells in the coming together of the sexes. Subsequently the hatching eggs were variously and increasingly protected, notably in the brooding of birds and in the placental gestation of mammals. The extension of parental care to the post-natal period opened the way to the evolution of conscious parental solicitude, gradually increasing in duration and intensity. The breeding rate is found to vary with the increasing scope and degree of care from parents. The decrease in the number of eggs and young is associated with a higher nervous organization expressing itself especially in intelligence, and helplessness is made concomitant with intelligence as its necessary condition.

The peculiar utility of parental care, according to Sutherland, consisted in providing an opportunity for variation in the direction of increasing intelligence. Intelligence in any large amount is necessarily associated with delay in the assumption of life-saving abilities. Among those animals without parental care variations favoring intelligence, with its coincident delay of maturity, would have been immediately rendered futile by the extinction of the immature animal. There were therefore strict limits to any extension of intelligence among the lower groups. It would increase only to a degree not inconsistent with an independent struggle for existence. With the coming of parental care the way was cleared for an indefinite amount of variation in the direction of intelligence, and thus it is that intelligence is peculiarly the possession of the higher mammals.

All these contributions to the discussion of infancy and parental care showed clearly that infancy and biological superiority are causally related without indicating *just how* the associated plasticity of the nervous system was used to bring the improved adaptation about. This last has been done by the psychologists. In connection with his studies upon young animals, reported especially in "Habit and Instinct" (1896), Lloyd Morgan demonstrated with considerable particularity how the imperfect instincts with which the young of learning animals come into the world are adapted to the peculiar circumstances of their existence by the

supplementations of habit. In the view of Morgan intelligence has two functions, that of setting up an equipment of specialized habits during immaturity, and that of the readjustment of these habits in some degree in maturity. "It is in the period of youthful plasticity that intelligence has its most important part to play so far as the genesis of habit is concerned."[10] Some intelligence remains over for adult life; the higher the mental grade and the more varied the conditions, the greater is the balance left over. But habit formation is peculiarly the affair of infancy.

Another significant idea from this writer, taken in turn from Hudson's "Naturalist in La Plata," as Morgan acknowledges, is that of *tradition*, or the transmission by imitation from one generation to another of successful acquired modes of behavior. This fact of imitation has been greatly emphasized in human society since by Tarde,[11] Baldwin,[12] Royce,[13] and Sumner.[14]

Imitation and tradition are to be regarded as two sides of the same fact, the one standing for the process by which the other is brought about. More recent study of animal behavior has tended to minimize the amount of imitation among animals in general, but its presence among the primates is admitted, and in the human species imitation and tradition are so impressive as to be considered by some authorities the most significant of all the factors of its life. It would follow logically, although confirmation from a sufficient knowledge of the life of the higher primates is still lacking, that in the evolution of man and especially in the progression from the ape-like to the human condition, biological well-being and success were closely identified with the transmission of socially derived habits or tradition, in connection with neuro-muscular plasticity. Nature's method of guaranteeing this transmission was through the invention of the instinct or impulse of imitation, a special device, according to Groos, by which modes of action not resting upon well-defined instinctive tendencies could be taken up by the young wholesale, so to speak. There seems to be no other way of adequately ac-

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[10] p. 157.
[11] Laws of Imitation, 2nd. ed. trans., 1902.
[12] Mental Development in the Child and the Race, 1895.
[13] Outlines of Psychology, 1903.
[14] Folkways, 1907.

counting for so profound a disposition as the imitative tendency in the human animal.[15]

In the course of the discussion of imitation the term has been found too inclusive, and there is a noticeable tendency among psychologists to distinguish between instinctive imitation or *suggestion* and true imitation based upon "copies" existing in terms of related "objects." Suggestion has now an important literature of its own, and while much of it has made slight reference to biological history and any relation to infancy, enough has been said in these connections to make of it a somewhat distinct factor in the transmission of social modes. Suggestion is differentiated from imitation in that its excitants are simpler, sensory rather than perceptive and relational. It is therefore found among gregarious animals before true imitation and is illustrated in the pseudo-imitation of schools of fish, flocks of birds, sheep, etc. But it has been retained in human evolution in great force and must be accorded high if not supreme importance in the transmission of social habit. Its primacy over true imitation can scarcely be denied when one considers the comparatively advanced nature of the latter, and its controlling power among primitive and less cultivated men.

Suggestion and imitation have been intimately associated with play, the biological value of which has been authoritatively shown by Karl Groos. With Groos "the very existence of youth is due in part to the necessity of play; the animal does not play because he is young, he has a period of youth because he must play."[16] Whether or not one should quite agree to the form of this statement, there can be no question of the most intimate relationship of play to infancy. Infancy is the period during which the young animal reaches the adult level of efficiency upon which the species is maintained in its struggle for

[15] For the purposes of the present account imitation is referred as to a single or unitary thing whereas the term of course denotes a highly intricate complex. In the mind of the writer much confusion in the use of the term is due to an unjust distinction of it from trial and error. Imitation is through and through a trial and error process, but this trial and error is incited by, and in its higher forms in part guided by, the behavior of others. The original or instinctive phase lies in the incitement to *some* response. This response may be comparatively general to begin with but it becomes more definite by trial and error with its resulting special habits. It is precisely in this combination of instinctive incitement and capacity for adapted and suitable behavior that its biological utility consists. For a specific instinctive *response* to the behavior of others would prevent the adjustment that imitation obviously provides for.

[16] Play of Animals, trans. 1898, preface, p. xx, and p. 75.

survival. This degree of efficiency involves some practice in all learning animals and in many a long continuation of it. This indispensable practice would be fatal if left to the period of independence. It might conceivably have been enforced by parents, as it is to a very slight extent among animals, but this implies a degree of intelligence and foresight beyond the capacity of animal parents, indeed not easily assumed by civilized human parents with all their higher resources. Self-imposed practice, or play, was therefore the simplest biological expedient. If the formula of Groos be understood to assert that infancy without play is useless, its truth must be admitted, and it is fair to assume that infancy and play evolved together. A merely docile plasticity could scarcely give rise to the habits of maturity. Play is the necessary middle term between plasticity on the one hand and intelligence on the other.

These several additions to the ideas of Fiske are brought together in Baldwin's "Development and Evolution" (1902), perhaps without explicit reference to their bearing upon a theory of infancy as such. Their interrelations are, however, there shown. The doctrine of "organic selection," also reported in this book, is not without its implications for the present topic.[17] This theory was presented by three writers independently—Osborn, Lloyd Morgan, and Baldwin—and has obtained a fairly general acceptance. Its general effect is to show how plasticity has determined in part the selection of non-plastic or fixed organic characters. It must have been noticed in the reported statements of Fiske that the evolution of both reflex or instinctive and intelligent behavior was explained in terms of use-inheritance. This explanation was not inconsistent with the views prevailing at the time Fiske wrote, but has come to be no longer tenable by reason of the change of emphasis since regarding the transmission of acquired characteristics. It was inevitable that plasticity and its effects should be made to accord with the more acceptable doctrine of the germinal origin of variation and mutation.

Organic selection assumes that although plasticity is physically inherited its resulting habits are not. But these habits, because of their effect in making adaptations more adequate, would

[17] See Appendix B for the original statements with others.

often have life-saving value as such, and would therefore in the long run preserve and select individuals in whom the fixed and physically inherited germinal variations should increase in the direction of better adaptations. Plasticity and its habits would thus blaze the way along which germinal evolution could follow, because the incidence of natural selection would fall first upon habits and only through them upon the physical make-up of the animal. With the rise of tradition the value of this process would increase, so that on higher simian levels and early human levels the selection of hereditary strains was increasingly determined by the character of the social habits directly or indirectly favoring survival and leaving of offspring. Infancy being especially responsible for the assumption of habits, in this manner becomes intimately related to organic evolution to the extent that the theory of organic selection is true.

In the light of these later contributions, Fiske's original statement of the theory of infancy requires some amplifying. The biological explanation of infancy assumes that with this period is associated species preservation and success, and in the case of man, species dominance. The advantages accruing to species because of infancy reside in the greater adaptability of individually acquired habits over the mechanical behavior of instinct. This is made possible by an elaboration of the central nervous system, especially in the cerebral portions. But the accumulation of habits requires time and practice and a degree of inefficiency and dependence corresponding to the difference at any time obtaining between the neuro-muscular condition of the young and that of the adult. Among the higher primates these habits are in large part socially derived, calling for the psychophysical adjustments of suggestion and imitation on the part of infancy to insure their transmission. The inefficiency of infancy necessitates counterbalancing parental oversight, and the indispensable practice is obtained by imposing upon the young an instinctive need of self-exercise or play. This spontaneous exercise is directed not only upon well-defined tendencies characteristic of the adult life of the species in need of perfecting, but also to modes of social action resting slightly upon an instinctive basis and more largely acquired by successive generations in response to the changing conditions of their lives. Play is therefore both specific in its forms and broadly imitative and general-

ized. As to its origin, plasticity is characteristic in small degree of animals other than the higher mammals, but mutations in this direction with their coincident delayed maturity were futile until accompanied by the protection of parents. Plasticity is for this reason conspicuous with mammals. In turn the assumption of valuable habits had the effect of preserving and selecting germinal mutations in a given direction which would otherwise have been sacrificed. Finally, the vital energy necessary to the production of organic complexity in the higher learning animals was made possible in some part by the saving from a lowered birth-rate due to the increasing parental care and solicitude given to the eggs and the immature young.[18]

Two recent volumes from the pens of accomplished naturalists discuss the infancy and youth of animals in a convenient and exceedingly attractive fashion.[19] In the main these books confirm the earlier accounts, but with important minor qualifications. The economic value of parental care as a substitute for great fertility in biological competition is accepted and illustrated by both writers. Pycraft, however, refers to "some puzzling facts" and rejects the view which finds in the mortality of young a cause of exaggerated fertility. Rather, it should be said, fertility encourages mortality by offering large numbers of young for food. Fertility, like extravagance in ornament and gorgeousness of color, is to be regarded as a specific character and not a direct response to biological necessity. Moreover, the relation of fertility to mortality can often be only surmised, from ignorance of the actual natural conditions surrounding many species. It still does not appear that Pycraft's position need be in essential contradiction to the older way of stating the matter, which perhaps failed to clearly affirm that the only effect of selection was the limitation or survival or inherent specific characters. There seems to be small reason for doubting the broad correlation of decreasing fertility and degree of parental care in relation to

[18] The following extract from Washburn's Animal Mind, 1908, p. 284, should be reported in this general connection: "One of the most vital meanings of the long period of helplessness and dependence constituting human infancy lies in the fact that by relieving from the necessity of attending exclusively to external objects, it renders possible attention to the sensations resulting from movement; and thus, by supplying an essential condition for the revival of such sensations in idea, it opens the way for the control of movement through the movement idea." The extract should be read with its context.

[19] Mitchell, The Childhood of Animals, 1912. Pycraft, The Infancy of Animals, 1913.

mortality, provided it be understood that natural selection need not always have produced an exact or refined adaptation.

The value of parental care as a necessary condition to the emergence of organisms of the higher types and the correspondence of youthfulness with this higher organization is also acknowledged by both writers. The greater capacity of the higher animals with the prolonged infancy period is due to a more or less extensive education to fit them for the strenuous activities of their life. This education varies with the different groups and conforms to the necessities of circumstances and the mode of living. To play is attributed a large importance in the prosecution of this education, and it is interesting to note that on the mooted question as to whether young animals learn directly from their parents both authorities speak with certainty in the affirmative. Mitchell's description of imitation below the monkeys is, however, a carefully guarded one, and amounts to scarcely more than a belief in organic predispositions to trial and error modes of action which are in some degree encouraged and facilitated by the presence of similar action on the part of others. With the apes this author holds for something akin to human types of conscious imitation.

In view of prevailing assumptions regarding the causes of the duration of youth Mitchell's statement in this connection may serve to call attention to the complexity of the facts and yet to show the degree of truth in the assumed parallel between youthfulness and intelligence in the species.

"The duration of youth in all [vertebrates] is settled by no invariable chain of organic necessity. It has no relation to the duration of the complete cycle of life from birth to death. It is linked with size, but only in an indirect fashion, most apparent in animals most akin. It is linked much more closely with complexity of organization, so that the higher forms usually take longer to mature than their near but lower relations. It is linked most closely with intelligence, the more intelligent animals having relatively longer youth. And as we pass downwards from intelligence to instinct we find that the duration of youth shortens."[20]

Helplessness in young animals has been very generally identified with the immaturity of neuro-muscular co-ordinations con-

[20] Mitchell, The Childhood of Animals, p. 54.

stitutive of intelligent or adaptive behavior. It appears from the two accounts now under discussion that other causes may contribute to this condition. The young of many carnivores are thought to be born in their imperfect physical state because the agility required of the mother in catching living prey would be seriously hindered by carrying heavy young. Among nestlings in the less precocious birds helplessness is alleged as a safeguard to premature hazardous beginnings in locomotion. Thus helplessness as a condition due to unlearned adaptive powers is to be distinguished from that induced by other biological needs, as well as from that which may be unrelated to any utility. The helplessness which associates with neuro-muscular plasticity is presumably not a general condition at all, but is relative to the learning that any species may accomplish in those special directions characteristic of it.

With regard to recapitulation in the period of infancy Mitchell's statement is as follows:

" . . . the young of nearly allied animals are much more alike than are the adults. . . . We explain this by supposing that the evolution of the individual to a certain extent repeats the evolution of the race. . . . We have to remember, however, that this explanation is not complete, and we shall find many characters of young animals to which it does not apply. The young animal owes its characters not merely to its ancestry; as much as the adult, it has to be fitted to the special environment in which it lives. It is not merely a stage in development, but an independent living creature with its own needs and its own aptitudes, presenting characters that are neither a memory nor an anticipation, neither a relic of the past nor a preparation for the future, but suitable for its own purposes."[21]

The tenor of Pycraft's statement is not greatly different:

"Time was when it was believed that these early-growth stages, if carefully followed, would reveal all the mysteries of evolution, since, it was supposed, every animal had to climb its own genealogical tree, so to speak. But it was soon found that such hopes were over-sanguine, for records of some of the most important phases have been lost completely, and others blurred; while some of the phenomena have nothing to do with ancestry,

[21] Mitchell, The Childhood of Animals, p. 7.

but represent what we may call scaffolding—features which have been introduced solely for the benefit of the individual. The study of young mammals does, nevertheless, throw a flood of light bearing on their ancestry. . . ."[22]

It must be noted that both writers, by the terms *infancy* and *youth*, refer not only to that period of plasticity in the early life of animals of the learning type, but to the period following hatching whether plastic, larval, or merely precocious and essentially unmodifiable, as with growing reptiles. If we limit the application of their remarks to the period of plastic neuro-muscular development, certain other statements of these authors should be considered. Mitchell, for instance, with reference to the mammals, the group in which the period of plastic infancy is most conspicuous, writes as follows:

"Mammals, when they are born or very soon afterwards, closely resemble their parents. The differences are due to greater likeness to ancestors and to their nearest allies, to the absence of special weapons or ornaments, or to the presence of characters useful to the young themselves."[23]

One gathers that the period of youth among mammals is not essentially recapitulatory but rather adaptive and anticipatory. Nevertheless, both these authors present a very considerable number of youthful characteristics which they explain as retained ancestral features. From the account of Pycraft are to be noted the following: certain cases of "milk-teeth"; horns of ruminants; antlers of deer; the presence of a hairy covering which does not persist; the under-fur of one group of seals; spines in certain Insectivora; and the familiar ape-like features of the human infant. Pycraft concludes his list with the remark, "We might add considerably to the number of instances of this kind."

In the matter of coloration the case is complicated and some difference of opinion is expressed, yet the two authors agree in the statement that the young of mammals very commonly show differences in coloration when compared with adults, the youthful coloration being regarded by both as older, the adult as a later modification.

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[22] Mitchell, The Childhood of Animals, p. 40.
[23] *Op. cit.*, p. 13.

Thus the youth of mammals is not devoid of ancestral features. These may be "recapitulatory" either because they resemble features of the youthful period of the ancestor, or because they represent the actual adult ancestral condition modified in descent. It would be a matter for study in each case. Still, this does not make youth essentially recapitulatory, for these features are comparatively few when measured against the total make-up of the young animal. They exist alongside others which are adapted to the infantile condition as such, and in spite of what is declared to be a close resemblance of young and adult mammals, taking the group as a whole.

3. Recapitulation and Human Infancy.

Before undertaking a discussion of the relation of the theory of recapitulation to human infancy—more especially to the mental traits of infancy—it will be well to consider just what may be properly understood by ancestral reference in this connection. It is obvious, in the first place, that there is nothing to correspond to palaeontological evidence, the court of last resort on the physical side,—unless something of value may be inferred from the structure of fossil skulls. Ancestral allusions to racial mind must be made in the main to what can be inferred legitimately from objective behavior in the scale of living animals, and since these animals are almost universally end-forms in a long process of specialization away from common ancestors, it is clear that inferences as to phyletic mentality are extremely hazardous. If, however, a mental or physical trait peculiar to infancy has a fairly well-defined homolog among lower animals that may be regarded as closely related to probable ancestors, there is ground for assuming an ancestral reference. If the case is one of degree, there must be reasonable certainty of a greater resemblance to the ancestral homolog than to the infant's own adult condition. There will be no justification for assuming an ancestral reference simply because an infantile trait shows some analogy to any animal trait whatever, and surely none merely because no prospective, adult, or adaptive reference can be made. Biological utility is no longer a category of universal application. Heredity is now known to carry much more than the materials of organic adaptations, having laws of its

own which operate without reference to such adaptations.[24] Unfortunately a very considerable number of the examples offered for recapitulation in infancy are merely fanciful or even wholly absurd because of a neglect of these obvious logical requirements. Unless these limitations are acknowledged the ancestral doctrine of childhood becomes meaningless. For if by recapitulation or ancestral reference is meant only that the organized and unacquired part of the mind is due to its history, without regard to a disparity in kind or degree as between infancy and maturity, this is simply equivalent to declaring that the hereditary part of the human mind is inherited, a statement of little descriptive value. That the recapitulationist has done good service in emphasizing the racial character of mind, whether adult or youthful, is not questioned. The point at issue is whether infancy is peculiarly ancestral, that is, older than maturity.

A faithful application of the traditional idea of recapitulation to psycho-physical behavior would mean that as the individual develops it will rehearse in a chronological way the chief stages of psycho-physical evolution in the phylogeny, except as this has been disarranged by direct or cenogenic modifications. There rests upon the advocate of this view, then, the necessity of showing that the sequence of developmental stages is really representative of the racial sequence, and that the constituent phases in the progression are truly homologous with the ancient stages and not merely analogous or convergent phenomena.

This consistent application of the biological theory has rarely been made to infancy and mental genesis. Recapitulation has taken the form, for instance, of the declaration that the psycho-physical functions appear in the individual in the order of their racial evolution. So stated the doctrine disregards the representativeness in development of the whole phylogeny. All existing functions may be comparatively recent and many, or even most of them, may have been lost. Those that do appear, however, rise in the phylogenetic order. This view of psycho-physical recapitulation varies from that derived from embryology in another particular, for whereas biological recapitulation assumes that the individual passes through and leaves behind, or radically makes over, its recapitulatory stages in the progression

[24] See Bateson, Problems in Genetics, 1913.

towards the specific adult form, the view in question has reference merely to the appearance of psycho-physical features, which thereafter remain functional for life; for example, in the statement that the emotions appear in the order of their rise in the race.

From these more or less direct applications of the biological theory there is noticeable a grading off to a less and less chronological notion of it, as there is in embryology, until recapitulation is supposed to be illustrated in any juvenile retention of ancestral adult characteristics, or indeed of any ancestral traits whatever, juvenile or adult.

However these interpretations of recapitulation may differ, they have in common the idea that infancy is essentially retrospective, rather than adaptive and preparatory. This idea therefore becomes the chief point of attack in any criticism of the theory of recapitulation in its psycho-physical applications.

There is perhaps little profit in attempting to assign to specific writers the different interpretations of psycho-physical recapitulation just alluded to. These have not been clearly distinguished in the literature of psycho-genesis, and since the guiding ideas were so directly taken from embryology the history of the discussion there is the really important matter.

Romanes seems to have been the first to undertake along inductive lines a detailed comparison of human psycho-genesis with the history of mind as exemplified in existing animals. A glance at the diagram at the beginning of "Mental Evolution in Animals" (1885) will reveal the results of his effort. A glance will suffice also to show its essentially artificial character. The comparison was extended with greater thoroughness in "Mental Evolution in Man" (1889). To the mind of Romanes the diagram indicates "in how strikingly quantitative, as well as qualitative, a manner the development of an individual human mind follows the order of mental evolution in the animal kingdom."[25]

As is well known, President G. Stanley Hall has had a large part in the extension of the doctrine into the field of infancy and mental genesis, and it is not surprising that his "Adolescence" (1904) should assume it throughout. Hall's statements are made with the full admission of cenogenic "distortion," "confusion," etc.; but the underlying adherence to the chrono-

[25] Mental Evolution in Man, p. 5.

logical conception is unmistakable. One allusion among many is the familiar one to the period of childhood from nine to eleven years as representing "a terminal stage in human development at some post-simian point." This period is followed by adolescence "which recapitulates the long pilgrimage of the soul from its old level to a higher maturity which must have taken place in the race in certain of its important lines long before the historical period."[26]

Statements of the kind are legion.[27] Two others will serve the present purpose. One is from the biologist Tyler, who says, "The child is naturally successively animal, anthropoid, half-barbarian, and then civilized."[28] The other is taken from the literature of the "boy problem" which is fairly saturated with the doctrine. "We are by turns vertebrates, gill-breathing vertebrates, lung-breathing vertebrates (we make the great change at birth), little monkeys, little savages, and finally civilized men and women."[29]

It now becomes our object to examine briefly the facts of human infantile recapitulation. It will be impossible to cite every allusion of the kind, for these have been made casually in the course of numerous papers on an indefinite number of topics. The present intention is limited to a general characterization of classes of cases and to probabilities in the light of accepted principles of general genetic psychology. The degree of ignorance still prevailing with respect to the course of individual and racial psycho-genesis prohibits more than a preliminary survey of the topic.

In making this survey of the facts we have the advantage of an hypothesis derived from the revision of the biological attitude toward the ancestral facts of embryology, as summarized in the preceding chapter, and illustrated further in the section on human embryogeny. What is true of embryogeny may be true of infancy. We may keep in mind the idea that the ancestral life-history has been transmitted from generation to generation as a whole, and that it has been altered with each step in descent rather than extended. In keeping with this view infancy prob-

[26] Vol. II, p. 73.

[27] See Thorndike, Original Nature of Man, 1913, pp. 249-252, for an interesting collection.

[28] Growth and Education, 1907, p. 53.

[29] Puffer, The Boy and his Gang, 1912, p. 77.

ably has had its own evolution, having been evolved when it was needed, and having been altered from age to age from germinal mutation, and by selection as the necessities of its circumstances required. We should expect to find in infancy a comparatively small number of traits having an ancestral reference merely. These traits would be scattered and not related in a chronological sequence suggestive of phyletic recapitulation, and their ancestral reference would be first to ancestral infancies and only indirectly to adult characters for which the infantile condition was preparing. Some ancestral traits would perhaps have been made over in part to meet new conditions, and there would likely be an insignificant number of useless rudiments.

The most important group of facts adduced in favor of mental recapitulation are those referring to a savage human condition, as illustrated in the behavior of lower living races of men.[30] These include a large number of instinctive tendencies, especially among boys, which are characteristically savage. Some of these are the love of games embodying running, dodging, throwing, hitting with a club, wrestling, boxing; a strong interest in adventurous undertakings, fishing, swimming, exploits requiring endurance, courage, self-control, daring; outdoor interests in rowing, sailing, climbing, exploring, the handling of animals, hunting; the instinctive grouping in "gangs," group undertakings, hero-worship, group loyalty, antipathy for outsiders, fighting, with all its savage excesses, predatory excursions. The facts are too familiar to require further illustration.

But this whole group of cases cannot be regarded as ancestral or in any sense recapitulatory; in fact it points quite the other way. The living races of men, to whose modes of life these examples all refer, belong to one species. The older view of Spencer, Galton, Fiske, and others, which held for an organic difference between savage and civilized human nature, has been supplanted by a conception of the essential identity in the hereditary make-up of all races regardless of the degree of civilization.[31]

The differences between civilized and savage men are chiefly, if not wholly, acquired and are due to the unlike exploitation of

[30] See Chamberlain, The Child, Chap. VIII, and Swift, Mind in the Making, Chap. II, for convenient summaries.

[31] See Boas, Mind of Primitive Man; also, Thomas, Source Book for Social Origins, Part II, and bibliographies.

human capacity by traditional and environmental forces. The savage character of boyhood is thus shown to be a necessary preparatory adaptation to the adult conditions prevailing at the period when human nature had assumed its *specific* form, conditions which are roughly pictured in the instinctive equipment of the boy whether the circumstances of his later life are still fairly true to the ancient pattern in some contemporaneous savage society, or whether they have been radically modified in the course of historical development. If this kind of boyhood in some respects seems out of place in civilization, it is not because it is rehearsing a former ancestral adult condition of life; it is due to the fact that the traditional and socially acquired habits have altered so much for the adult in some societies that what the boy is by nature disposed to do is not, superficially at least, just what is expected of him as an adult in these societies. Civilization has affected boys and adults probably equally. If this should not be admitted, and a greater resemblance be found among the young in different culture levels, this could very well be accounted for by the fact that the inhibition, selection, and organizing of the inborn qualities by habit and intelligence, have had less time to register their differentiating effects.

This last thought may be used to explain another class of facts which has been supposed to illustrate recapitulation. Children are thought to betray ancestral limitations in their primitive tastes, their love of myth and of melodrama, of crude music, dancing, the spectacular, strong colors, etc., and on the side of conduct, in their laziness, desultoriness, dislike of work, discontinuity of attention, stealing, lying, truancy, teasing and bullying. But these things are not peculiar to children; they are found equally among uncultivated adults in civilized and uncivilized societies, and merely record the lack of cultural and moral discipline and the coercion of civilized industry. They manifest themselves wherever civilization is lacking, as in isolated or unfortunate classes in modern life, or in tramps or delinquents who for some reason have escaped its influence, and they are not unknown in cultivated adults when the tension of civilized habit is temporarily or suddenly removed.

Continuing the process of elimination, we may refer to one other group of alleged recapitulatory facts. This includes certain emotional attitudes associated with objects acting as their

excitants. These may be illustrated by the fear of snakes and other animals, of celestial objects, of fire, darkness, eyes, teeth, solitude, death, disease, ghosts, etc. A very large number of similar attitudes have been cited as evidence of the recurrence in childhood of ancient attitudes which have been inherited. In all these cases there is evident a confusion of the inherited and the acquired. We are indebted to McDougall's "Introduction to Social Psychology" (1908) for a lucid explanation of this matter. Each of the basic instinct-emotions has its characteristic "native excitants," with the inherent power of rendering it vital, or setting it up in psycho-physical behavior. Sensory abruptness, especially of sound, has this effect with fear; interruption of normal functions is a similar excitant for anger; as is the infant wail for parental solicitude. The various native excitants have not as yet been satisfactorily described but the general principle seems clear enough. It follows that certain "objects" or acquired units of perception built around these excitants, will often have an emotion-exciting value because they so vividly contain the native excitants; such objects are thunder for fear or substances of vile odor for disgust. Other objects will have these emotion-exciting effects by association with the original ones, and it is apparent from the observed variety of these derived or acquired excitants that there is scarcely any limit to their multiplication. Almost every aspect of the natural world has been such a fear excitant, if we may believe the ethnologists, and there is probably no conceivable object which may not have this function under appropriate suggestion. Only native excitants, then, can have ancestral reference, and we may safely neglect all objects connected with emotional attitudes and confine our attention to the possible recapitulatory value of excitants as such.

Undoubtedly native excitants are very old, but as common experience testifies, they are not peculiar to infancy, and they cannot therefore be regarded as recapitulatory in this sense. It is not impossible that such native excitants may become so embedded in complexes with more dominant emotion-exciting excitants as to lose their original force. Such may be the case with aesthetic or religious objects containing essentially ugly or even essentially disgusting elements, but this does not of itself assign the native excitant to infancy because it works there

in simpler fashion. As to the excitants of attention, curiosity, and their derivative "interests," it is probable that the more conspicuous of these (such as sensory intensity, massiveness, visible motion), are common to children and adults. The strange-in-the-familiar as an incitement to attention and thought apparently affects both alike. Much of the "peculiarity" assigned to children's interest in natural phenomena and in the images of their minds can with practical certainty be assigned to the unlikeness in apperceiving content due to intellectual immaturity. The incitements to activity seem very closely related to children's capacities; when they find they are able to grasp they are interested in grasping, when they discover they can walk or climb, they take to these things with avidity, and so on through the succession of childish, youthful, and adolescent "activities." In these things childhood and youth are very obviously preparatory. Excitants are here nicely adjusted to disposing the young animal to undertake his own education the moment the underlying structures are ready.

It is generally assumed that instinct represents the ancient basic structure upon which plasticity has supervened. A natural inference would identify the native excitant as the original cue to the unmodifiable action which preceded the plastic or habit-induced action in the phylogeny. This is of course not necessarily the case, for the original cue may have altered in descent along with the supervening plasticity, in accordance with the theory of organic selection. However, it is at least likely that the native excitant is a conservative and comparatively ancient feature of psycho-physical organization, even if it has not remained wholly unchanged. If this is so, the progression in the infant from the native excitant to the "meaning" which absorbs it, is homologous with the original phyletic progression from the ancient sensori-motor to the percept-motor action system, and we are apparently confronted with a genuine case of ontogenetic rehearsal or "recapitulation."

If now we turn to the motor aspect of the presumably ancient instinctive structure we find the distinction, commonly assumed, between its inherited and involuntary expressions and the acquired habits which grow up with use and exercise. But the case here is not the same as with excitants and meanings. Plasticity presumably has not been merely added to instinctive muscular

action; it has reduced it, permeated it, and substituted for it; that is, essentially *altered* it rather than supplemented it. As Lankester puts it, plasticity can rise only as instinct yields it place. It is customary, therefore, to speak of the involuntary instinctive motor expressions,—those discussed by Darwin and other students of the emotions—as remnants of older and more complete action systems. With what degree of justice this assumption is made is a question, for the evolution of skill is a comparatively neglected topic. Students of the animals have thus far been chiefly concerned with the problems relating to animal intelligence.

Still, there is probably no counterpart to the genetic sequence from native excitant to meaning on the side of motor control. In fact the situation seems just reversed. For phylogenetically there was a progression from stereotyped behavior to less and less fixed modes of behavior. Ontogenetically the progression is from a few established modes to an indefinite number of adapted voluntary habits. And these acquired habits cannot be homologous with the instinctive phylogenetic action systems, for the very good reason that motor plasticity was evolved for the express purpose of substituting better and different action systems for them.

There is, however, the possibility that there may be examples of recapitulation among the various types of inherited modes of movement: the automatic visceral control, the involuntary accompaniments of the emotions, (fear, joy, grief, "expression"), the random movements of early infancy, and the true reflexes. With respect to the first two, so far as the writer is aware, there are no essential differences between youth and maturity excepting such as are induced by habit with the second, and none that requires an ancestral explanation. Mumford[32] advanced the theory that the random movements of early infancy, associated with the gradual ripening of the lower centers, are reminiscent in certain cases of ancient aquatic modes of action. The suggestion is perhaps a possible one without being at all convincing, and surely the resemblance is not conspicuous. Besides, as Miss Shinn notes, in commenting on the suggestion, many of the movements such as the asymmetrical movements of the eyes,

[32] *Brain*, Vol. XX, 1897.

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for themselves. The plumpness of babies as a precaution against famine, infantile attractiveness as an evidence of primitive parental selection, the strong interest in animals, the carrying of things to the mouth, and many other childish characteristics are given their appropriate recapitulatory explanation. The value of this type of evidence will doubtless vary with the sense of credulity, but, accepting them at their face value, it is to be noted that some of these traits may still be of value to the species in existing savage societies, others refer to infantile adaptations in the past and not to remote recapitulations, and once more illustrate the familiar principle of ancestral ontogenetic resemblance. Infants today resemble the infancies of their ancestors just as adults today resemble ancestral adults.

As for emotional equipment, children and youth have no characteristic attitudes of the kind which are inaccessible to the sympathetic appreciation of adults. Like native excitants their early character may be simpler, but they are not different in quality. The one attitude, which by reason of its oddity for adults has been designated a "mania," is that of collecting.[36] One has difficulty in seeing a preparatory value in this propensity. Perhaps it had an adaptive value in earlier infancies. Seemingly fear is intensified with young children, and it may be the egoistic sentiments are more powerful relatively throughout the earlier part of immaturity. It has been noticed that Robinson saw in these things illustrations of infantile adaptation. The two great sources of altruism are more especially associated with advanced stages of development,—friendship with the clannishness and romantic love of the pubertal and adolescent years, parental regard with the coming of offspring. Childhood, although not devoid of these sentiments, does not need them in the same way. Its major business is to practice its own individual powers.[37]

Drummond,[38] following Romanes, asserted categorically that the order of the appearance of the emotions in growth is the order of their distribution on the scale of animals. As to this

[36] Thorndike finds abundant evidence of this instinct among adults, *op. cit.*, p. 267.

[37] For a pungent criticism of the recapitulation theory as applied to mental genesis, together with a clear statement of the "utility" theory, of which he is an advocate, see Thorndike, *op. cit.*, chapter XVI. For an earlier statement of this latter theory, see King, Psychology of Child Development, 1904.

[38] Ascent of Man, p. 133.

it must be said that the lack of knowledge of the probable facts in either series prohibits inferences.[39]

Grouping together the less propulsive and more passive inherited psycho-physical traits under the head of "sensibilities," it is to be noted that President Hall and others have called attention to possible recapitulations in this region. Certain hedonic qualities attached to sensations of touch, smell, and taste, especially, are thought to require an ancestral explanation, one reason for this being the probable degeneration of these senses and their old-time greater importance. This is not an unreasonable attitude, for the protection afforded by the evolving higher senses might well permit the carrying down of useless remnants of the kind. Instincts, intelligence, and modes of action under the guidance of sight and hearing, would doubtless be more directly subject to natural selection. There is, however, a lack of convincing evidence of any predominance of such traits with the young as such, and until this is forthcoming there is no need of appealing to recapitulation for an interpretation of such cases as may seem truly vestigial to adults.

Baldwin's acceptance of recapitulation was due in part to his belief in its unimpaired standing in biology as late as 1906, to the idea that it was logically required as an effect of heredity, and to the parallel he found between the great epochs of psycho-physical evolution in the race and comparable epochs in individual mental development.[40] It is true Baldwin noticed very significant departures from a faithful psycho-physical recapitulation, some of which have been referred to in the present discussion. Indeed they might well seem to his reader much more impressive than the arguments he adduced in support of the theory. Baldwin's first two reasons for a modified acceptance of recapitulation have been sufficiently discussed. Without following his analysis in detail we may consider briefly his empirical support of the theory in terms of current ideas of psycho-physical evolution and development. The students of comparative psychology have agreed fairly well upon the main outlines in the evolution of behavior. The series of epochs in this evolution is represented as follows: The period of the tropisms; that of the reflex and the essentially unmodifiable instinctive behavior; that of very grad-

[39] Compare Thorndike, *op. cit.*, p. 256.

[40] Mental Development, Chap. I. Development and Evolution, Chap. I.

ually modified instinctive behavior; that of intelligence, or the more abrupt adjustment of instinctive modes to the perception of related "objects," with its associated revival and desire; that of the imitative and lower types of conceptual intelligence of the primates; and finally the rational learning of man.[41] These are of course not distinctly marked periods but rather points of emphasis in a gradually changing evolution. To what extent is the series paralleled by the development of the human individual? It is wholly beyond the scope of the present discussion to make a careful study of the correspondence. One can here speak of probabilities only, in view especially of our ignorance of the course of individual development. The underlying organic structures are of course wholly incomparable. They are as unlike as the complicated human nervous system at birth and undifferentiated protoplasm, to refer to the two extremes; or as the infant human and pithecoid brain, to narrow the interval of contrast. The point at issue is whether the rise of psychophysical functions in the human child follows in an homologous fashion the course marked out by the evolution of behavior.

The nervous control of human behavior offers no ground of comparison with the tropisms. With regard to the reflexes of infancy, it is obviously impossible to establish genuine homologies with the lowest animal reflex action systems. In their origin they were undoubtedly removed from primordial phylogenetic systems by inconceivable intervals of time, and their only common attribute is their reflex quality. Moreover, they do not constitute an "epoch" in development, in the sense that they are succeeded by a later and different mode or organization, for they persist throughout life. The random movements do subside and give way to higher systems, but even if these be regarded as peculiarly ancestral, they are so only as fragments of older more complete instinctive systems and not as representative ancient reflexes. Again, it is not at all obvious that the particular reflexes that remain in man are especially old in comparison with his instinctive make-up. The sucking reflex has risen with the mammals; it is probably much younger than the basic fear structure. What is true of this reflex may be true of others.

[41] See Hobhouse, Mind in Evolution, 1901; Morgan, Animal Behavior, 2nd. ed. 1908; Holmes, The Evolution of Animal Intelligence, 1911.

Similarly the instincts do not constitute an epoch in human development for they also rise early and persist through life, speaking generally. But we have noted that the progression from the native excitant to "meaning" seems to represent a phylogenetic rehearsal, and we are confronted by the very significant fact that the sequence from assimilative through intelligent to conceptual learning is one that has been illustrated in the accounts of the evolution of intelligence indifferently from the animal series and the course of the child's intellectual progress. Romanes, for instance, believed implicitly in the closest possible correspondence of animal and childish modes of thought, up to the point where human intelligence passes beyond the limit of animal capacity.[42] And this assumption of a fundamental likeness of childish to animal modes of learning is not confined to older accounts but passes as a sort of commonplace in current discussions of intelligence. It has been very generally held since Romanes that the differences in intelligence whether exhibited in animals, primitive men, or children are differences not in kind but in degree, and there is undoubtedly implicit in these views the thought that there exists some kind of scale or genetic progression against which all acts of intelligence may be measured. It has, in fact, been assumed, whether properly or not, that intelligence in its representative character *cannot* differ in kind but only in degree. For intelligence has been regarded as yielding a direct acquaintance with the environing world, so that a better acquaintance with this world could only mean a more adequate relationship of the same kind. If, then, lower animals have any intelligence they must possess some amount of the same thing which higher animals and human beings possess in larger measure.[43] The progressive character of the

[42] Mental Evolution in Man, *passim*.

[43] That its *a priori* attractiveness has favored this assumption is probably true. An adequate treatment of it in the light of the available facts is beyond the possibilities of this account. Yet a few obvious considerations may be noted. The low type of learning involved in the dropping of useless movement or in threading a maze may be *effective* without being *representative*, and so escape the implication of the assumption in question. The possession of a free prehensile organ has been noted as of first importance in the perception of objects and their qualities, and as a probable source of difference between human or pithecoid and lower animal intelligence (compare Washburn, Animal Mind, p. 279). And the contribution of the linguistic function to intelligence must be remarked, whatever this is. That much remains to be said for the view here referred to, despite such considerations, is apparent. See, for instance, Morgan, Animal Behavior, pp. 332 *et seq.*

evolution of intelligence has derived added support from the views currently held of the historical increase in complication of the nervous system, especially of the cerebral portions. The original segmental nervous system has been successively integrated, first by co-ordinating centers of limited scope, and successively by hierarchies of increasing range and inclusiveness. This evolution has been in the main one of gradual progression in a given direction, and those portions associated with intelligence are regarded as being peculiarly illustrative of this order.

In a passage in which he characterizes the method of his work on the evolution of mind Hobhouse speaks somewhat explicitly of the homologies existing between human and animal modes of intelligence. Referring to the stages in mental evolution as summarized in Chapter XV of his book, this writer says,

"The fourfold method of correlation differing stage by stage (a) in respect of the factors explicitly taken into account, and (b) therewith in extent of the sphere comprehended, appears to the writer to be realized in human consciousness as we run the gamut from philosophical reflection down to the quasi-mechanical response of habit. Whether these stages into which developed human reason can be analysed correspond to stages by which it *grew* is of course another question—a question only to be answered by a much wider knowledge of animal psychology and of the distinct processes of human development than we at present possess. If we accept evolution, analogy suggests that human intelligence is a specific and higher development of a more general form of intelligence. Hence, if we cut away the higher development, we should come to something roughly common to man and the higher animals. If we cut further, we should come to something common to man and a wider class of animals, and so forth. But there is a caution to be borne in mind. No two species will come to a quite identical development. No part of the physical structure of man, I suppose, is precisely equivalent to the homologous part in another mammal, still less in another vertebrate of a different class. It is the same with the mental structure. We must not expect to find any animals whose intelligence falls readily into any classification based on the analysis of human experience. We can only expect to find homologous developments. That being understood, it may be said that the method of the preceding chapters, so far as they relate to animals, has been to analyze out the phases of intellectual development as distinguishable in human experience, and to discover what homologous structures

are to be found in the animal world. In accordance with these homologies animals are ranked in the classification.[44]

Hobhouse here again gives expression to the pervasive idea that has played so large a part in all ontogenetic study, namely, that the theory of evolution implies a progressive historical sequence that becomes registered in development. We now know that this is not the only method in evolution. Rather, if the evidence presented in the first chapter is representative, it is the unusual one, the life history being so altered in the successive stages in descent as to leave comparatively few evidences in any one ontogeny of what took place in the phylogeny. But it may be that in the case of intelligence there has been just such a progression. The theoretical considerations to which reference has just been made, and the degree of success which has attended the work of students of mental evolution who have assumed it, give a fair presumption of its actuality. The principle of homologous relationships obtaining between animal and childish modes of thought therefore remains as a valid working hypothesis, and recapitulation may reasonably be expected to find illustration in this direction. What we already know of the correspondence, however, forbids the acceptance of Romanes' belief in a close similarity. It may be, for instance, that the phylogenetic order is not so much shown through chronological periods of immaturity as in the progression from ignorance to conceptual or rational control at any period of growth. And there is the further possibility that intelligence has been adapted not only to human interests as contrasted with animal interests—which is obviously the case—but to particular phases of psycho-physical organization, as in connection with the development of skilled voluntary movements. As Hobhouse suggests, we are not yet in a position to speak with any confidence of the real character of the correspondence, if it exists.

This survey of the facts offered in behalf of psycho-physical recapitulation is far from complete, but the more prominent illustrations have been referred to, and they probably warrant tentative conclusions. On examination the more striking cases are found to refer not to ancestral savage conditions, but to

[44] Mind in Evolution, p. 327, footnote.

traits characteristic of the human species in general which have been differently affected by the contingencies of historical development. The civilized societies work differently with the same human nature and by contrast the fundamental inborn traits seem ancestral when they are only less trained. Other cases rest upon analogies due to a confusion of inborn and acquired elements in mental organization. Assertions of a phylogenetic rehearsal in the order of appearance of traits have been made without empirical warrant. In the interests and activities which more especially characterize development as such, the preparatory nature of immaturity is obvious, and this is well illustrated in the group of cases which have had greatest emphasis in connection with mental recapitulation. In the matter of intelligence certain general considerations, as well as a considerable amount of inductive study, give a fair presumption of some degree of ontogenetic-phylogenetic correspondence in this region.

4. Cultural Recapitulation.

Cultural recapitulation, or the theory of culture epochs, has had a curious status in educational literature. While its separate origin has been acknowledged, and its integrity as a subject of discourse has been maintained by an independent title, as a matter of practise the discussion of biological recapitulation has encroached upon its territory with impunity and apparently without full knowledge of what it was doing. For it is clear that any application of biological recapitulation to mental development as a whole deals directly with the question of how its cultural acquisitions are assumed, whether in the order followed by the race in the historical development of its cultural products, or in some other way. And it is a commonplace of the literature of recapitulation based upon the biological analogy that the transition from barbarism to civilization concludes the phylogenetic sequence.

Now the doctrine of biological recapitulation had reference to ancestral species. By the statement that ontogeny rehearses phylogeny was meant that ontogeny repeats the succession of steps in the biological evolution of ancestors. This was due to the force of heredity operating in descent despite the modifications which marked the successive stages. But the transition from primitive to civilized man, according to pre-

vailing views, is not a biological progression. Primitive man and civilized man represent the same species and the same mentality. The differences between the two are due in the main to the unlike use of this common mentality by social and environmental forces. Therefore historical development is not phylogenetic, but ontogenetic, i. e., has taken place in individuals of the same species. Biological recapitulation applied to the mind of man must be held to refer to the alleged correspondence of the hereditary sequence of psycho-physical functions in individual development with the succession of homologous functions in the series of ancestors. It applies then to the appearance of reflexes and instincts, and to psycho-physical modes; only indirectly to habits or acquired products represented in culture. Our treatment of these matters has just been concluded in the preceding section. We address ourselves at present to the somewhat distinct issue of cultural recapitulation.

There is no need of recounting the history of the theory of cultural recapitulation here. This has been done elsewhere.[45] The general bearing of the present discussion upon the theory may, however, be briefly indicated. Cultural recapitulation rests upon three distinct propositions: 1. The historical development of culture, either as a whole or in particular lines, was determined in some degree by the inherent nature of the human mind which permitted this order and no other. 2. There is an inherent and necessary order in the acquisition of culture by the immature mind. 3. The underlying necessity in development is identical in the two series.

Let us consider the status of each proposition. 1. The conception of an inevitable order in the development of culture was apparently a derivative and special application of the idea of biological evolution to social phenomena when the prestige of the new doctrine was very great and when the sciences of anthropology and sociology were yet in their early stages. The application is due chiefly to Spencer, Tylor, and L. H. Morgan.[46] The empirical basis of the conception consisted of similarities which were at first found conspicuous among all races, and more especially of parallel lines of development in culture which were

[45] Vincent, Social Mind and Education, 1897, Chap. III and IV; Dewey, art. Culture Epochs Theory, in Monroe's Cyclopedia of Education. See also, Henderson, Principles of Education, 1910, Chap. VI.

[46] Boas, Mind of Primitive Man, Chap. VII.

considered general. Later investigation and discussion seems to have sadly shaken the foundations of the conception. It has been pointed out that similarities may be due to factors other than common mentality, such as similar geographical environments, common points of radiation of culture, common traditions, and convergence from unlike sources of origin. Investigation has dealt even more seriously with parallels in development. The words of two anthropologists writing with high authority will suggest the present situation in the science with respect to the conceptions in question.

"The theory of parallel development, if it is to have any significance, would require that among all branches of mankind the steps of invention should be followed, at least approximately, in the same order, and that no important gaps should be found. The facts, so far as known at the present time, are entirely contrary to this view. We are thus led to the conclusion that the assumption of a uniform development of culture among all the different races of man and among all tribal units is true in a limited sense only."[47]

The different races cannot be arranged, therefore, on a scale of culture.

"While parallelisms of a certain kind were shown [by the older students] to occur, this does not hold for parallelisms of any degree of complexity and duration, nor for integral historic processes, the individuality of which seems so conspicuous that doubt prevails in the highest quarters as to whether anything like historic laws in the strict sense will ever become more than a *desideratum*."

"Whether the parallelisms refer to entire historical complexes and embrace millenniums, or modestly comprise parallel developments of less extent and duration, when demonstrated they do not constitute a solution, but a problem which has not so far been successfully attacked."[48]

It will be noticed that these writers do not wholly repudiate parallelisms in development due presumably to common mentality. Their expressions have the force of setting positive limits to the idea of their general prevalence held by the older anthropologists. They also may not do justice to the fact that there exists in their science an element or school laying great stress upon the factor of common mind. Wundt's "Völker-

[47] Boas, *op. cit.*, pp. 182, 195.

[48] Goldenweiser, *Jour. of Amer. Folklore*, July-Sept., 1913, pp. 281, 283. See also, Boas, in Thomas, Source Book of Social Origins, 313-15.

psychologie" represents the farthest advance in this direction, and while this work is regarded as having the imperfections of a pioneer effort, promise in this type of anthropological study is not denied. As a matter of fact the sciences of anthropology and psychology have not as yet been vitally joined in the investigation of culture, a significant thing in itself for our topic. For the present it must be admitted that the idea of a necessary order in historical development of an inclusive sort is somewhat under suspicion. The possibility, or rather the actual existence of isolated cases of cultural parallels, seems to be generally acknowledged.[49]

2. Passing to the second proposition contained in the theory of cultural recapitulation we find an equally uncertain situation. That there is a determined order in some part of the progressive development of the child mind no one doubts, and serious efforts have been made with a view to its description. But it cannot justly be held that a description of this order in general terms has as yet been agreed upon by the students of child psychology. More especially, the distinction necessary to an application of the culture-epochs theory, between *deferred* inborn or original traits and those traits which are to be regarded as the results of exercise and cultural stimulation, has not yet been determined with clearness, and until this distinction is made it is obviously impossible to institute comparisons between racial modes of cultural acquirement and genetic sequences characteristic of the learning of children. Speaking broadly, the many existing characterizations of "periods of development," of "interests," or of "nascencies," etc., besides being too various for general acceptance, deal indifferently with the appearance of original traits and the development of acquisitions. Valuable special studies in certain lines are not wanting, notably in language and drawing. Recently, in connection with mental testing, progress towards maturity has been measured, but as yet a qualitative description of this progress has not been undertaken. On the whole, there is no question of genetic sequences in many aspects of mental and cultural growth. We are, however, still in the dark as to just how these sequences should be systematically described.

[49] A philosophical and critical survey of the history of human progress conceived largely in genetic terms is that of Santayana's Life of Reason (5 Vols., 1906).

3. Notwithstanding the insecurity of the two primary assumptions underlying the theory of culture-epochs, the development of the individual and that of the race have been found by serious students to have much in common.[50] A competent examination of any one of the many applications of the theory of cultural recapitulation is beyond the scope of this paper. They range from religion to mathematics, and call in each case for very special knowledge of the history of the branches of culture in question, as well as for a broad equipment in the psychology of the mental processes implicated. We can deal here with but a few logical considerations.

It would not be surprising if the theory held that mature men in a given society were required by their inherent nature to follow in some degree the development of the culture that had been evolved by mature minds in the course of history, for this would imply, apart from the differentiating effects of environmental influences, only some common mentality among adults in the same species and some common elements in their modes of progression in any given cultural direction. We have already noticed the difference of opinion between the anthropologists and psychologists with reference to this possibility.

But the theory goes beyond this. It asserts that unlike ontogenetic periods may be compared with respect to their cultural acquisitions. The child's mind is said to rehearse the history of culture, which is essentially the expression of maturity. Supposing, then, that a true genetic sequence had been determined in the historical development of a given branch of culture, based upon parallels among the different races of men, is there a possible warrant for the assumption, made in the culture-epochs theory, that a child's progress in this branch of culture may be so accelerated that he can accomplish in his immaturity what adults in the past could with difficulty attain to? The answer to the question could be determined of course only by an appeal to fact, but such acceleration is not impossible if certain conditions be assumed. If the underlying organic basis for the historic progression has always been the possession of childhood, and the conditions in civilized societies

[50] See the account and references of Vincent, *loc. cit.*, also Ribot, Evolution of General Ideas, 1899; Branford, A Study of Mathematical Education, 1908; Huey, Psychology of Pedagogy of Reading, 1910, Part II.; Baldwin, Thought and Things, Genetic Logic, 1906.

are now especially favorable to its functioning, it need not be surprising if children should exhibit achievements that were characteristic of adult societies in past times. For adults in these societies were, on the present assumption, in a state of arrest. *From childhood* they had had the capacity for advancing beyond the point of their actual adult attainments, but their advance was prevented by the limitations of their cultural environment. To illustrate, if in a genetic sequence symbolized by the series a, b, c, d, e, f, childhood or youth has the inherent capacity for rising to stage d, and does so in the highly favorable environment of civilized societies, it is easily conceivable that adults in historical times, laboriously evolving their culture independently, should remain life-long at points b or c. This is no more than the equivalent of the thought that primitive and historical men were relatively childlike, a familiar and widespread idea among students of early cultural expressions. From this it would follow that cultural recapitulation need not be expected in any regions where *organic* differences between children and adults exist. If certain branches of culture are expressive of characteristically adolescent or mature attitudes it will be idle to search for illustrations of their genetic rehearsal in earlier periods. And since cultural recapitulation has to do with acquisitions and processes of acquiring we must limit our search for such recapitulations to the course of development taken after the basic instinctive structures have begun their functioning, at whatever period of growth this may be.

It is perhaps not possible as yet to characterize the distinguishable lines of growth within the complex field of cultural acquisition. They are broadly represented by taste, moral and social character, motor skill, and ideas, but these obviously overlap. An adequate analysis of the general principles of mental development will doubtless deal with much finer categories. It is worthy of notice that those who have done most with the cultural recapitulation hypothesis have worked more particularly in the field of thought and it is not impossible that reasons may be found for regarding the plasticity represented by thought and ideas as being available so early in life as to make possible a genuine comparison of childish and historical processes. And since ideas are most intimately related with every aspect of cultural acquisition the possibility may be extended in some degree to motor, moral, and aesthetic development.

CHAPTER IV

CONCLUSION

The history of recapitulation is an instructive one. A principle of limited application within the field of its origin was elevated to a position of wide generality, and so gave rise to a conception in the main misleading. Carried into a new territory without a sufficient examination of its merits, it was applied broadly as an explanatory principle and thus distributed its misleading influence beyond its own borders.

Disregarding the qualifications which were forced upon it by recalcitrant facts, the conception represented a view of individual development as successively extended in the course of evolution, in such fashion that in any ontogeny the earliest features are oldest, the later ones in succession increasingly recent. Thus embryogeny as a period was oldest, infancy less old, and maturity the last to evolve. From this form the conception degenerated to a less and less chronological notion, until it came to mean often no more than that any particular feature in development which had an historical rather than a present reference was illustrative of it.

A more thorough consideration of the facts has led to a view of development essentially contradictory of this recapitulatory one. Ontogeny represents the ancient life-cycle which as such has been transmitted from the beginning. The chronological sequence from egg to maturity is not a rehearsal of a like historical series of events throughout the phylogeny of species; it is but the recurrence of an order which has been repeated in the lifetime of each individual from the beginning. In general, the effect of the modifications induced by germinal mutations and selection in the successive ontogenies constituting the phylogeny, was to alter these ontogenies, to make them over, and to destroy the resemblance of later ones to their predecessors.

Still this alteration was not complete; neither was it regular in its effects. Some very ancient forms are still hinted at in

existing ontogenies; more especially particular structures were often retained through long periods of time with considerable faithfulness. Because of the slowness with which modifications occurred, any ontogeny repeats most of the features of its proximate ancestral ontogeny, and in general the record grows less and less true of phyletic ontogenies with remoteness in descent. Because any ontogeny thus throws some light upon earlier ones, and particularly upon proximate ones, the facts of ontogeny gathered together help to reconstruct the whole line of descent. Probably this is what is often meant by the statement that ontogeny is a record of phylogeny. The statement should read that genetically related ontogenies when compared supply some ground for reconstructing phylogenies.

Although the effect of mutation and selection was in general productive of alteration of the life-cycle, evidence points to a considerable amount of extension of the life-cycle coincidentally with alteration. This happened at times with the form of the organism as a whole, but more often with particular organs or structures.

These considerations apply to the period of infancy with qualification. Infancy was evolved from an ancient life-cycle which did not possess such a period, presumably during and since the Age of Mammals. We can only guess as to the nature of its origin. It may represent a modified later part of the ancient embryogeny set over into the post-natal period, or it may be a remodelled part of the ancient period of precocious maturity, or it may be both. In any case it is probably not due to the successive extension of the mature end of old ontogenies, and there is no need presupposing evidence within it of such extensions.

It is, rather, probably the ancient structure of maturity, either in process of growth or in completion, shorn of and supplemented by those things which plasticity presupposes. In its most ancient features, such as the emotional phases and involuntary rudiments of instinct, it probably retains the characteristics of maturity. We have seen no reason for assigning differences between human infancy and adulthood in these respects. As for the rest, we may tentatively bring over the classification of features employed by Duckworth in connection with human embryogeny, as follows:

The infantile condition as such explains many adjustments that natural selection might have insisted upon—the early dependence, both physical and mental, upon the mother; the later larger degree of self-care and self-protection, through fearfulness, shyness, greediness, and selfishness. Then there is the necessity of preparing for the adult condition—the spontaneous interest in self-practice, the close correlation of mental need and maturing structure as exhibited in the succession of interests, followed by the palpably preparatory conditions of puberty and adolescence. Finally there remains the small group of vestiges and "recapitulatory" cases referring to ancestral infantile necessities or adult preparation no longer required.

The period of infancy can have then no single explanation. Many factors have conspired to give it its peculiar character. As time passes we may be able to speak of these with greater assurance. For the moment we may conclude with reasonable certainty that infancy is not as such older than maturity; from the same starting point the two evolved together, the one giving character to the other by reason of those improvements which have entered upon the horizon of later evolution—those, namely, of intelligence and sociability. Infancy is obviously incomplete; it is older, apparently, only in the degree, yet to be determined, in which the growth of intelligence is required to follow a phylogenetic order.

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