

With 209 Illustrations

HAECKEL'S
GREATEST WORK

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THE
**EVOLUTION OF
MAN**



ERNST HAECKEL, A.C.

Vol. I.

HUMAN EMBRYOLOGY, OR ONTOGENY

WATTS & CO.,

17, JOHNSON'S COURT, FLEET STREET, LONDON, E.C.

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THE EVOLUTION OF MAN

A POPULAR SCIENTIFIC STUDY

BY
ERNST HAECKEL

Vol. I.
HUMAN EMBRYOLOGY OR ONTOGENY

TRANSLATED FROM THE FIFTH (ENLARGED) EDITION BY JOSEPH McCABE

[ISSUED FOR THE NATIONALIST PRESS ASSOCIATION, LIMITED]

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GLOSSARY

- ACRANIA** : animals without skull (*cranium*)
- ANTHROPOGENY** : the evolution (*genesis*) of man (*anthropos*)
- ANTHROPOLOGY** : the science of man
- ARCHI-** : (in compounds) the first or typical
—*as*, *archi-cytula*, *archi-gastrula*, etc.
- BIOGENY** : the science of the genesis of life (*bios*)
- BLAST-** : (in compounds) pertaining to the early embryo (*blastos* = a bud); hence :—
- Blastoderm** : skin (*derma*) or enclosing layer of the embryo
- Blastosphere** : the embryo in the hollow sphere stage
- Blastula** : same as preceding
- Epiblast** : The outer layer of the embryo (*ectoderm*)
- Hypoblast** : the inner layer of the embryo (*entoderm*)
- BRANCHIAL** : pertaining to the gills (*branchia*)
- CARYO-** : (in compounds) pertaining to the nucleus (*caryon*); hence :—
- Caryokinesis** : the movement of the nucleus
- Caryolysis** : dissolution of the nucleus
- Caryoplasm** : the matter of the nucleus
- CENTROLECITHAL** : see under **LECITH-**
- CHORDARIA** and **CHORDONIA** : animals with a dorsal chord or back-bone
- CÆLOM** or **CÆLOMA** : the body-cavity in the embryo; hence :—
- Cœlenterata** : animals without a body-cavity
- Cœlomaria** : animals with a body-cavity
- Cœlomation** : formation of the body-cavity
- CYTO-** : (in compounds) pertaining to the cell (*cytos*); hence :—
- Cytoblast** : the nucleus of the cell
- Cytodes** : cell-like bodies, imperfect cells
- Cytoplasm** : the matter of the body of the cell
- Cytosoma** : the body (*soma*) of the cell
- CRYPTORCHISM** : abnormal retention of the testicles in the body
- DEUTOPLASM** : see **PLASM**
- DUALISM** : the belief in the existence of two entirely distinct principles (such as matter and spirit)
- DYSTELEOLOGY** : the science of those features in organisms which refute the "design-argument"
- ECTODERM** : the outer (*ekto*) layer of the embryo
- ENTODERM** : the inner (*ento*) layer of the embryo
- EPIDERM** : the outer layer of the skin
- EPIGENESIS** : the theory of gradual development of organs in the embryo
- EPIPHYSIS** : the third or central eye in the early vertebrates
- EPISOMA** : see **SOMA**
- EPITHELIA** : tissues covering the surface of parts of the body (such as the mouth, etc.)
- GONADS** : the sexual glands
- GONOCHORISM** : separation of the male and female sexes
- GONOTOMES** : sections of the sexual glands
- GYNEMAST** : a male with the breasts (*masta*) of a woman (*gyne*)
- HEPATIC** : pertaining to the liver (*hepar*)
- HOLOBLASTIC** : embryos in which the animal and vegetal cells divide equally (*holon* = whole)
- HYPERMASTISM** : the possession of more than the normal breasts (*masta*)
- HYPBRANCHIAL** : underneath (*hypo*) the gills
- HYPOPHYSIS** : sensitive-offshoot from the brain in the primitive vertebrate
- HYPOSOMA** : see **SOMA**

LECITH-: pertaining to the yolk (*lecithus*); hence:—

Centrolecithal: eggs with the yolk in the centre

Lecithoma: the yolk-sac

Telolecithal: eggs with the yolk at one end

MEROBLASTIC: cleaving in part (*meron*) only

META-: (in compounds) the "after" or secondary stage; hence:—

Metagaster: the secondary or permanent gut (*gaster*)

Metaplasm: secondary or differentiated plasm

Metastoma: the secondary or permanent mouth (*stoma*)

Metazoa: the higher or later animals, made up of many cells

Metovum: the mature or advanced ovum

METAMERA: the segments into which the embryo breaks up

METAMERISM: the segmentation of the embryo

MONERA: the most primitive of the unicellular organisms

MONISM: belief in the fundamental unity of all things

MORPHOLOGY: the science of organic forms (generally equivalent to anatomy)

MYOTOMES: segments into which the muscles break up

NEPHRA: the kidneys; hence:—

Nephridia: the rudimentary kidney-organs

Nephrotomes: the segments of the developing kidneys

ONTOGENY: the science of the development of the individual (generally equivalent to embryology)

PERIGENESIS: the genesis of the movements in the vital particles

PHAGOCYTES: cells that absorb food (*phagein* = to eat)

PHYLOGENY: the science of the evolution of species (*phyla*)

PLANOCYTES: cells that move about (*planein*)

PLASM: the colloid or jelly-like matter of which organisms are composed; hence:—

Caryoplasm: the matter of the nucleus (*caryon*)

Cytoplasm: the matter of the body of the cell

Deutoplasm: secondary or differentiated plasm

Metaplasm: same as preceding

Protoplasm: primitive or undifferentiated plasm

PLASSON: the simplest form of plasm

PLASTIDULES: small particles of plasm

POLYSPERMISM: the penetration of more than one sperm-cell into the ovum

PRO- or **PROT-**: (in compounds) the earlier form (opposed to **META**); hence:—

Prochorion: the first form of the chorion

Progaster: the first or primitive stomach

Pronephridia: the earlier form of the kidneys

Prerenal: same as preceding

Prostoma: the first or primitive mouth

Protists: the earliest or unicellular organisms

Provertebræ: the earliest phase of the vertebræ

Protophyta: the primitive or unicellular plants

Protoplasm: undifferentiated plasm

Protozoa: the primitive or unicellular animals

RENAL: pertaining to the kidneys (*renes*).

SCATULATION: packing or boxing-up (*scatula* = a box)

SCLEROTOMES: segments into which the primitive skeleton falls

SOMA: the body; hence:—

Cytosoma: the body of the cell (*cytos*)

Episoma: the upper or back-half of the embryonic body

Somites: segments of the embryonic body

Hyposoma: the under or belly-half of the embryonic body

TELEOLOGY: the belief in design and purpose (*telos*) in nature

TELOLECITHAL: see **LECITH-**

UMBILICAL: pertaining to the navel (*umbilicus*)

VITELLINE: pertaining to the yolk (*vitellus*)

PREFACE

[BY JOSEPH McCABE]

THE work which we now place within the reach of every reader of the English tongue is one of the finest productions of its distinguished author. The first edition appeared in 1874. At that time the conviction of man's natural evolution was even less advanced in Germany than in England, and the work raised a storm of controversy. Theologians—forgetting the commonest facts of our individual development—spoke with the most profound disdain of the theory that a Luther or a Goethe could be the outcome of development from a tiny speck of protoplasm. The work, one of the most distinguished of them said, was “a fleck of shame on the escutcheon of Germany.” To-day its conclusion is accepted by influential clerics, such as the Dean of Westminster, and by almost every biologist and anthropologist of distinction in Europe. Evolution is not a laboriously reached conclusion, but a guiding truth, in biological literature to-day.

There was ample evidence to substantiate the conclusion even in the first edition of the book. But fresh facts have come to light in each decade, always enforcing the general truth of man's evolution, and at times making clearer the line of development. Professor Haeckel embodied these in successive editions of his work. In the fifth edition, of which this is a translation, reference will be found to the very latest facts bearing on the evolution of man, such as the discovery of the remarkable effect of mixing human blood with that of the anthropoid ape. Moreover, the ample series of illustrations has been considerably improved and enlarged; there is no scientific work published, at a price remotely approaching that of the present edition, with so abundant and excellent a supply of illustrations. When it was issued in Germany, a few years ago, a distinguished biologist wrote in the *Frankfurter Zeitung* that it would secure immortality for its author, the most notable critic of the idea of immortality. And the *Daily Telegraph* reviewer described the English version as a “handsome edition of Haeckel's monumental work,” and “an issue worthy of the subject and the author.”

The influence of such a work, one of the most constructive that Haeckel has ever written, should extend to more than the few hundred readers who are able to purchase the expensive volumes of the original issue. Few pages in the story of science are more arresting and generally instructive than this great picture of “mankind in the making.” The horizon of the mind is healthily expanded as we follow the search-light of science down the vast avenues of past time, and gaze on the uncouth forms that enter

into, or illustrate, the line of our ancestry. And if the imagination recoils from the strange and remote figures that are lit up by our search-light, and hesitates to accept them as ancestral forms, science draws aside another veil and reveals another picture to us. It shows us that each of us passes, in our embryonic development, through a series of forms hardly less uncouth and unfamiliar. Nay, it traces a parallel between the two series of forms. It shows us man beginning his existence, in the ovary of the female infant, as a minute and simple speck of jelly-like plasm. It shows us (from analogy) the fertilised ovum breaking into a cluster of cohering cells, and folding and curving, until the limb-less, head-less, long-tailed foetus looks like a worm-shaped body. It then points out how gill-slits and corresponding blood-vessels appear, as in a lowly fish, and the fin-like extremities bud out and grow into limbs, and so on; until, after a very clear ape-stage, the definite human form emerges from the series of transformations.

It is with this embryological evidence for our evolution that the present volume is concerned. There are illustrations in the work that will make the point clear at a glance. Possibly *too* clear; for the simplicity of the idea and the eagerness to apply it at every point have carried many, who borrow hastily from Haeckel, out of their scientific depth. Haeckel has never shared their errors, nor encouraged their superficiality. He insists from the outset that a complete parallel could not possibly be expected. Embryonic life itself is subject to evolution. Though there is a general and substantial law—as most of our English and American authorities admit—that the embryonic series of forms recalls the ancestral series of forms, the parallel is blurred throughout and often distorted. It is not the obvious resemblance of the embryos of different animals, and their general similarity to our extinct ancestors in this or that organ, on which we must rest our case. A careful study must be made of the various stages through which all embryos pass, and an effort made to prove their real identity and therefore genealogical relation.

This is a task of great subtlety and delicacy. Many scientists have worked at it together with Professor Haeckel—I need only name our own Professor Balfour and Professor Ray Lankester—and the scheme is fairly complete. But the general reader must not expect that even so clear a writer as Haeckel can describe these intricate processes without demanding his very careful attention. Most of the chapters in the present volume (and the second volume will be less difficult) are easily intelligible to all; but there are points at which the line of argument is necessarily subtle and complex. In the hope that most readers will be induced to master even these more difficult chapters, I will give an outline of the characteristic argument of the work. Haeckel's distinctive services in regard to man's evolution have been: (1) The construction of a complete ancestral tree, though, of course, some of the stages in it are purely conjectural, and not final; (2) The tracing of the remarkable reproduction of ancestral forms in

the embryonic development of the individual. Naturally, he has not worked alone in either department. The second volume of this work will embody the first of these two achievements; the present one is mainly concerned with the latter. It will be useful for the reader to have a synopsis of the argument and an explanation of some of the chief terms invented or employed by the author.

The main theme of the work is that, in the course of their embryonic development, all animals, including man, pass roughly and rapidly through a series of forms which represents the succession of their ancestors in the past. After a severe and extensive study of embryonic phenomena, Haeckel has drawn up a "law" (in the ordinary scientific sense) to this effect, and has called it "the biogenetic law," or the chief law relating to the evolution (*genesis*) of life (*bios*). This law is widely and increasingly accepted by embryologists and zoologists. It is enough to quote a recent declaration of the great American zoologist, President D. Starr Jordan: "It is, of course, true that the life-history of the individual is an epitome of the life-history of the race"; while a distinguished German zoologist (Sarasin) has described it as being of the same use to the biologist as spectrum analysis is to the astronomer.

But the reproduction of ancestral forms in the course of the embryonic development is by no means always clear, or even always present. Many of the embryonic phases do not recall ancestral stages at all. They may have done so originally, but we must remember that the embryonic life itself has been subject to adaptive changes for millions of years. All this is clearly explained by Professor Haeckel. For the moment, I would impress on the reader the vital importance of fixing the distinction from the start. He must thoroughly familiarise himself with the meaning of five terms. *Biogeny* is the development of life in general (both in the individual and the species), or the sciences describing it. *Ontogeny* is the development (embryonic and post-embryonic) of the individual (*on*), or the science describing it. *Phylogeny* is the development of the race or stem (*phulon*), or the science describing it. Roughly, *ontogeny* may be taken to mean embryology, and *phylogeny* what we generally call evolution. Further, the embryonic phenomena sometimes reproduce ancestral forms, and they are then called *palingenetic* (from *palin* = again); sometimes they do not recall ancestral forms, but are later modifications due to adaptation, and they are then called *cenogenetic* (from *kenos* = new or foreign). These terms are now widely used, but the reader of Haeckel must understand them thoroughly.

The first five chapters are an easy account of the history of embryology and evolution. The sixth and seventh give an equally clear account of the sexual elements and the process of conception. But some of the succeeding chapters must deal with embryonic processes so unfamiliar, and pursue them through so wide a range of animals in a brief space,

that, in spite of the 200 illustrations, they will offer difficulty to many a reader. As our aim is to secure, not a superficial acquiescence in conclusions, but a fair comprehension of the truths of science, we have retained these chapters. However, I will give a brief and clear outline of the argument, so that the reader with little leisure may realise their value.

When the animal ovum (egg-cell) has been fertilised, it divides and sub-divides until we have a cluster of cohering cells, externally not unlike a raspberry or mulberry. This is the *morula* (= mulberry) stage. The cluster becomes hollow, or filled with fluid in the centre, all the cells rising to the surface. This is the *blastula* (hollow ball) stage. One half of the cluster then bends or folds in upon the other, as one might do with a thin indiarubber ball, and we get a vase-shaped body with hollow interior (the first stomach, or "primitive gut"), an open mouth (the first or "primitive mouth"), and a wall composed of two layers of cells (two "germinal layers"). This is the *gastrula* (stomach) stage, and the process of its formation is called *gastrulation*. A glance at the illustration on p. 61 will make this perfectly clear.

So much for the embryonic process in itself. The application to evolution has been a long and laborious task. Briefly, it was necessary to show that *all* the multicellular animals passed through these three stages, so that our biogenetic law would enable us to recognise them as reminiscences of ancestral forms. This is the work of Chaps. VIII. and IX. The difficulty can be realised in this way: As we reach the higher animals the ovum has to take up a large quantity of yelk, on which it may feed in developing. Think of the bird's "egg." The effect of this was to flatten the germ (the *morula* and *blastula*) from the first, and so give, at first sight, a totally different complexion to what it has in the lowest animals. When we pass the reptile and bird stage, the large yelk almost disappears (the germ now being supplied with blood by the mother), but the germ has been permanently altered in shape, and there are now a number of new embryonic processes (membranes, blood-vessel connections, etc.). Thus it was no light task to trace the identity of this process of *gastrulation* in all the animals. It has been done, however; and with this introduction the reader will be able to follow the proof. The conclusion is important. If all animals pass through the curious *gastrula* stage, it must be because they all had a common ancestor of that nature. To this conjectural ancestor (it lived before the period of fossilisation begins) Haeckel gives the name of the *Gastræa*, and in the second volume we shall see a number of living animals of this type ("gastræads").

The line of argument is the same in the next chapter. After laborious and careful research (though this stage is not generally admitted in the same sense as the previous one), a fourth common stage was discovered, and given the name of the *Cœlomula*. The *blastula* had one layer of cells, the *blastoderm* (*derma* = skin): the *gastrula* two layers, the *entoderm* ("outer skin") and *ectoderm* ("inner skin"). Now a third layer (*mesoderm*

= middle skin) is formed, by the growth inwards of two pouches or folds of the skin. The pouches blend together, and form a single cavity (the body cavity, or *cœlom*), and its two walls are two fresh "germinal layers." Again, the identity of the process has to be proved in all the higher classes of animals, and when this is done we have another ancestral stage, the *Cœlomata*.

The remaining task is to build up the complex frame of the higher animals—always showing the identity of the process (on which the evolutionary argument depends) in enormously different conditions of embryonic life—out of the four "germinal layers." Chap. IX. prepares us for the work by giving us a very clear account of the essential structure of the back-boned (vertebrate) animal, and the probable common ancestor of all the vertebrates (a small fish of the lancelet type). Chaps. XI.-XIV. then carry out the construction step by step. The work is now simpler, in the sense that we leave all the invertebrate animals out of account; but there are so many organs to be fashioned out of the four simple layers that the reader must proceed carefully. In the second volume each of these organs will be dealt with separately, and the parallel will be worked out between its embryonic and its phylogenetic (evolutionary) development. The general reader may wait for this for a full understanding. But in the meantime the wonderful story of the construction of all our organs in the course of a few weeks (the human frame is perfectly formed, though less than two inches in length, by the twelfth week) from so simple a material is full of interest. It would be useless to attempt to summarise the process. The four chapters are themselves but a summary of it, and the eighty fine illustrations of the process will make it sufficiently clear. The last chapter carries the story on to the point where man at last parts company with the anthropoid ape, and gives a full account of the membranes or wrappers that enfold him in the womb, and the connection with the mother.

In conclusion, I would urge the reader to consult, at his free library perhaps, the complete edition of this work, when he has read the present abbreviated edition. Much of the text has had to be condensed in order to bring out the work at our popular price, and the beautiful plates of the complete edition have had to be omitted. The reader will find it an immense assistance if he can consult the library edition. He must remember, too, that the present volume is only half the work. A second and longer volume, illustrated with equal generosity, will shortly be issued. This second volume will endeavour to trace the line of man's ancestry from the primeval microbe right up to the ape-man of Java, in a long series of chapters, and with illustrations of every step, and will also deal separately with the evolution of each set of organs in the body. A glossary will be found at the beginning of each volume, and an index to the two volumes will be printed at the end of the second volume.

JOSEPH McCABE.

HAECKEL'S CLASSIFICATION OF THE ANIMAL WORLD

Unicellular animals (Protozoa)

- | | | |
|------------------|----------------------------------|--|
| 1. Unnucleated | { Bacteria
Protamæbæe } | } Monera |
| 2. Nucleated | { a. Rhizopoda
b. Infusoria } | { Amœbina
Radiolaria
Flagellata
Ciliata } |
| 3. Cell-colonies | { Catallacta
Blastæada } | |

Multicellular animals (Metazoa)

- | | | |
|--|---|---|
| I
Cœlentera,
Cœlenterata, or
Zoophytes.
Animals without
body-cavity, blood
or anus. | { a. Gastræads
b. Sponges
c. Cnidaria
(stinging animals)
d. Platodes
(flat-worms) } | { Gastremaria
Cyemaria
Protospongiæ
Metaspongiæ
Hydrozoa
Polyps
Medusæ
Platodaria
Turbellaria
Trematoda
Cestoda
Rotatoria
Strongylaria
Prosopygia
Frontonia
Cochlides
Conchades
Teuthodes
Annelida
Crustacea
Tracheata
Monorchonia
Pentorchonia
Copelata
Ascidia
Thalidiaz
I. Acrania-Lancelet
(without skull)
II. Craniota
(with skull)
a. Cyclostomes
("round-mouthed")
b. Fishes
c. Amphibia
d. Reptiles
e. Birds } |
| II
Cœlomaria or
Bilaterals.
Animals with body-
cavity and anus,
and generally
blood. | { a. Vermalia
(worm-like)
b. Molluscs
c. Articulates
d. Echinoderms
e. Tunicates
f. Vertebrates } | { Selachii
Ganoids
Teleosts
Dipneusts

{ Monotremes
Marsupials
Placentals :—
Rodents
Edentates
Ungulates
Cetacea
Sirenia
Insectivora
Cheiroptera
Carnassia
Primates } |

¹ This classification is given for the purpose of explaining Hæckel's use of terms in this volume. The general reader should bear in mind that it differs very considerably from more recent schemes of classification. He should compare the scheme framed by Professor E. Ray Lankester.