CORNELL
UNIVERSITY
LIBRARY

BOUGHT WITH THE INCOME
OF THE SAGE ENDOWMENT
FUND GIVEN IN 1891 BY
HENRY WILLIAMS SAGE

Cornell University Library
QH 366.R96

Evolution of continuity in the natural w

3 1924 024 754 487

Cornell University Library

The original of this book is in
the Cornell University Library.

There are no known copyright restrictions in
the United States on the use of the text.

http://www.archive.org/details/cu31924024754487

THE EVOLUTION OF CONTINUITY IN THE NATURAL WORLD

THE EVOLUTION *of* CONTINUITY *in the* NATURAL WORLD

By DAVID RUSSELL, M.D.

DIRECTOR OF THE BRITISH HOSPITAL,
AND DOCTOR TO THE BRITISH LEGATION, LISBON

LONDON: GEORGE ALLEN & UNWIN LTD.
RUSKIN HOUSE, 40 MUSEUM STREET, W.C. 1

Do

First published in 1922

(All rights reserved)

PREFACE

THIS book is a modest attempt to show that there is one Evolutionary Principle ruling in all Nature; that, true to this principle, all Matter has, as it were, evolved into being, and the many fundamental species of dead and living Matter have been differentiated. Also, that the outstanding phenomena of living Growth and Reproduction reflect the action of the Common Factor behind all Evolution.

The greater part of the book is, however, concerned with the evolution of living Species, and the development of the theory that this is based on our fundamental evolutionary principle, the Evolution of Continuity.

It is curious that though the general principle of Natural Evolution is on an unshakeable basis, the bed-rock of the process has never been clearly displayed. Perhaps one explanation of this may be that all workers have been under the influence of the aphorism, "Natura non facit saltum." Thus, attention has been specially given to resemblances between nearly related types and, following Darwin's lead, to the variation resulting from artificial selection; it being taken for granted that if we could see all the past evolutionary road, this would be revealed as a continuous chain each of whose links was a step onwards in a more or less gradual transformation. The specially large gaps in the road are attributed to lost evidence, to an imperfect geological record, and their mystery has been accepted as impenetrable in the continued absence of new fossil discoveries.

While, no doubt, a more perfect geological record would provide us with wonderful information, yet it is suggested that very large gaps in the road would still remain to be explained. For it is our belief that Nature does take leaps, small and large, and our purpose is to show this. Modification is in its essence always sudden.

It is the fundamental architectural plan of living types with which we shall deal, and the following questions serve to indicate the direction of our theory:—

How is it that in Nature we have living Individuals composed of separate, independent cells or protoplasts, alongside of other Individuals composed of long filaments or single-celled series? How is it that there are Individuals composed of many separate little cylinders or tubes, each built up of cells united in tissue-continuity? Or how have been produced Individuals composed of many such tubes united together?

Or what of the organism with a central tube leading to radially arranged chambers, or of the colony composed of many such organisms united in continuity?

These are fundamental questions, and they can be answered in harmony with our common principle, and, be it noted, through a study of present-day living types and not through the geological record.

It is through the Individual types of present-day living Continuity that the main features of Evolution's main road can rise before us, a true classification of living organisms be made in terms of living Continuity, and the Fundamental be distinguished from the Sub-species.

D. R.

CONTENTS

PAGE

Preface 5

Introduction 19

CHAPTER I

Attraction and Repulsion 23

The recognition of Cause more important than that of Purpose—Relation between Growth and Reproduction—Attraction and Repulsion—The universality of the two opposing forces—The antithetic basis of a character—Equilibrium and Matter—Atoms and molecules—Dissociation and decomposition—The atomic cycle of Attraction-Repulsion-Attraction—Suggested definition of Life—All Growth is cyclical.

CHAPTER II

The Unit Growth-cycle 32

The unit growth-cycle, an act of attraction followed by one of repulsion—The basis of all growth-cycles.

CHAPTER III

Protoplasm. The Individual 35

Protoplasm a mixture—" Basoplasm "—All Growth is evolution on main and side paths—There are species of atoms, molecules, and cells, as well as of organic types—The " plasmolecule "—The amœba—The plasmolecular cycle—Definition of the " Individual "—A unicellular Individual an improbability—The multicellular cycle—Suggested basic propositions regarding Growth.

CHAPTER IV

The Discontinuously Multicellular Individual . . 42

Its general features—The malarial amœba—Its asexual and sexual cycles not true cycles—Cycle-advance with each successive sporulation—The complete Individual all gametes; this because of Discontinuity—The size of the Individual must have its inevitable limits—The true hæmamœba cycle—The law of " 2 to the Nth "—Fundamental significance of branching—Sphærella—A true gamete may develop vegetatively, without conjugation.

CHAPTER V

PAGE

THE FILAMENTOUS INDIVIDUAL 49

Cell-continuity in its simplest form—Continuity introduces Arrest—Environment and its wide significance—Always in terms of attraction or repulsion classifiable as suitable or unsuitable—The mutual attraction of cells has had no part in the evolution of cellular continuity—A special factor necessary as a compressing agency—Living Continuity has evolved by leaps and bounds—Temporary and Permanent cell-arrest—The price of Continuity is Cell-arrest—The four all-important laws of Growth—Spirogyra—Theory of the development of its growth-cycle—Cell-intercalation—Sexes of filaments—Progressive diminution—Ædogonium supports Spirogyra theory—Parthenogenesis and Alternation of Generations—Alternation of Cycle-stages.

CHAPTER VI

THE CŒNOCYTIC INDIVIDUAL 59

Lateral Continuity—Cœnocytic Continuity not on main road of Continuity's evolution—Mucor as an example of Cœnocytic Individual—Comparison of mycelial hypha with cell-filament—*Mucor mucedo*—Mycelial alternation of generations—"Torula" condition in Mucor—False Tissue; a multiplication of Continuity *within the Individual,* and connected with reproduction—In Eurotium; in Agaricus.

CHAPTER VII

BACTERIA 67

Restricted sense in which the term is here employed—A bacterium probably not a unicellular "Individual"—The bacillary filament or cœnocyte; its possible significance.

CHAPTER VIII

THE DISCONTINUOUSLY ZOOIDAL INDIVIDUAL . . . 70

Its general characters—Serial and Lateral Continuity—The strict definition of a "zooid"—The freshwater Hydra; its description—Discontinuous gemmation—Sexual reproduction in Hydra—Possibility of zooidal progressive diminution—Effects of mutilation in Hydra—Discontinuity produces Release from Arrest—Alternation of generations—Graphic representation of Continuity's evolution up to the Discontinuously Zooidal Individual.

CHAPTER IX

THE CONTINUOUSLY ZOOIDAL INDIVIDUAL 77

Demonstrates the further intensification of Continuity—Diagram showing this—Continuity produces Arrest—Zooidal arrest—Striking examples of alternation of generations offered by this type of Individual—Hydrozoal colonies—All Hydrozoa not Continuously Zooidal Individuals; and many Hydrozoal colonies not strictly so; reason why—Terminal compression and "megazooidal" Continuity.

Chapter X

PAGE

Megazooidal Individuals. The Monomegazooidal Individuals 82

Summary of Continuity's evolution up to the Megazooidal Individual—The alternation of Serial with Lateral Continuity—The three classes of Megazooidal Individual—The first is the Monomegazooidal, and of it there are two types:
(1) The Sea-anemone type—General description—Its megazooid represents a multiplication of Continuously Zooidal Continuity—Reasons supporting this view—Illustration of wax model—The multiplication of Continuity must have occurred during development.
(2) The Medusoid type—Its Continuity fundamentally similar to that of the Sea-anemone type—The two different plans explained—Hydrozoal colonies and the formation of the sporosac—The evolution of the sporosac-gonoblastidium—The evolution of the medusiform "gonophore"; its structure—The sea-anemone contrasted with the medusoid type of megazooid—The "open cœlom."
The Individual Medusa.

Chapter XI

The Discontinuously Megazooidal Individual. The Continuously Megazooidal Individual . . . 102

Description of the Discontinuously Megazooidal Individual—Aurelia as an example—Development of Aurelia—Interpretation of the Continuity of the "strobila."
The Continuously Megazooidal Individual—Compound Corals—Megazooidal serial Continuity.

Chapter XII

The Radiate Individual 107

Exemplified by Echinodermata—These have not evolved on Evolution's main road—The Starfish—Difficult to classify the Echinoderms in terms of living Continuity; they, however, show distinct evidences of medusoid derivation—The closed cœlom; the excretory anus—Suggestions regarding the evolution of the sea-urchin and starfish—Possibility of the Echinoderms being debased Segmental Individuals of a kind.

Chapter XIII

Segmental Individuals 112

Segmental Individuals have not been divided into segments, but "built up" in segments—The significance of the "segment"—Segmental organisms not necessarily Individuals—Discontinuous and Continuous Segmental Individuals; through the latter passed the main road of Evolution.
The Continuous Segmental Individual—Example, the Earthworm; brief description—Suggested theory of the Earthworm's evolution, and explanation of the animal's Continuity—The different forms of living Continuity have appeared as the fundamental Acquired variations behind all living Evolution.

CHAPTER XIV

PAGE

CONTROL. ARREST 122

Control, and the preservation of Identity and Equilibrium—Atomic, plasmolecular, and nuclear control—Control in the ascending scale of Individual Continuity—Control cannot obtain apart from Continuity.

Arrest—Fundamentally, Environment produces Arrest—The limits to Environment's powers—The different ways in which Arrest is manifested—Temporary and Permanent Arrest—Nature is really not prodigal; in all but lower forms of Life, she arrests more than she releases from Arrest—The evolution of the fixed cell-species—Breach of Continuity and Release from Arrest—Restoration of lost parts—The interesting case of Amphioxus.

CHAPTER XV

HEREDITY. NATURAL AND ACQUIRED VARIATIONS . . 133

Theory of transmission of parental characters—Always Variation in offspring—The two chief classes of Variations; the Natural, and the Acquired.

Natural Variations; three main forms—Sex possibly a matter of natural variation—Fertilisation involves Variation.

Acquired Variations—The acquisition of a variation is essentially a sudden process—Environment the basic factor at work in the acquisition of variations—Every acquired variation is "adaptive," and useful for life in the environmental conditions which produced it—Acquisition of variation implies environmental change of some sort—All natural characters *originated* in acquired variation—Life began as acquired variation—The basic variations acquired by Life were the successive multiplications of Continuity.

Transmission of Acquired Variations—Reasons for holding that it can occur and has occurred—The case of the Tortoiseshell butterfly—For a variation to be acquired the modifying force must act during development—Experimental evidence that acquired variations can reappear in the offspring—Quoted explanation not satisfactory—The earlier the application of the modifying force on the devoloping growth-cycle, the more correct ought to be the "transmission" of the resulting variations—A useless variation cannot be acquired—Recapitulation.

CHAPTER XVI

THE EVOLUTION OF CONTINUITY 147

We must distinguish (1) the evolution of the different types of living Continuity from (2) the evolution of different species within each Continuity-type—Present chapter deals with former question—Probability that the main road of evolution, leading to Man, has not passed through any of the organisms actually known to us, past or present—The testimony of the rocks throws little light on the Evolution of Continuity—It is to the living world of the present time that we must turn for information.

The formation of the Globe; a process of Continuity-intensification—The "Nebular Hypothesis"—The alternation of Attraction and Repulsion—The appearance of the first life on the globe must have marked a stage in the evolution of Continuity—The Living evolved from the Inorganic—Primitive Life enjoyed an aqueous environment—At the present day the waters of the globe provide examples of living Continuity which clearly indicate the past main road of Evolution—This road ran in an aqueous environment right

PAGE

up to a high form of Segmental Continuity—The sea has been the great storehouse from which, from time to time, the earth has received its primitive terrestrial types—How the "gaps" in the evolutionary chain can be explained—The step from one form of Continuity to a higher form must always have been sudden. At each step a certain proportion of the Continuity-type in question developed as a new type with multiplied Continuity, while the remainder bred true to type as regards Continuity, or were "permanently arrested" as regards Continuity—Parallel between growth-cycle evolution and that of Continuity-types in Nature's body—The action of Environment in producing, maintaining, and intensifying Continuity—Force of Gravity—No multiplication of Continuity has taken place on land as it has in water, but the successive terrestrial Continuity-types are all probably derivatives and representatives of ancestral fixed marine Continuity-types.

CHAPTER XVII

THE EVOLUTION OF CONTINUITY (*continued*) 158

The crust of the earth; its strata, and sections—Successive Continuity-types do not regularly appear as fossil remains with successive strata—In the earliest ages all the known forms of Continuity had already evolved; this is known by the fossils found in Silurian rocks.

Force of Attraction, as an indirectly compressing agency, has been the factor which produced the successive forms of living Continuity—Attraction has all along acted as Gravity, or terrestrial attraction—How Gravity may have produced its results—Relative density—Water-pressure—The production of Filamentous Continuity—The diminution of cell-density with development—The evolution of the Zooid, and megazooid—Suggestion that the repeated multiplication of Continuity may have been due to the development of fertilised ova under higher water-pressure conditions than usually obtaining—The factor responsible for fertilised ova being brought to develop in these increased pressure conditions would be SEGREGATION, or Repulsion acting in special ways—Different forms of Segregation, and their probable effects—It may be that as many strata were laid down before the Silurian Period as have been deposited since that time.

CHAPTER XVIII

THE EVOLUTION OF PHANÆROGAMS 169

The main groups of the Vegetable Kingdom—Theory to the effect that each group may have a distinct derivation from a marine type which exhibited an identical form of Continuity—The chapter briefly deals with the origin of the Phanærogams—The views generally held at the present time regarding the evolution of Phanærogams—Some new suggestions—Marine zooidal colonies; their "cones" and "flowers"—The sporosac; the sporosac-gonoblastidium and the Gymnosperm cone—The evolution of the medusiform gonophore, and of the gonoblastidium containing such gonophores—The Angiosperms came suddenly into existence; probably not as an offshoot from the disappearing Cycadophytes, but as a new type suddenly derived from a primitive Hydrozoal type possessing some form of medusiform gonophore—The Gymnosperms would be derived in an earlier age from a still more primitive Hydrozoal type which possessed sporosac-gonoblastidia—The homologies of the medusiform gonophore and the typical Angiosperm flower.

CHAPTER XIX

PAGE

THE EVOLUTION OF THE VERTEBRATE 180

What was probably the plan of the marine segmental type from which Man evolved ?—The megazooidal derivation this type must have had—The light which Aurelia throws on the subject—Man evolved from a primitive piscine type.

The evolution of the typical Fish—How the Fish's ancestry must have been serially-medusoid in structure—The evolution of the Fish's respiratory and circulatory systems—The nectocalycine canals and the branchial arches—The formation of mouth and gill-clefts—Terminal compression—The probable factors which called for the formation of a heart and the institution of a circulatory system—The closure of the vessel system—The first beats of the heart—The circulatory system of Sænuris—The evolution of the Fish's nervous system—The alimentary tract.

CHAPTER XX

THE EVOLUTION OF THE ATYPICAL FISH 196

The "Atypical Fish" exemplified by the Cephalopod—The effects of the absence of locomotion in the primitive type—How a terminally compressed head would come to be formed at the end which in the Typical Fish becomes the tail end—The formation of a primitive brain ; of gill-cleft, and of vascular and respiratory systems—The factor of the rhythmic contraction of body-walls—The branchial arches ; the alimentary tube, and the formation of an anus—Support for foregoing suggestions from the structure of the present-day Cuttlefish—Its general anatomy—Further support from the methods of Cuttlefish movement—Man has not evolved through a primitive Cephalopod type.

CHAPTER XXI

THE EVOLUTION OF MATTER 204

Indications that Matter has evolved into being, and has done so through the Intensification of Continuity—Matter and Force—The possibility of the "ultimate unit" of Matter being an "insulated" force-system—Through the alternation of Attraction and Repulsion, the former force being dominant, an ascending scale of Matter-systems could have resulted, each manifesting a multiplication of its forerunner's Continuity ; after the manner already shown to have occurred with living Continuity-types—Matter is Potential Energy

Electrons, and Atoms—The different species of atoms and elements—The significance of their distinctive atomic weights—The Periodic Law, or Law of Octaves—Probably a key to the problem—Some possibilities the Periodic Law suggests.

CHAPTER XXII

THE ORIGIN OF SPECIES 211

The term used here in the sense of the Origin of Sub-species within the Fundamental Species of Continuity.

Rough outline of Darwin's theory—Some objections to the theory—Several new propositions in connection with the Origin of Species—The Mutation Theory.

CHAPTER XXIII

PAGE

THE EVOLUTION OF SYMMETRY 217

Symmetry of Form accompanying Continuity is here dealt with—The result of special factor, and one necessarily exercising symmetrical power—The symmetry of the Discontinuously Multicellular Individual is that of Numbers; this is not the basis of Symmetry of Form in cellularly-continuous organisms.
Symmetry of Form finds its explanation in terms of Attraction and Repulsion—The action of the former force more important—Three ways in which Attraction has probably acted: as (1) Terrestrial, (2) as Solar, and (3) as Food Attraction—The different ways in which Terrestrial Attraction, or Gravity, has acted, and continues to act—Directly—Indirectly, as atmospheric and as water-pressure—Specific Gravity—Solar and Food attraction frequently compete with Gravity; Gravity also competes with itself—The share of Repulsion in producing Symmetry—Cells grow in Continuity not as the result of mutual attraction, but owing to external compressing force; owing to Gravity—The production of the symmetry of the discontinuous Zooid; of the Megazooid.

CHAPTER XXIV

SEGMENTAL BILATERAL SYMMETRY 224

Symmetry of Form in the Fish—Gravity, alone, could not have made the Fish symmetrical; Food-attraction has shared in the process—Movement during development, in presence of water pressure, would give the developing primitive Fish a symmetrically tapering form, but could not unaided produce the bilateral symmetry the body actually exhibits—The influence of the digestive tract and its contents in the matter—"Ventral ballast"—In all vertebrates the abdominal viscera are pulled by Gravity to face the earth's surface—The swimming-bladder and its functions; its absence in flat fish—The loss of equilibrium in the developing flounder.

CHAPTER XXV

SEGMENTAL BILATERAL SYMMETRY (*continued*) . . . 229

Terminal compression and the Fish's brain—Why this organ develops at the anterior end of the organism—Sources of attraction or repulsion which call for the response of Locomotion demand that this be in as straight a line as possible to or from the source; they call for NO DEVIATION—The attracting and repelling forces would demand the formation of locomotive appendages, and of a kind capable of exercising bilateral symmetry of power—The bilateral symmetry of site and shape of the fish's fins would thus result.
Repulsion induces movement as strongly as Attraction—Repulsion from one point is equivalent to attraction towards another—In movement the chief deviation to be corrected would be lateral—How such correction would demand a duplicate and bilaterally symmetrical brain—How the over-correction of deviation would be avoided—How a crossed motor nerve tract would be inevitable; the decussation of pyramidal tracts—The call for crossed sensory tracts; the decussation of optic tracts—Why there is a spreading

PAGE

out of nerve tracts towards the brain cortex—The situation of cortical motor areas in the vertebrate brain; suggested fundamental explanation—The correction of deviation in Birds and Quadrupeds.

CHAPTER XXVI

ALTERNATION OF GENERATIONS. PARTHENOGENESIS . . 240

Alternation of generations: usual definition—Term itself inappropriate—Alternation of intermediate and Terminal Cycle-stages—this alternation summarised in the successive types of Individual Continuity.
Parthenogenesis—the common definition not satisfactory—The process can only be exhibited by a part of an Individual—Suggestion that the true parthenogenetic cell is never an ovum, but always an intermediate cycle-stage—Loeb's experiment—"non-specific fertilisation."

CHAPTER XXVII

KARYOKINESIS 248

The phenomena are exhibitions of Attraction and Repulsion in action—Three forms of Karyokinesis: with double chromosomes, with single chromosomes, and as it occurs in polar extrusion—Double chromosome karyokinesis; the three main stages of the process, and some suggestions regarding their significance.
Extrusion of Polar Bodies, a form of Karyokinesis—the process described—its significance a mystery.

CHAPTER XXVIII

ABNORMAL GROWTH. TUMOURS 260

The explanation of abnormal growth to be looked for in the light of the laws of normal growth—Two aspects of the question.
Classification of Tumours—The characters of the main varieties—The problem viewed in the light of Arrest, and Release from Arrest—Natural Arrest—Unnatural Arrest.
Tumours which are the result of Escape from Unnatural Arrest—(1) when the unnatural arrest is of late application; (2) when it is applied early—In the former case the tumours are typical, and their growth not completely uncontrolled; in the latter case growth is uncontrolled and atypical—The possibility of a "tumour-Individual" and of "tumour-gametes"—Cancer-bodies—Secondary growth.
Tumours whose origin is due to Escape from Natural Arrest; their nature—The healing of wounds, and the regeneration of tissue—Natural Arrest and Control—The restraining influence of connective-tissue on overlying epithelium—Experiments of Champy—The origination of epitheliomata; some speculations—Cell-damage or breach of Continuity probably always precedes the formation of such tumours—The stroma of malignant tumours.

INDEX 275

ILLUSTRATIONS

FIG. PAGE

1. A method of Continuity-multiplication 21
2. The life-cycle of the malarial parasite 43
3. The true growth-cycle of the malarial parasite . . . 45
4. Illustrating the law of "2 to the Nth minus 1" . . 46
5. Another way of drawing Fig. 4 47
6. Proximal arrest in filamentous development 53
7. Release from proximal filamentous arrest 55
8. Formation of cell-caps in Ædogonium 56
9. The formation of cell-caps in the light of proximal arrest 57
10. Showing the nature of a cœnocyte 61
11. The protoplastic series in mould hyphæ 62
12. The sexual process in Eurotium 64
13. The conidiophore of Agaricus 65
14. Examples of bacterial filament 67
15. Bacterial filamentous branching 68
16. (1) Plan of Hydra zooid. (2) Hydra vulgaris 72
17. Possible zooidal progressive diminution 74
18. Four successive stages in the evolution of Continuity . 77
19. General plan of Hydrozoal colony, and significance of the cœnosarc 80
20. Continuity's evolution from the free cell to the megazooidal series 84
21. A Sea-anemone 85
22. Vertical and transverse sections of Sea-anemone . . 86
23. Transverse section of Adamsia 87
24. To explain the evolution of the Sea-anemone's Continuity 88
25. Additional to Fig. 24 89
26. Sexual repetition in the Sea-anemone 90
27. The Hydrozoal sporosac compared with the vegetative zooid 92
28. Diagram of sporosac-gonoblastidium 93
29. The evolution of the medusiform gonophore 94
30. Structure of free medusiform gonophore 95
31. Vertical section of Sea-anemone contrasted with that of medusiform gonophore 97
32. Imaginary drawing of a Sea-anemone developed on a medusoid plan 98
33. An Individual Medusa 99
34. Development of Aurelia 103

FIG. PAGE
35. The evolution of strobilar continuity 104
36. Astrea pallida, a compound coral 105
37. Cross-section of a simple coral 106
38. Sectional diagram comparing Starfish with Medusa . . 108
39. A suggestion concerning the evolution of Echinoderms . 109
40. A suggestion concerning the evolution of Starfish . . 110
41. The Earthworm's central nervous system 115
42. Significance of Earthworm's Continuity. The "hearts" . 117
43. The evolution of the nervous system of Earthworm . . 120
44. (a) The probable nervous system of the Phanærogam. (b) Diagrammatic Node of Ranvier 124
45. The nervous system of a Sea-anemone 126
46. The main road of Continuity's evolution, and the side-paths, with reference to aqueous and terrestrial environment 152
47i The possible manner of evolution of the tubular zooid . 165
48. The different forms of sexual structure in marine zooidal colonies 172
49. Suggested homologies connected with Gymnosperm evolution 174
50. Site of sexual organs in medusiform gonophores . . . 176
51. Significance of sexual parts of Angiosperm flower . . 176
52. The significance of the perianth 177
53. Diagram of suggested theory of plant-evolution. . . 178
54. The development of Aurelia 181
55. The gills of the typical Fish 182
56. The branchial circulation of typical Fish 183
57. (a) Plan of medusoid "circulatory system." (b) The multiplication of this in continuity. (c) The circulatory system of Sænuris 184
58. Mouth-formation, etc., in primitive Fish 186
59. How the development of the primitive piscine mouth would entail a closed circulatory system 188
60. Formation of mouth and gill-clefts in primitive Fish . 189
61. The evolution of the segmental nerve-chain 192
62. Evolutionary significance of the plans of the Invertebrate and Vertebrate nervous systems 194
63–65. The evolution of the Atypical Fish 197, 198, 199
66. Plan of a Cephalopod 200
67. Table of the Periodic Law 208
68. Effects of water-pressure on the developing evolving primitive Fish 225
69. The Fish's cross-section 226
70. Repulsion from one direction is equivalent to attraction in an opposite one 231
71, 72. Correction of deviation in the evolving Fish . 232, 233
73. The main directions taken by light-waves passing to the primitive Fish's brain 234
74. The course of fibres in human optic tracts 235

FIG. PAGE
75, 76. THE NECESSITY FOR SENSORY DECUSSATION IN THE PRIMITIVE FISH 236
77. THE NECESSITY OF CROSSED MOTOR OPTIC TRACTS 237
78. THE FUNCTIONAL AREAS OF THE RIGHT HUMAN CEREBRAL HEMISPHERE 238
79. ALTERNATION OF CYCLE-STAGES WHERE THERE IS CELL-DISCONTINUITY 241
80. ALTERNATION OF CYCLE-STAGES IN FILAMENTOUS GROWTH . . 241
81. PROTOPLASTIC, CŒNOCYTIC, AND MYCELIAL ALTERNATION OF CYCLE-STAGES 242
82. ALTERNATION OF CYCLE-STAGES IN PRESENCE OF ZOOIDAL DISCONTINUITY 243
83. ALTERNATION OF CYCLE-STAGES IN ZOOIDAL CONTINUITY . . 243
84. CELLS WITH KARYOKINETIC CHROMATIN FIGURES 249
85. THE "MONASTER" AND "DYASTER" 249
86. THE LINES OF MAGNETIC FORCE OF A BAR MAGNET 251
87. THE MAGNETIC FIELD BETWEEN DISSIMILAR POLES 252
88. THE MAGNETIC FIELD BETWEEN SIMILAR POLES 253
89–92. SUGGESTIONS CONCERNING SIGNIFICANCE OF KARYOKINETIC PHENOMENA 254, 255, 256
93. FORMATION OF POLAR BODIES IN ASTERIAS GLACIALIS . . . 257

THE EVOLUTION OF CONTINUITY

INTRODUCTION

BEFORE developing our theory piece by piece it would be well to indicate what is meant by the phrase used in the title of this book—"The Evolution of Continuity." At first sight, no doubt, the words will appear meaningless ; for one would naturally suppose that there could be no evolution from Discontinuity to Continuity ; that from the former to the latter there could be but one step. If, for example, we place two glass beads on a tray at a little distance from each other, the beads are in Discontinuity ; but if we bring them into close touch with each other, or thread them on a string in close contact, they are, we may say, in Continuity. And no matter how slowly we bring them together, there is but one step from Discontinuity to such Continuity as is roughly manifested in contact.

We know that there is no such thing in reality as absolute continuity of matter, and that the very electrons which constitute the atom are separated from each other by space ; that the densest metal is in reality porous owing to intermolecular spaces, and that the cells of our body tissues are not in absolute continuity.[1] But for the purposes of our theory we shall neglect this fact, and the Continuity of which we shall speak, obtaining in the natural world, is the continuity of more or less firm attachment, or such as resists on the whole any forces making for its severance, or for dissipation into wide discontinuity. Thus, the atom preserves the relative continuity of its system of revolving electrons, the living cell its protoplasmic continuity, and our bodies their cellular and tissue continuity.

---

[1] Similarly, Discontinuity is never absolute, in the sense of the complete isolation or dissociation of one entity from the rest of the Many.

What the phrase "Evolution of Continuity" really indicates is that there are a number of different types, kinds, or species of living Continuity, and we shall presently try to show that this is the case; and also that, fundamentally, natural living evolution has passed upwards through a regularly ascending scale of Continuity-types.

How there can be different types of Continuity can easily be shown if we make use again of our beads. Let us place a large number on a tray. Each single bead has, it is true, its own Continuity which preserves its bead-identity and holds its bead-molecules together; but we shall ignore this and take the single bead as our unit.

First of all we begin by arranging the whole collection in a state of Discontinuity, no two beads touching each other. The beads are the discontinuous units.

Our next step is to produce not only bead-continuity, but the humblest form of this as our "primitive type," and we find that our object is attained if we arrange the collection of beads in one continuous single chain, or thread it tightly on a fine wire. This gives us a "bead-filament," the simplest form of Continuity for the whole collection of beads, in that the terminal ones are in contact with but one bead, and the intermediate ones with never more than two. Any reduction of these contact proportions would bring about the discontinuity of the series.

Now, if we followed no guiding principle we might proceed to form new bead arrangements of many sorts, all showing an intensification of "bead-filament" continuity; or make patterns in which the number of points of bead-contact was greater. But unless we worked on a *fixed* principle we would not be *evolving* Continuity. This, however, we might do in many ways, and a simple one would be as follows:—

We could regularly increase our unit. Thus, after making the single bead-chain we could take as our unit two beads joined in lateral continuity, and make a chain of such units, as in Fig. 1, *c*. After this we could make a chain in which four beads united in lateral continuity constituted the unit; and so on till, for a given number of beads, we would have the highest form of bead-continuity possible on the system followed.

The above, needless to say, is not the method followed by Nature in evolving living Continuity, but nevertheless it can be shown that a special form of progressive multiplication of Continuity has been brought about by her. Also, that *fundamentally* the "evolution of species" has been the evolution of Continuity-types in an ascending scale, and that within each of these there has been origination of animal and vegetable species, as the term "species" is generally understood.

The evolution of Living Continuity, whose attempted demonstration is the main object of this book, is, it may be remarked, only one aspect of an evolution of Continuity going on throughout creation. Any material system whatsoever, be it that of the invisible atom, or that of the planet, or of a solar system, preserves its identity as a system owing to forces which have built up and maintain the (relative) continuity of its component parts. Matter owes its existence to the institution of Continuity. The natural evolution of non-living Matter has not, however, in terms of Continuity, advanced as far as the natural evolution of living Matter. Everywhere it has attained to the Continuity of the molecule by what we may call an inevitable process, and then, except in one direction, has leapt to the varyingly multiplied and "accidental" Continuity of Mass. The exception mentioned refers to crystallisation, where molecules of definite identity are naturally united in Con-

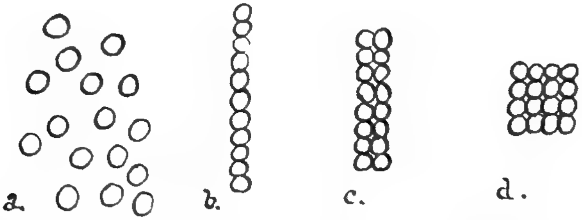


FIG. 1.—An example of the evolution of Continuity on the principle of multiplying the unit. *a*, collection of discontinuous beads; *b*, a continuous chain of single-bead units; *c*, a similar chain of double-bead units; *d*, one of quadruple-bead units. If the original collection of beads numbered 16, the evolution of Continuity finishes with *d*, on the system followed.

tinuity to form the beautiful structure which is the crystal. The amorphous mass has molecules as its highest units, the crystalline has definite bodies composed of many molecules in continuity.

Artificially, Man can produce endless systems of Continuity higher than molecular. For example, he can make a large number of similar bricks; can unite them together to form a house; can make a number of similar houses joined together in a row; can make a town composed of rows of tenements, and so on; but such action is not inevitable.

CHAPTER I

ATTRACTION AND REPULSION

When one is searching for the basic principles underlying any Growth process or phenomenon, it is wise to put aside completely all thoughts regarding the "purpose" manifested. One should presume that the elementary laws which are being sought for set in action and control a sequence of reactions which must inevitably have definite results; these results being frequently the originators of similar sequences. We have to study our problem in the light of Causes and their Effects, and not of Purpose. On every hand in Nature we see what may truly be interpreted as the exhibition of beneficent Purpose, but, scientifically, we recognise Harmony: the phenomenon, whatever it may be, is the harmonious effect of a definite cause, or definite causes. Keeping in mind the object of our search, we shall be wise to relegate Purpose to behind the basic laws, and to regard all that follows from these laws as natural result, for there can be no doubt that to look for Purpose often makes it difficult to see the Cause; we arrive at knowledge sooner by tracing back causes than by following purposes. To take an illustration. In the study of the multiplication of a unicellular organism by simple division it throws no light on fundamental processes to look for the purpose exhibited—for example, the avoidance of extinction, or the perpetuation of species. More will be learnt by ignoring Purpose and by reasoning somewhat as follows: that the organism is governed by, and is the result of relentlessly working laws; that it divides because it has to, owing to these laws; that for certain discoverable reasons one part of the organism has to separate and withdraw itself from the remainder; and that as a *result* of the constant application of the governing laws the organism in question does not become extinct. Similarly, in the facultative mottling of certain flat fish, or the green colouring of certain insects, the detection of the purpose of protection or concealment in no way increases our knowledge. We wish to find causes, and conclude that in both the examples mentioned the colouring is ultimately the inevitable effect of environmental cause, and that the capacity for concealment is equally inevitable.

Thinking on these lines, let us take the case of a multicellular animal. This grows as a potential Individual till it reproduces itself, or (as we shall see later) more correctly, till through its growth there occurs the reproduction of one or both of the original entities with whose fusion the growth-cycle began. We reason that the animal grows or enlarges because its component cells do likewise, and in a spurious way "reproduce" themselves; and, taking it for granted that a fundamental law is at work, we may conclude that the growth and multiplication of the cell is the multiple expression of the growth of its component parts, and so backwards, till we stop at the multiplication of ultimate growth-units by a process of addition. At the present time we do not truly know what the ultimate material unit is, but in a series of progressive multiples any one of these serves as a common factor for those succeeding it, so that the matter is not of absolute importance.

As a general statement it may be said that every living Individual in Nature grows to reproduce itself, but this is not literally correct, or is only half the truth; for while reproduction is the inevitable result of normal growth, it is not, strictly speaking, the Individual which is reproduced. The growth-cycle begins with the union of sexual elements, and it is these which are reproduced at the end of the cycle after having temporarily lost their identities. The Individual, as will be shown, is really the sum of the reactions involved in the restoration of the sexual elements, and the alternating loss and recovery of their identities in a given line of descent involves the reappearance of the intermediate "reactions" composing the evanescent Individual. Understanding this, however, we may call this reappearance "reproduction," and say that while from the loss of sexual element identity evolves the reproduction of the element, so also does the

Individual representing this evolution grow to reproduce itself.

Growth being on the whole a matter of addition to existing substance, it may thus be said that every developing Individual, by additions from outside to its substance, is finally reproduced. And this brings us to the bed-rock of our theory, for the addition is the result of the action of one ubiquitous, fundamental force—the FORCE OF ATTRACTION. All vital processes manifest its action.

But it does not rule alone; and indeed if it did there could be no growth. It is in constant strife with its antithesis, the FORCE OF REPULSION, and it will be shown as we go along that these two Forces—in reality, one force in two opposing aspects—are the basic factors in all Growth and its accompanying phenomena.

Growth is a reaction, or series of reactions, running to a definite end, and with this peculiarity, that the series finishes definitely only when the original elements or substances with which it started are restored or reproduced. In other words, living growth is a cycle which passes through many stages to arrive at the original starting-point—when a new cycle may begin. When we view the phenomena of Growth in complex organisms, what we see is the mass or multiple exhibition of component phenomena or processes, each of which is in turn a multiple exhibition of others more simple. That is, the Individual growth-cycle is composed of smaller cycles, and these of still smaller ones, till a unit cycle is reached, the basis of all. This unit cycle runs its course in obedience to the law of Attraction and Repulsion.

ATTRACTION AND REPULSION.

The forces of Attraction and Repulsion govern all matter, and there is every reason to believe that it is through their action that matter exists as matter. As we shall see, it has doubtless been through the action of attraction that the planet we inhabit assumed material form, and we know that, like the other planets of the solar system, it pursues its orbit under the influence of the sun's attracting force; in the same way the moon is subject to the attraction of the earth. It is through this force that the land and water composing the globe cohere in mass and to each other, the attraction in mass being the sum total of the earth's component molecular attractions.

On the whole, the world may be regarded as a huge system of bound force, or as a mass of energy which is for the most part bound up "potentially," though frequently becoming "kinetic" or active. When, however, energy becomes kinetic it strives with all its might to return to the potential state, for Nature abhors disequilibrium; her ideal, her goal, is equilibrium. It is with the upsetting of equilibrium in any system that energy is set free or becomes kinetic, and work is done while the lost equilibrium is being regained, the whole process showing itself as a series of reactions. All forms of kinetic energy are manifestations of the forces of Attraction and Repulsion in action, but it is important to recognise that kinetic energy can only be produced and disequilibrium manifested through Repulsion coming into play, for where Attraction alone obtains all is rest and equilibrium, all energy is potential, all is bound fast in the absence of the opposing force. This being so, and we ourselves observing that all kinetic inevitably transforms itself as quickly as possible into potential energy, we conclude that the dominant force in Nature is that of Attraction; and it may be remarked that the truth of this will be borne out by the evolution of living Continuity. Equilibrium is, in truth, Nature's ideal, and its attainment by any system shows that in that system the fundamental force is acting solely as force of Attraction; but whenever disequilibrium is produced, or whenever any of the potential energy becomes kinetic, then we are dealing with the manifestation of Repulsion. Further, such Repulsion is always *induced*; for Attraction induces Repulsion, and vice versa. The force which at one time binds in peace and rest, at others separates and repels, only, however, to bind once more. In the living world, where there is constant liberation of energy and resultant disequilibrium, the two opposing manifestations of the One Force are in constant strife, and their alternation clearly displayed, with Attraction dominant.

Wherever energy is liberated there is resultant movement; the movement of "ultimate particles," atoms, molecules, or their multiples in mass; there is a setting free, an embarking on a period of unrest, and this is true whether the system in question be living or dead in nature. Every one of our mechanical contrivances exhibits throughout the action of the two universal forces. The matter of which the contrivance consists exists as matter by Force of Attraction, and is shaped, adapted to and performs its work by means of, and in terms of this force and that of Repulsion ; and movement in some form inevitably represents the work done. The same is the case with living organisms, Life being always associated with movement, in which we can clearly recognise the action of one or both of the fundamental forces.

For example, amœboid, ciliary, flagellar, and muscular movements, and those of any organism as a whole, are inevitably towards or away from any given point. We ourselves grasp or let go, advance or retire, unite in groups or separate from each other. The ovum is repelled from the ovary, the sperm is attracted to the ovum, the products of cell-growth repel each other in cell-division. And we are conscious of the action of the opposing forces within ourselves. We like or dislike, are pleased or pained, happy or sad ; we affirm or deny ; we unite into families and separate into communities. Our bodies assimilate and also excrete. In fact, a little thought will make it clear that there is nothing which happens which does not do so in terms of Attraction or Repulsion, that these factors rule everywhere in the living and dead worlds, and that they are the fundamental principles of creation. It is our purpose to show that they govern equally the formation of the atom and the origin of species. Furthermore, as everything in Nature exists and acts in terms of the opposing forces, so does everything possess its characters "antithetically," so to speak. There is no quality which has not its opposite quality, or which could exist as one had it not its antithesis. Truly, there could be no pleasure without pain, no content without discontent, no good but for the presence of evil. A line is straight in that it is not bent or crooked, or can only be described as bent because it is not straight. There is no adjective we can think of which has not its antithesis, or which exists except through its antithesis, and *this is simply because the fundamental principle which is and rules* *all things manifests its action in two opposing ways—as Force of Attraction and Force of Repulsion.*

An essential characteristic of inorganic matter is its comparative stability or equilibrium ; putting on one side the question of radiation, its energy is naturally potential, and when on the upsetting of equilibrium it is converted into kinetic energy it returns as quickly as possible to the potential state. Living matter differs from inorganic in that although its activities similarly reflect the action of the basic forces, and though it is the scene of earnest strife for equilibrium, this goal is for all purposes never attained, or, if so, only temporarily. The very efforts of living matter to attain equilibrium at any point upset the advances towards this state at some other point. The attainment of lasting equilibrium implies death.

As has been said, matter in any form owes its existence to the Force of Attraction. It is this which preserves Matter's personality whether in large masses, in molecules, or in atoms. Indeed, if we are consistent, we must hold that our theoretical ultimate unit of matter retains its identity and personality through attracting force, and that were the unit's equilibrium upset the infinitesimally small particle would be dissipated. Into what we cannot safely say, though we may hazard the evasion of "Power" or "Force."

Until recent times the smallest particle of matter which could exist was held to be the "atom," its name signifying that it could not be divided into anything smaller. Each one of the various elements was believed to possess unalterable qualities owing to the ultimate nature of its atoms. But at the present day there is abundant proof that all atoms are complex systems of enormous numbers of smaller particles called "electrons," and it is very possible that the different kinds of atoms reflect different electronic contents and "arrangements." We know also that the elements have not unalterable natures, and that atoms can break down and their electrons fly off in radiation, and that through the breaking down of some elements simpler ones may be formed. The atom which is stable owes its stability and the preservation of its identity to central attraction, which on the whole refuses to let its discontinuous and revolving electrons fly away; on the other hand, in such atoms as break down, Repulsion has clearly become the dominant force.[1]

The atom, then, is to be regarded as a multiple of electrons united in continuity to the extent that they are bound within the atomic system. But atoms themselves are brought into continuity by Attraction to form the higher system of the molecule. The number thus united may vary from two to a hundred, or more, according to the nature of the molecule, but in all cases the identity or personality of the molecule is maintained through the Force of Attraction.

Now the molecules of any substance are, as long as this preserves its identity, also bound together by Force of Attraction, but the attachment is not absolute; there are "spaces" between the molecules, and spaces which can be made larger or smaller, the molecules moving past each other at a greater or slower speed. Thus, a given volume of water can be converted into steam by heat, when it occupies a vastly greater space owing to the *dissociation* or mutual repulsion of its molecules. The personality of each molecule is, however, preserved, and the steam can be made to condense so that there is water once more. On the other hand, by what is called chemical action, the molecules of a substance can be broken up, be *decomposed*, through the induction of Repulsion, and the dissociation of its contained atoms, which are set free to form molecules once more—it may be of a new kind. It is quite clear, then, that molecular decomposition is the same thing as atomic dissociation.

This brings us to an important truth, namely, that in both cases we have a *Cyclic Reaction*, or the loss of a state followed by its recovery; for if the state of water reflects association, and that of steam dissociation, the condensation of the steam into water represents re-association, and the cycle is a sequence of Attraction—Repulsion—Attraction, when a new cycle may commence. Similarly, if we decompose water by electrolysis (water molecules being composed of 2 atoms of Hydrogen and 1 of Oxygen), the atoms are dissociated and the molecules broken up. We get the dis-

---

[1] The revolving electrons in the atom are widely separate from each other. Their common attraction to the atomic centre induces their mutual repulsion.

tinct gases, Oxygen and Hydrogen, with their specific molecules. So that the cycle here is atomic Attraction—Repulsion—Attraction.

What must be noted here is that in its true sense the word "cycle" always indicates the cycle of a *state*, or one leading to the reproduction, not of an actual entity, but of a manifestation or state of matter; not of actual particles, but of given particulate states. This, in our belief, is the law of reproduction in all creation, and we regard all cyclic development, whether of molecular systems or living Individuals, in this light. The sexual element of the son is living matter in the same state (we may say) as was manifested by the sexual element of the father; it is obviously not the paternal element re-associated after dissociation. Similarly, when a Leyden jar discharges its electricity and is recharged to an exactly similar extent, there is reproduction, but not of the actual original charge of electricity.

In the dead world we cannot predict how the reproduction of the lost identity of a substance will come about; we can foretell the results of given equations, but we cannot as a rule predict the terms of the equations. But the outstanding feature of the living growth-cycle is that though its real mechanism is unknown to us we can recognise it on the whole as a vast series of reactions which must end in the reproduction of a lost initial state along a definite road.

While Life is not a matter of chemical reactions and inter-reactions in the ordinary sense, it is highly probable that, fundamentally, chemical and vital processes are the same. Life, we might say, is super-chemistry. When one considers that the world which evolved Life was once a molten inorganic mass, it seems clear that living matter is only a manifestation of special results produced by the laws governing the inorganic world along (it may be added) with everything.[1] There is no satisfactory definition of what Life is, but it can truthfully be said that Life is self-sustained perpetual disequilibrium; self-sustained, that is, with the help of Environment. The paradox is that this

---

[1] The probable evolution of living from inorganic matter is dealt with on a later page.

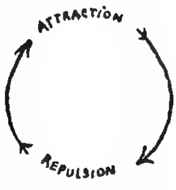
perpetual disequilibrium is the result of perpetual striving for equilibrium. Disequilibrium can only be maintained in presence of a more or less constant supply of foreign particles, and these by inducing atomic attractions and repulsions perpetuate unrest; failing such a supply, the living atomic inter-reactions will steadily diminish, Life will cease, and the comparative equilibrium of dead matter be established. But whatever one's views regarding the nature of Life, the fundamental action of the One Force which acts as the opposing forces of Attraction and Repulsion must be admitted. These are the forces which actuate (and we might say *are*) all Growth whatsoever; which, whether living or dead in nature, is essentially cyclical.

CHAPTER II

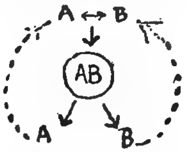
THE UNIT GROWTH-CYCLE

As has already been said, we do not really know what the ultimate unit of Matter is. It may be that the future will reveal it as a relatively "insulated" revolving force-system, in a sense independent, and of definite "charge," and whose reaction must be one or the other of the two opposing reactions of the universal Force; that is, one of Attraction or of Repulsion. In other words, Matter may simply be potential energy. At the present time the smallest material particle recognised by science is the electron. It will make for greater simplicity and brevity, however, if we attribute ultimate characters to the atom, and take this complex particle as our growth-unit, and the atomic cycle as the unit growth-cycle. And we shall look for evidence that all higher growth-cycles are but multiple expressions of this unit growth-cycle.

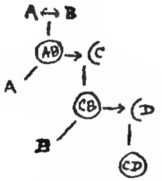
It is to be repeated that all cycles are essentially cycles of states or conditions, being represented by the diagram,



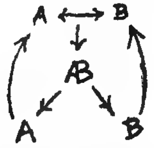
but they may also be regarded as cycles of acts. Thus, although atoms do not exist in the free state, nevertheless they must be momentarily free when repelled or split off from given attachments; and in this sense it can be said that the Atomic Cycle begins with an act of attraction between two atoms which results in loss of independent identity, followed by an act of repulsion leading to the restoration or reproduction of independent identity—when a new cycle begins. That is, the unit-cycle of growth requires two units for its commencement, course, and conclusion. It is simply an act of attraction followed by one of repulsion, a unit diphasic reaction. The unit growth-cycle may therefore be represented as below.



Here, A and B are two atoms mutually attracted. As a result there is unit growth, AB. Repulsion is induced between A and B, and each is restored or reproduced; or better, their original independence is thus affected. They are now ready to begin a new cycle with each other, or two separate new cycles with two new units. It is to be noted that the repulsion which "reproduces" A and B is induced. Were AB not interfered with, there would be no repulsion and no reproduction. For these to occur there must be present other atoms capable of upsetting the atomic attachment and equilibrium of AB. Thus, the figure might be drawn as below.



Here the atom C, being stronger in attracting power on B than is A, induces the repulsion of A and attaches itself to B. As a result the independence of A is reproduced. Similarly, B may be reproduced in the presence of D, whose affinity for C is stronger than B's. However,



may be taken as the diagram of the unit growth-cycle, which, it is to be repeated, represents AN ACT OF ATTRAC-

TION FOLLOWED BY AN ACT OF REPULSION. This is offered here as the key to all growth-cycles, be they those of bacteria, plants, or animals, all higher cycles being but multiple expressions of this unit-cycle. Thus, we recognise in the act of attraction between A and B atomic "conjugation"; in AB, the unit "somatic tissue"; in the restoration of A and B, the "reproduction" of the "atom-gametes," whose union started the cycle. The diagram, in fact, would represent the growth-cycle of a complete bi-atomic "Individual."

CHAPTER III

PROTOPLASM. THE INDIVIDUAL

To the essential matter of all living organisms the name of Protoplasm has been given. The term, however, is not a very fortunate one, for what it is used to indicate is not a definite basic substance, but a fine mixture or emulsion of many substances in a fine state of suspension. At the same time it seems more than probable that amidst the many different molecular " species " of the living cell there is always one representing the essential living matter of protoplasm. But beyond the fact that it is proteid in nature we know nothing definite of its composition, the insurmountable difficulty being that its analysis involves its death ; and clearly living proteid must be a very different substance from dead proteid. To this essential living matter, whose molecule has received the name of " biogen molecule," we have ventured to apply the term " basoplasm " in order to distinguish it clearly from protoplasm. It can be well understood that there are many distinct varieties of protoplasm and species of basoplasm in the living world, reflections of different lines of evolution under differing environmental influence.

All Growth is Evolution. From the conjugation of two gametes to their restoration at the end of the Individual cycle there is a straight path of evolution, and in the tissue differentiation of the higher-growth types we have the side-path evolution of cell-species ; and similarly within each cell there are different species of substances, molecules, and atoms.

In descriptions of simple or elementary protoplasm it has been customary to refer to one of the most structurally simple of living organisms whose vital phenomena are at all observable—the freshwater Amœba; a tiny jelly-like particle possessing the power of changing its shape and position by protrusions and retractions of its substance. But the amœba is only comparatively simple; it has evolved through ages to its present condition, and is the latest edition of some much more primitive prototype. We may imagine this to have been smaller and more homogeneous in structure, and unprovided with a nucleus, in the accepted sense of the term, though necessarily possessing some system of control. Nevertheless, the basoplasm of such an elementary organism would be composed of highly complex "plasmolecules," and obedient to the forces of Attraction and Repulsion the component atoms of each, controlled by their attraction-centres, would unite, separate, and reunite in ceaseless change. There would be countless atomic cycles run, and through them each plasmolecule would all the time be trying to attain full satisfaction and complete equilibrium on a definite plan.

THE PLASMOLECULAR CYCLE.

The different characteristics of dead and living matter may reasonably be attributed to marked differences of molecular constitution or plan. They cannot be attributed to electronic or atomic differences, for the elementary atoms composing living matter are all found in non-vital combinations. Any analysis of living matter is impossible, as it involves death, and becomes the analysis of dead matter; but even so there is revealed a molecular complexity far higher than that of dead inorganic matter. The result of death is, moreover, inevitable Discontinuity or Decomposition, the dead organism breaking up in its parts, tissues, cells, and molecules; and it is credible that the molecule of living basoplasm, the "plasmolecule," is a far more complex structure than that of dead proteid, which might be pictured as a part of its disintegration.

And one is drawn to presume an extreme complexity of the basoplasmic molecule in order to explain certain phenomena of living growth, and especially why it is that so much cell-multiplication is required after a conjugation or fertilisation act before the originally combining elements are restored or reproduced.

The development of the living Individual, whatever its kind, is a process of cell-multiplication and differentiation; it is *evolution.* The undifferentiated embryonic cells become in their product the original elements, whose union started the Individual; it is an evolution leading to the restoration of the original and temporarily lost sexual element "plans," a restoration depending, according to our suggestion, on that of the "plans" of their basoplasmic molecules. Where the Individual is cellularly continuous there is also a very obvious evolution in gradual somatic tissue-differentiation, and this must surely be based on progressive basoplasmic molecular change. In a word, our supposition is that as after sexual elements combine their identities disappear, so also is there a loss of identity of the respective basoplasmic molecules, the complete Individual representing all the growth-reactions necessary for the restoration of identity.

We could picture the fusion of conjugating elements as entailing a fusion of their plasmolecules with resulting loss of plasmolecular identity, followed by the division of the enlarged plasmolecules, and finally the first act of cell-division. But a plasmolecule in either division-result would have an unstable constitution and resemble neither of the original plasmolecules whose fusion produced it. And it would try to recover its lost equilibrium and identity by growing; that is, by attaching to itself atoms from outside its personality, discarding many in the process. But before more than a slight advance had been made on the road to the recovery of lost identity or plan it would attain an enlargement which obliged it to divide into two, giving, in the mass, a renewed act of cell-division. And the process would go on till in a straight line of production a huge number of division acts ended in the recovery of lost plasmolecular plan and the restoration of one of the original sexual elements: leaving out of account the side-path evolution and tissue differentiation which occur in presence of cell-continuity.

This in its broadest lines is the suggestion offered regarding the plasmolecular cycle. That when sexual elements fuse, their plasmolecules do likewise; and that the plasmolecular cycle begins with an act of plasmolecular *attraction*, and is continued through many acts of plasmolecular *repulsion* or division till the original plasmolecular plans are restored in the sexual elements. This supposition does not seem unreasonable in view of the undoubted fact that the growth-cycles of living Individuals begin with the attraction of sexual elements, and are continued through many acts of cell-division (repulsion) till the elements are reproduced. Admittedly, it entails the acceptance of the living protoplast as essentially a multiple of plasmolecules, and makes cell-division the immediate sequence of plasmolecular division.

As in cellularly continuous organisms the main road of evolution leading to sexual-element reproduction gives off many side-roads ending in the fixed tissue cells, so one may believe that in the cell, which is on the whole a molecularly continuous organism, the main road of plasmolecular evolution gives off side-roads leading to the differentiation of fixed substances—the " somatic substances " of the cell.

The Individual.

Before going farther it is necessary to define exactly what an " Individual " is, as the term will be constantly used, and always within the limits of the definition.

Every independent living entity is not an Individual in the scientific sense of the term. Far from it. For example, a single aphis or greenfly is never one, nor is a queen bee, nor a drone. On the other hand, a worker bee always is, with rare exceptions. One rosebush may be a developing Individual, while another may not be. A malarial amœba can never become an Individual, and no more can an independent alga cell.

A living Individual may be defined as the Sum of a Complete Growth-cycle, from its beginning up to where it finishes with the full possible reproduction of the originally combining elements.

Two things follow from this. First, when the Individual cycle runs through many organisms, unicellular or multicellular, which enjoy a free and independent existence, as in the case of Hydra or Aphis, no such organism even when producing sexual elements can be termed an Individual. A seedling rosebush is a potential Individual, but a rosebush grown from a cutting can never be anything but a part of an Individual.

In the second place, if the complete cycle comprises the Individual, one is not literally correct in applying the term to any organism—or group of organisms—before it has grown to its utmost limits and finished all its cell-cycles to the extent permissible to the class of Individual in question. A man can loosely be described as an Individual, but he is only potentially one as long as he can produce sexual elements and repair tissue loss. It is as indicating all the content of the living growth-cycle that the term "Individual" will be used in succeeding pages, and to denote this it will always be written with a capital "I."

It may well be questioned if there are such things as "unicellular Individuals." Certainly, every unicellular organism is not an Individual, nor is there necessarily *reproduction* when a unicellular organism divides into two. There is reason for the belief that all unicellular organisms, whatever their kind and however marked their independence, are but parts of or stages in the development of some Discontinuously Multicellular Individual type. Our unit growth-cycle is an act of atomic attraction followed by one of repulsion, and our belief is that the repulsion manifested in the division of a unicellular organism, itself an atomic multiple, indicates that somewhere and sometime previously an act of unicellular attraction, or "conjugation," must have occurred.

Our suggestion is, in fact, that the "unicellular Individual" is fundamentally on a par with the intermediate cell of the continuously multicellular organism, and that it is the independence due to *discontinuity* which is misleading and obscures the truth.

On the other hand, the Individual composed of *many* unicellular organisms is common in Nature, the cycle always beginning with an act of attraction and the conjugation of two of the organisms, and ending with their multiple restoration or reproduction. And here one can but conclude that the long series of cell-division acts which occur before reproduction mark so many stages on the road to this goal. In its sum total, all the intermediate cell-growth of the Individual is the inconceivably immense number of atoms which must be supplied and incorporated from without to keep the process of restoration of the originally combining elements on the move.

A very crude illustration might be used to make clear our interpretation of the multicellular Individual Cycle.

Let us picture one sexual element, or "gamete," as a house built of bricks and on a definite plan, and the other as another house similarly constructed but on a different plan. The houses fuse together, breaking up into a large heap of bricks, with the loss of the original plans. The whole mass is then to be pictured as dividing into two masses, each of which obtains new bricks from outside, whose presence sets going a restoration of lost house structure. In time each mass doubles its size and divides, so that there are four masses, and each of these incorporates new bricks and the process repeats itself. But all the time, accompanying mass-enlargement there is a steady progressive restoration of lost house plan of the one kind or the other, until a time is reached when instead of the original two houses there is a great multiple of them.

In the living growth-cycle restoration proceeds by geometrical progression; one becoming two, two becoming four, four becoming eight, and so on; and we conclude that as *two* different sexual-element plans or identities have been lost and are striving for restoration, a stage in the process will occur when divergence must take place; in other words, when cells will be produced whose further product will be all "male" or all "female."

The propositions, then, which we put forward are:—

I. All Growth, in every aspect, exhibits the action of One everywhere obtaining Power which manifests itself as the opposing forces of Attraction and Repulsion.

II. All living Individuals are the product of a conjugation act, or its equivalent. In other words, Conjugation Implies Multicellularity, or vice versa.

To these we shall have to add two others, namely,

Environment produces Continuity, and
Continuity produces Arrest,

in order to throw light on the principles of Growth in living organisms, and the method of their evolution in the ascending scale.

We shall now take one by one the main forms of living Continuity in the ascending scale, beginning with the Discontinuously Multicellular. It must be noted that the illustrative examples given are offered as *types of Continuity,* and that in no case is a given organism put forward as an actual milepost on Evolution's main road, *except in regard to its Continuity.* The question of *how* the different types of Continuity probably evolved will be dealt with later in the chapters on EVOLUTION.

CHAPTER IV

THE DISCONTINUOUSLY MULTICELLULAR INDIVIDUAL

THIS we take as the simplest form of multicellular, if not of living Individual, and is all the product of two fused gametes. Its component cells[1] are not continuous or bound to each other, but are free to live as independent entities or pseudo-Individuals, in general contrast to those of Continuously Multicellular Individuals in whom the cells are bound together in one mass, or in several independent masses, and live for the good of the whole continuous number. The developing Discontinuously Multicellular Individual is composed of many free cells which are probably cycle-stages on the road leading to gamete formation, but the theoretical complete Individual is composed of nothing but terminal stages or gametes.

The hæmamœba of malaria will serve as our example.

The malarial amœba, whatever the species, is usually described as having two distinct "life-cycles," but it is to be noted that these are in no sense growth-cycles. One "life-cycle" is in man—the "asexual cycle"—and the other in the body of the anopheles mosquito—the "sexual cycle." But the so-called "asexual cycle" is only a cycle in that there is a repetition of immediate environmental conditions, while the "sexual cycle" is not a true one in any sense. The diagram below shows the life-story of the amœba, and while correctly depicting the phenomena observed, it is nevertheless, as has been said, misleading from the growth-cycle point of view.

---

[1] A "cell" is the term used to indicate a protoplasmic entity or "protoplast" surrounded by distinct walls, and is not strictly applicable to an amœboid or an unwalled protoplast. But the word is employed here in the widest sense to indicate any protoplast, walled or unwalled. An alternative heading to the chapter would be "The Discontinuous Polyprotoplastic Individual."

As is well known, when the human body is infected with malaria the amœbæ, tiny unwalled protoplasmic masses, come to occupy the red blood corpuscles, where they increase in size, each finally dividing into a number of spores which varies with the class of infection. Each of the spores when liberated then enters a fresh blood corpuscle, becomes an amœba, and the process is repeated. After a certain time, however, spores are produced which on entering corpuscles do not grow to sporulate, but enlarge into male or female gametes.

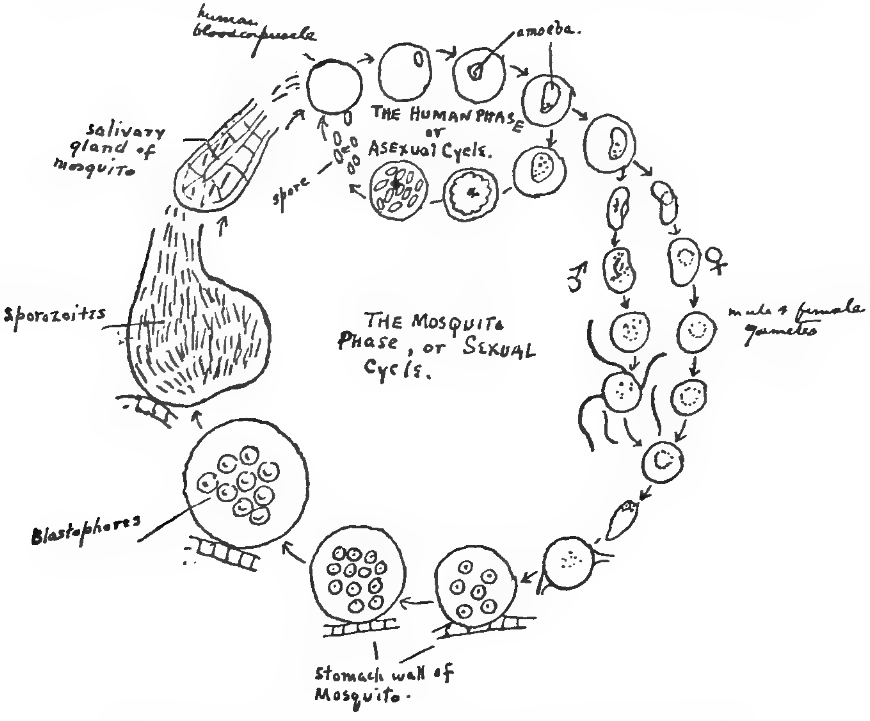


FIG. 2.—The life-cycle of the malarial parasite. (After Daniels.)

To quote Daniels :—

"In the warm-blooded host reproduction takes place asexually by the breaking up of each organism into a number of young forms or spores. This is the endogenous or asexual cycle of development. The host during this cycle is the intermediate host. The parasites which develop in this manner are known as sporocytes. Some of the spores, however, instead of forming sporocytes assume the sexual or gamete form. These do not reproduce or undergo any change whilst in the intermediate host. If they are taken up by the definite host (mosquito) they become sexually active, conjugation takes place and further development follows. The product of conjugation, the fertilised female, increases in size and forms a cyst. The contents of the cyst divide into several masses, blastophores, from which small thread-like bodies, sporozoites, are formed. These bodies when introduced into a suitable animal—the intermediate host—become sporocytes. This cycle is a sexual one, and the host is therefore the definitive host."

Now our view is that these asexual and sexual cycles are not true cycles and that *reproduction* does not take place asexually. In one sense we can recognise an asexual cycle in that there is regular repetition of the phenomena of amœba—spores—amœbæ, and the repetition of entering and leaving corpuscular immediate environment. But what we would call the "true" cycle is the Individual growth-cycle. This begins with gamete-conjugation and ends with gamete-reproduction or restoration.

The products of the division of the "zygote," or conjugated gametes, are the sporozoites mentioned, and these on entering the blood corpuscles become the first infecting amœbæ. And the point we wish to suggest is that no amœbæ reproduce themselves in the amœbæ resulting from their sporulation. Under the microscope, it is true, there are all the appearances of asexual "reproduction"; the amœbæ resulting from one act of sporulation do appear to be identical with the amœbæ which became them; but it is very probable that this is purely a matter of appearances. Our belief is that each amœba is cyclically further advanced than that which grew to produce it, and that each amœba produced is, as it were, a *stage* in the cycle determining the reproduction of the original conjugating gametes.

This reproduction is multiple; more than one gamete of each sex is reproduced, and every amœba resulting from the initial act of conjugation is the starting-point of a longer or shorter series of amœba-stages ending in gamete reproduction. According to our hypothesis such series will vary in length according to the situation in line of "descent" of the amœba originating them. It is the cellular Discontinuity of the Individual which allows every amœba produced to carry on the growth-cycle to gamete-formation, or to the inevitable end, in the absence of special opposing factors.

From this it would follow that the hæmamœba Individual is not indefinitely large, and there is reason for holding this to be true of all living Individuals. In fact, it is our belief that every living Individual, no matter its type or complexity, has a definite theoretical limit to its existence; the length of its existence under the most ideal conditions being the time necessary for the full determination of its contained cycles, within the limits permitted (as we shall see) by Continuity to the Individual in question, plus, in higher types, the time occupied by the process of decline. In the case of the hæmamœba the fullest determination of the contained cycles of the Individual is theoretically possible; the whole Individual should, theoretically, come to be represented solely

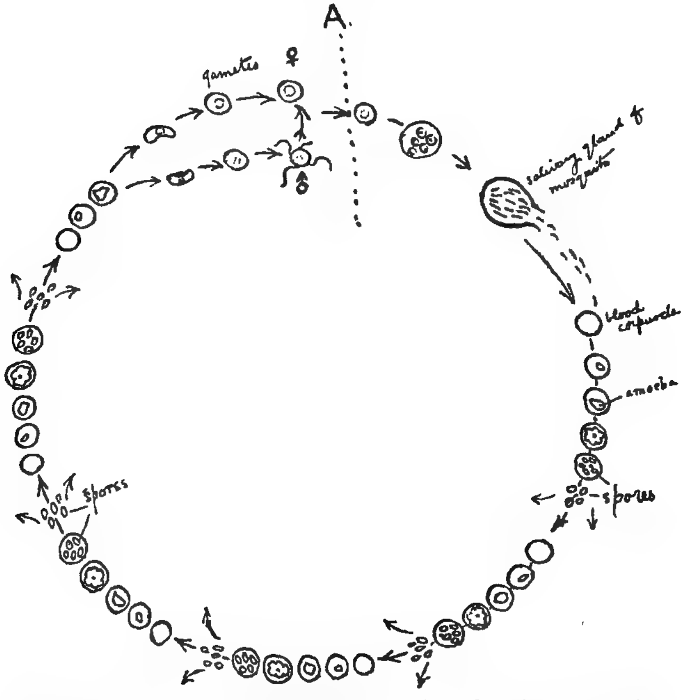


Fig. 3.—The true hæmamœba growth-cycle; diagrammatic. It begins at A. Only five sporulations are figured, and these in straight line of "descent."

by gametes, for the multicellularity is *discontinuous*. In the higher forms of Continuity the case is very different.

To repeat; the course

Amœba—Spore—Amœba

does not constitute a growth-cycle, as the second amœba is not *reproduced* but *produced*; it is not identical with its predecessor, but a stage nearer towards becoming, in its future product, gametes of one kind or the other. Nor does

Spore—Gamete—Zygote—Spore

represent a cycle, but two parts of different growth-cycles. The real growth-cycle is from conjugated gametes to restored gametes; the Individual cycle.

The growth-cycle is therefore correctly figured as above.

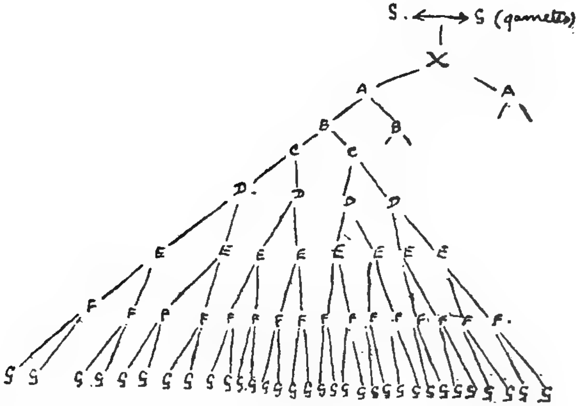


Fig. 4.—To illustrate the law of "2 to the Nth minus 1."

The developing hæmamœba Individual increases by geometrical progression, as is shown in Fig. 4. Here the gametes are represented by the letter G, and all the stages leading to them are evanescent. B gives rise to, or becomes 32 gametes, while the intermediate stages, including B, number 31. The full number of gametes is equal to 2 to the Nth power, and that of the intermediate stages, alone, or with the addition of the gametes, equals 2 to the Nth minus 1. Thus the full Individual in our diagram would be X plus 126 stages plus 128 gametes, or 2 to the 8th minus 1. The true

Individual is, of course, 128 gametes; for the stages are evanescent.

It is interesting to draw the last figure in the form of a main line or stem of cell "descent" with lateral branches, and this without really mutilating it in any respect. The significance of this will be evident when we come to consider the main stem and lateral branching plan of certain Individuals whose organic units are continuously multicellular.

Here we notice a progressive diminution in the intermediate stage content of successive branches, whether

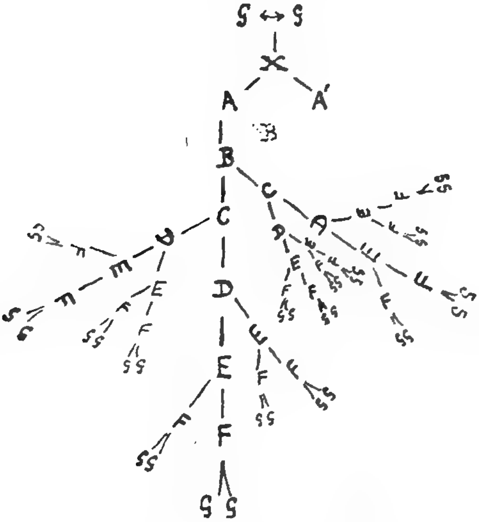


FIG. 5.—Another way of drawing Fig. 4.

primary or secondary, and the content of any whole branch system is always two times plus one that of its successor. These points, though fairly obvious, are of great importance in that in them there lies a key to some of the phenomena of higher growth-cycles. In certain higher growth-types where each intermediate cell in the above figure becomes represented by a cell-multiple, and an arrested or non-evanescent one, there is reason for believing that the above branching plan holds true, and that in these cases the *full* theoretical Individual's content (that is, of multicellular units) equals 2 to the Nth minus 1.

It may be added that in the hæmamœba Individual's development we have the exhibition in a Discontinuously Multicellular Individual of the phenomenon known as Alternation of Generations in its true sense. For before the sexual elements can be reproduced there must be intervening stages, "asexual," or containing only potentially the temporarily lost plans of the originally combining gametes. The alternation is that of the intermediate stages with the terminal sexual forms.

SPHÆRELLA.

Another example of Discontinuously Multicellular Individual is Sphærella, usually termed a "unicellular alga." Its growth-cycle is fundamentally similar to that of the hæmamœba, but it is mentioned here for one point of special interest. For one finds it stated that at times if the gametes of Sphærella fail to conjugate they may behave like zoogonidia (spores) and originate motile vegetative cells. There is, it is suggested, an error here. In normal conjugation there is, as it were, a shattering of "plans," and an institution of complete disequilibrium, and all subsequent growth is for the restoration of what has been lost—gamete characters or identity. It may well be that a gamete which has failed to conjugate may lose its equilibrium of identity in a non-specific manner—and the cases of the punctured unfertilised ovum of the frog, and the chemically fertilised egg of the sea-urchin are parallel cases in point—but if such a gamete did give rise to vegetative growth it would not really be comparable to a spore in its behaviour. It would start an abnormal Individual cycle. The spore, on the other hand, is always an intermediate cycle-stage and can only originate a *part* of an Individual. This matter is referred to again at the close of the chapter dealing with Parthenogenesis.

CHAPTER V

THE FILAMENTOUS INDIVIDUAL

The Filamentous Individual introduces us to the phenomenon of cellular continuity.

This type of Individual is the simplest of all Continuously Multicellular Individuals, for in it the component cells are united in single series. It owes its existence to a special continuity-producing factor—one by means of which, we may say, Evolution became possible; and as a result of the production of cellular continuity there appears the phenomenon of cell-arrest. It has already been suggested that the Discontinuously Multicellular cycle is the key to all higher growth-cycles, and it might further be said that all higher living Individuals represent this cycle modified to a greater or less extent by Continuity and Arrest. And what has evolved cellular continuity from cellular discontinuity? The answer is Environment acting in a special form, and this it is which has not only maintained its results, but also multiplied or intensified them into higher forms of continuity.

Environment, in its widest interpretation, represents all the different ways in which the Universal Force, one of whose manifestations we take to be Life itself, acts on any given one of its manifestations in Nature. In its relation to growth-cycles it may be regarded as the sum total of all the force influences playing on a living entity which issue from all things living or dead surrounding it, or from all sources whatsoever outside of the entity.

Environment, as it directly affects an organism, may be suitable or unsuitable, healthy or unhealthy, friendly or hostile; and it may be stated as a general truth that unsuitable environment makes for discontinuity and suitable environment for continuity: this is not in any way surprising, for hostility or unsuitability denotes a quality directly in terms of Repulsion, the force acting for discontinuity, while its opposite, friendliness or suitability, is in terms of Attraction the force acting for continuity. In other words, an act of attraction is an indication of suitable environment and one of repulsion the reverse, and this is true whether the entities attracted or repelled are atoms, molecules, cells, or multicellular organisms. Thus, in the case of cells, it is clear that the act of cell-division reflects the institution of hostile immediate environment; the prospective division-results become mutually repulsive and separate because each is to the other a hostile environment.

Unsuitable environment may be the result of an organism's own activities, and when this is the case the environment is always a limited one. For example, the malarial amœba's proper environment is the red corpuscle substance, but this happens to be limited in amount and is finally used up by the enlarging amœba. The corpuscle not only contains no more food for the amœba but has instead the toxic by-products of the organism's metabolism, and the result is that the amœba breaks up into spores and these separate from each other and escape to enter fresh corpuscles.

The limitation of the malarial amœba's environment is absolute; the corpuscle is of a definite small size and is bounded by a containing membrane; but even where an organism's environment is not thus limited in size to begin with, it may virtually become so by reason of the accumulation and non-removal of noxious waste-products. In such cases the organism will occupy a medium of more or less solid consistency. Possibly this may be the reason why the continuity of the threads or "hyphæ" of a simple fungus mycelium is interrupted periodically by spore-formation. Certainly increasing environmental hostility must be a factor in producing the discontinuity of the spore, for when the spore enters a suitable environment growth in continuity is once more manifested.

Hostile environment in the form of all external forces working for the production and maintenance of discontinuity will always be encountered by living organisms.

Now the act of gamete-conjugation with which the growth-cycle begins is due to mutual personal attraction, and it is not repeated within the Individual cycle. All following "personal" or mass acts of the developing Individual's cells are acts of repulsion. It is through personal repulsion that one cell divides into two, two into four, and so on, and the cells thus formed have no personal attraction to each other. If after separation they do not continue to be mutually repellent, at least they are neutral, and there are numberless forces at work whose action tends to scatter more widely the already discontinuous. But it is just these scattering intermediate cells of the Individual cycle which, as they were produced, have been obliged to remain in cellular continuity to form the Filamentous Individual; and in a similar way, we shall see, have scattering intermediate *multicellular* parts of higher Individuals been obliged to develop in higher forms of continuity than filamentous.[1]

One is drawn to the conclusion that for the scattered product of gamete-conjugation to develop in serial attachment a special factor must have intervened; one powerful enough to overcome all forces working for the separation and independence of the division-results, and one whose action was (and is) evenly and constantly applied, and ready to act on its last results. That the factor in question had these characters will become more obvious as we go up the ascending scale of living Continuity (though the definite way in which it acted is not under consideration at present); for living Continuity has apparently evolved by leaps and bounds, each advance representing the multiplication of the preceding form. In a word, the factor at work has been a compressing force, so balanced and constant in its action as to produce inevitably constant results. This force has all along acted, and continues to act, directly and indirectly as force of Attraction and of Repulsion, but in producing Filamentous Continuity, and in steadily evolving and maintaining the higher forms of Continuity, it reflects the unalterable truth that Attraction is the dominant force.

It is unnecessary to say that the form of Continuity which Attraction, as compressing force, has managed to produce

---

[1] It may be advisable to remind the reader that the cell of the Discontinuously Multicellular Individual is itself a triumph of the Evolution of Continuity, being an enormous system of parts held together.

is the result of its work in the face of, or as affected by Repulsion. Nor has Attraction been sweepingly victorious all along the line. Thus we have Discontinuously Multicellular Individuals with us at the present day, as well as fixed examples of the higher forms of Continuity, but each continuity-form (and this includes the free cell itself) marks a further victory for dominant Attraction which evolved and maintained it. As will be shown later, the compressing factor has constantly proceeded by maintaining a certain "percentage" of its results, and by multiplying or intensifying the remainder into something higher.

To repeat our opinion. Environment as special evolutionary force has produced Continuity, maintained it, and multiplied it; and Evolution is *fundamentally* the evolution of Continuity.

Continuity, however, is only obtained at a certain cost, and the price paid for cellular continuity is *Cell-arrest*. On the other hand, it is through this Arrest, the product of Continuity, that special cell-function has been made possible. It is through Continuity that in higher types certain cells of the developing Individual evolve on side-paths to become differentiated fixed tissues, and fail to finish their cycles.

But living Continuity varies in its severity or thoroughness, and thus there are organisms in whom it is more apparent than real, and in whom there is only slight or temporary arrest and no special cell-adaptation to function; while in those of higher Continuity the great majority of the developing cells are ultimately *permanently* arrested to perform special functions for the common good. Such cells, whose cyclic evolution has been on side-paths, and which do not finish their cycles, remain to represent what are called the "somatic tissues."

This brings us to a statement of the four all-important laws of Growth, namely:—

ALL GROWTH IS A MANIFESTATION OF THE FORCES OF ATTRACTION AND REPULSION IN ACTION.
FERTILISATION PRODUCES MULTICELLULARITY.
ENVIRONMENT PRODUCES CONTINUITY.
CONTINUITY PRODUCES ARREST.

As an example of a Filamentous Individual we will take the Alga, Spirogyra.

Spirogyra.

This freshwater Alga grows as a long green thread or filament of cells in single series, but although these are united in continuity, they are virtually independent organisms. The only function the cells may be said to perform for the general good is that of maintaining continuity; apart from this, each cell lives for itself; thus the Continuity of Spirogyra is not comparable with that of organisms whose cells are truly interdependent, each living for the good of the whole cell-mass.

Theoretically, each cell of the Spirogyra filament should become sexual in its descendants, or, as we might put it, the theoretically complete Individual should be, as in the case of the Discontinuous Multicellular Individual, an immense number of gametes. Nevertheless, Continuity prevents the cells from carrying on the growth-cycle simultaneously. Temporary cell-arrest is exhibited. This arrest is indicated by the appearance of gametes at varying intervals in the length of the filament, for if each cell as it was produced grew to divide at one uniform rate there would be more or less simultaneous gamete-production; every cell being at a given moment at the same distance from the end of the cycle. On what system, then, does cell multiplication take place? A definite answer cannot be given to this question, but there are reasons for supposing that the Spirogyra filament develops on a plan somewhat like that illustrated in Fig. 6.

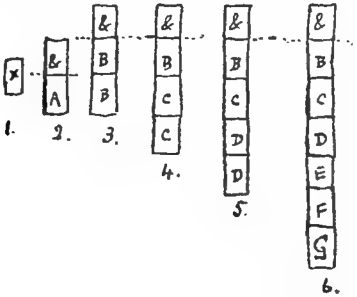


Fig. 6.—Proximal cell-arrest in Filamentous development.

In this figure, A and &, the division-results of X, a zygote, respectively originate lines of cells of male and female gamete potentialities. A and & are attached end to end and compose a filament of two cells. Let us follow the development of A. It grows to divide into B, B. But both these two do not straightway grow to divide; the proximal B, that is the one next to &, is arrested, and it is distal B which presently divides. The filament is now composed of &, B, C, C (for the sake of convenience we are not allowing & to do anything). Proximal C is now arrested, while distal C becomes D, D. In the same way distal D becomes E, E, and then distal E becomes F, F. Finally distal F becomes G, which we will take to represent a gamete. Thus the complete series resulting from A is B, C, D, E, F, G.

As a rule gametes are produced singly at intervals in the length of the Spirogyra filament, and not in pairs as one might expect seeing that the division-results of distal F are identical penultimate cycle-stages; and the presumption is that distal F is alone allowed to carry on the further development necessary to give it its true gamete characters, proximal F remaining arrested in a pre-gamete condition.

The further development of the filament in the figure will depend in its details on the plan followed with respect to *release* from arrest. We shall suppose that this release takes place on a regular plan, and that one after another the successive cells of a series are set free to produce new series. Thus if we let B (Fig. 6, 6) grow to divide we would have the result drawn in the next figure.

According to our hypothesis, B will become a new series C, D, E, F, G (Fig. 7, 7); and this series will be intercalated between & (which was not allowed by us to develop) and C of the first series. In Spirogyra all newly formed cells are intercalated in the single series, and there is no lateral branching.

The intercalated series is shorter by one cell than B, C, D, E, F, G, and as it takes the place of B the result is that there is now a series of C, D, E, F, G, C, D, E, F, G. Similarly, the release from arrest of the two C's would bring about the intercalation of a new series in place of each; that is, D, E, F, G, D, E, F, G, as in Fig. 7, 8.

By developing on such a system Spirogyra would form in time a very long filament, showing gametes at varying intervals, and suggesting perhaps that gamete-formation was proceeding on no definite plan. Sooner or later the filament would get broken, and then there would be several filaments, apparently Individuals, but really only parts of one Individual.

Were the intercalated series of Spirogyra produced as lateral outgrowths or branches, then the plan of growth would be like that of a racemose plant, and the primary and secondary branches would end in gametes, and we presume that there would be a progressive diminution in branch cell-content. But in Spirogyra the filament "branches" are interposed in the line of the filament, and the terminal nature of the gametes is not obvious.

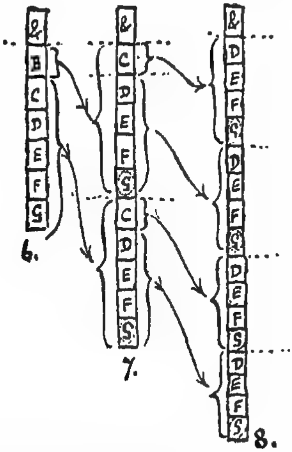


Fig. 7.—Release from proximal cell-arrest in a diagrammatic filament.

Now while this theory of the development of the Spirogyra Individual receives support from the proximal "zooidal arrest" in certain zooidal series of higher types, it is also confirmed in a curious way by phenomena observed in another unbranching filamentous Alga called Ædogonium.

Ædogonium.

In this Alga, whose general characters are those of Spirogyra, there are certain cells provided with what are known as "cell-caps," and their presence is explained as follows: When a cell is about to divide, "a ring-like cushion of cellulose is formed on the inner surface of the cell-wall near the upper end of the cell (Fig. 8) and the nucleus of the cell divides into two. The cell-wall then splits all round just outside the cellulose cushion, and the latter is stretched out so as to give rise to a membrane which is intercalated in the cell-wall (Fig. 8, *b*). The dividing wall, laid down between the two nuclei, is formed opposite the lower end of the intercalated membrane. The bounding wall of the upper cell therefore consists chiefly of the intercalated membrane; but there is a portion of the old cell-wall, fitting like a cap, at the upper end of the cell, where it produces a transverse ring-like mark. If the process is repeated, the new cellulose cushion arises immediately below the previously formed ring. In this way cells frequently come to show a series of 'caps' or rings at their upper ends (Fig. 8, *d*)." (Lowson.)

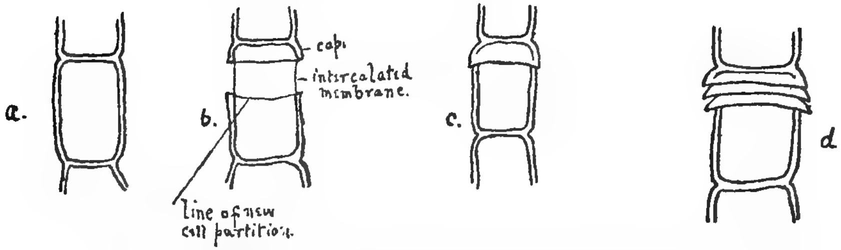


FIG. 8.—The formation of cell-caps in Ædogonium. (After Lowson.)

From all this we can deduce that in Ædogonium cell-division proceeds on the plan suggested in the case of Spirogyra; that temporary cell-arrest is experienced by the proximal result of a cell's division, the distal result alone growing to divide for the time being; and that none of the uncapped cells in the filament have performed an act of division. And it is to be presumed that when an uncapped cell is released from arrest proximal cell-arrest is a feature in the formation of the resulting intercalated series.

Thus if we draw for Ædogonium a figure on the lines of Fig. 7, we have a filament in which appear cells provided with a varying number of caps, and between them others with no caps at all. Naturally, it would be a capped cell which would usually produce a gamete. It would, however, be possibe for an uncapped cell to produce a gamete if the cell immediately followed a capped gamete-producer. Fig. 9 very diagrammatically illustrates our suggestions.

The Spirogyra filament is commonly held to represent the gametophyte. "There is no sporophyte and therefore no alternation of generations. The zygospore, instead of giving rise to a purely asexual plant, produces a new gametophyte." (Lowson.)

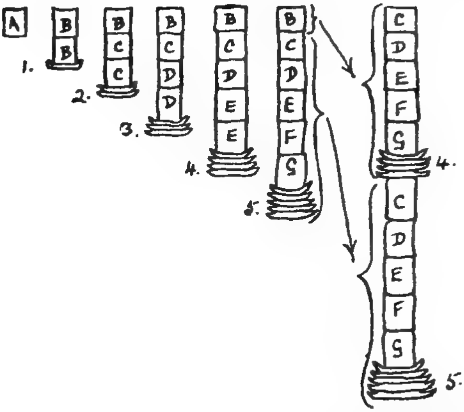


Fig. 9.—The formation of cell-caps in the light of proximal arrest. The process here is the same as in Fig. 7, with this difference, that when A becomes B, B, distal B will have one cap and proximal B none. Distal B becoming C, C, distal C will then have two caps and proximal C none; distal C becoming D, D, distal D will have three caps and proximal D none. In this way the process will go on till the series ends with distal G possessing five caps, and in this cell is produced the gamete. B, when released from arrest, will give rise to an intercalated series, C, D, E, F, G, the last being the gametangium with four caps.

But Spirogyra is surely not a "plant" in the strict sense of the term; its continuity is more apparent than real; it is a "cell-colony." Its cells are virtually independent although attached in series, and each lives as an Individual although only part of one, and does so in spite of temporary arrest. The filament as a whole cannot therefore be compared to the gametophyte of the proper plant where there is true cell-continuity, for it is nothing more than a series of virtually independent cell-units. It is to these that we must turn, and doing so we recognise that any asexual cell of the filament is a *potential* gametophyte, through its product. But the cell which divides to produce a gametangium may be regarded as the true gametophyte, and all preceding cell-stages of the cycle as sporophytes in that they divide into or produce "asexual" cells. The production of two cells by a simple act of division may, in fact, be regarded as elementary parthenogenesis, the commonly accepted and limited application of the term dealing only with the phenomenon when exhibited by a continuously multicellular organism, and not by a single cell. And in the fact that asexual cells must appear as stages on the road to the production of sexual cells or gametes we have the key to "alternation of generations." It is not really an alternation of generations, but of intermediate or "asexual" cycle-stages with terminal or "sexual" forms.

CHAPTER VI

THE CŒNOCYTIC INDIVIDUAL

We naturally expect that the next step in the evolution of living Continuity will be the Lateral Continuity of filaments or single-cell series, and this we find to be the case. But Nature presents us with this intensification of Continuity in two distinct forms. One of these is what might be termed irregular, and occupies a place of its own, and it is to the Individuals exhibiting it that the term "cœnocytic" has been here applied.

It cannot be denied that Cœnocytic manifest a higher form of Continuity than Filamentous Individuals, but at the same time there is every reason to believe that the evolution of the former has proceeded on a side-path, and that none of the higher forms of Continuity have evolved from the Cœnocytic. No existing organism or Individual in Nature is, as it were, a milepost on the *main road* of evolution *except in the matter of the Continuity it may exhibit*, for fundamentally the evolution of the human species has been through primitive types which existed long ago and whose Continuity alone is still with us in certain present-day types. But a cœnocytic was probably never one of these primitive types. Cœnocytic Continuity evolved on a side-path, and though possibly through the intensification of some form of primitive Filamentous Continuity, from it evolved no higher form. The truth of this will be more evident when later pages make it clear that Continuity has evolved by a process of steady multiplication, Serial alternating with Lateral Continuity.

Cœnocytic Individuals are as a whole represented by those organisms called Fungi, though a few Algæ are also cœnocytic ; and as examples we may briefly refer to the common moulds, of which Mucor is typical.

If one soaks a piece of bread in water and covers it with a glass dish, a good growth of Mucor is sure to develop within a few days. At first it appears as white dots on the surface of the bread, resembling moist spots of uncooked flour. Each of these spots is a growing " mycelium " or network of mould which has originated from a spore—millions of which are everywhere about in the air and dust ; and thus each mycelium is only a part of a Mucor Individual, though several Individuals may have been involved in the production of the spores producing the mycelia.

For a day or two appearances remain more or less the same except for the extension of the mycelia, then with startling suddenness the bread becomes covered with a white swansdowny growth of exquisite fineness, which close inspection shows to be composed of innumerable branching threads like the finest spun glass, while scattered over the surface are minute white dots. This is due to the development of aerial branches which are produced with the view to forming spores, the white dots being the " sporangia," or little cases full of spores, at the tips of the aerial branches or " hyphæ." The spores are produced in enormous numbers, and every one which falls into a suitable environment can originate a new mycelium.

Within a certain time the fluffy mass of mould, composed of how many mycelia it is impossible to say, so close is the interweaving, begins to look as if fine soot had fallen on it ; but regarding it with attention one can see that this is due to an immense number of black dots similar in size to the pre-existing sporangia. These are the " zygospores " resulting from the conjugation of gametes which have been produced. Some varieties of Mucor, such as *Mucor mucedo,* produce gametes rather infrequently, and from this we infer that the growth-cycle is a long one and has to run through many mycelia (linked together by the discontinuous spores) before it ends with a gamete-forming mycelium.

In the case of all moulds growth takes the form of a mycelium, and this is simply a species of filament which in growing gives off so many branches, and these so many others, that it becomes an intricate network of filamentous tubes or " hyphæ." But in addition to the fact that there is no chlorophyll in it, the mould hypha differs in two important respects from the Spirogyra filament; in the first place, it is not a single-cell series, and in the second, lateral branching takes the place of intercalation. The hypha of the mould mycelium is not composed of separate cells shut off from each other by walls, but has a long tubular structure containing multinucleate contents, and divided or not divided at intervals by transverse septa. Each such non-septate mycelium, or segment of septate mycelium, is what is termed a cœnocyte. This, however, is not to be regarded as a species of long multinucleate cell.

When we talk of the "cells" of Spirogyra we really refer to the separate nucleated protoplasmic entities or "protoplasts," *plus their containing walls*, which compose the filament; but the walls are only containers, they are not essential parts of the entities, and the Spirogyra filament is simply a long succession of protoplasts separated from each other by partitions, whereas in mycelial growth there is an increase of Continuity which shows itself in two ways; for between the septa or partitions of a cœnocyte there are many protoplasts in series as compared to one protoplast in the case of Spirogyra, and there is also the lateral continuity of parallel protoplastic series running along the hypha (Fig. 10).

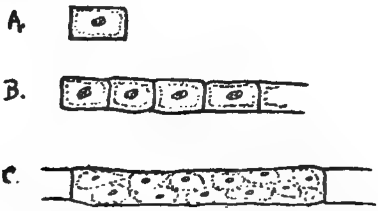


Fig. 10.—Showing that cœnocytic is higher than filamentous Continuity. A, diagram of a protoplast enclosed by walls, the whole being termed a "cell"; B, part of a cell-series or filament of Spirogyra, presenting Serial Continuity; C, cœnocyte of septate mycelium: in one respect a serial multiple of any cell of B, but containing as it does two parallel series of protoplasts, it presents us with the multiplication of B's serial into Lateral Continuity.

The cœnocyte, in fact, might be looked on as the simplest of all forms of "tissue," were it not that we restrict this word to denoting the serial and lateral continuity of protoplasts provided with walls—in other words, of "cells"; for the multinucleate content of the hypha is really two or more parallel successions of protoplasts in lateral continuity, a fact which can be made out by carefully staining a specimen and examining it under a microscope (Fig. 11).

In moulds of the Mucor type the hyphæ are not as a rule divided by septa. As the result of continued growth, and as described on page 60, spores are formed in spore sacs borne at the ends of aerial branches. Each spore when set free can under suitable conditions develop into a new mycelium, which, if it is intermediate in the cycle, will likewise in time produce spores; but sooner or later mycelia are formed which produce not spores but gametes. In fact, we have discontinuous mycelia taking the place of the independent cells of the Discontinuously Multicellular Individual in the growth-cycle sense. And as the Mucor cycle is composed of mycelial units which are stages on the road to sex, and others which become sexual, there is exhibited a *mycelial* alternation of generations.

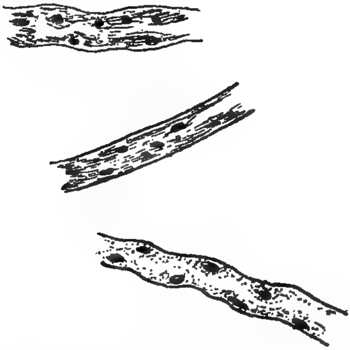


FIG. 11.—Examples of mould cœnocyte showing protoplastic series in lateral continuity. Greatly magnified.

A fact of great interest is that at times the Mucor mycelium may go into a "torula" condition, developing chains of distinct cells after the manner of Yeast, or as lines of cells in filamentous series. This confirms the polyprotoplastic nature of the cœnocyte. The converse of the phenomenon is to be seen in the cases of certain bacillus-Individuals where the usually free bacilli may be produced in what is apparently cœnocytic or hyphal continuity.

The Mucor Individual is all the product of gamete-conjugation; all the mycelia, asexual and sexual, which result from an original zygospore. Each mycelium in direct line of "descent" is, we presume, nearer to gamete-formation than that preceding it, till finally some appear which cannot produce spores but must produce gametes. Similarly, the successive protoplasts of a hypha may be regarded as successive "cell-stages" in the growth-cycle. The growth-cycle runs on through the spores, which are but links between successive mycelia.

We might say that Cœnocytic Individuals of mould type are, in contrast with Discontinuously Multicellular Individuals, Discontinuously Mycelial; that in place of discontinuous cells or protoplasts the Individual is composed of discontinuous protoplast-multiples. In such moulds as are septate (e.g. Eurotium) we can recognise the multiplication of true Filamentous continuity; for whereas in Spirogyra we are dealing with the serial continuity of single protoplasts enclosed within walls, in Eurotium we have the serial continuity of multiples of naked protoplasts enclosed within walls. The Spirogyra filament is a series of cells, the Eurotium hypha is a series of cœnocytes. On the other hand, while Spirogyra is a cell-colony, Eurotium is something more than a cœnocyte-colony; for the asexual cells of the Spirogyra series are only temporarily arrested, whereas in Eurotium great numbers of cœnocytes remain permanently arrested as vegetative supporting structure—the price of Continuity.

FALSE TISSUE.

In certain of the higher Fungi there is, within the Individual, a multiplication of the lateral continuity of the cœnocyte into a higher form of continuity, the discrete vegetative cœnocytes being joined laterally together to form the "false tissue" of the reproductive organs. The effect is roughly what one would get by pressing together into a compact mass a fungus mycelium, and there can be little doubt that a physical compressing force was the factor at work in the evolution of primitive false tissue, the result showing a beautifully interwoven plan.

We may notice two examples of false tissue, and the first is that occurring in Eurotium. In this mould the end of a hypha becomes coiled in a close spiral forming what is called the *archicarp* or female organ; while from below it arise several thin hyphal branches, one of which, the *pollinodium* or male organ, curves over to enter the coiled archicarp and fertilise its contents. The remaining branches wrap round the archicarp and by repeated branching penetrate its coils and fill it with matted false tissue. The fertilised archicarp produces small buds whose tips become cut off by septa and form unicellular spore-sacs called *asci*. "The young ascus has at first two nuclei. These fuse together, and then by a process of free cell formation eight *ascospores* are formed inside the ascus" (Lowson). (Fig. 12.)

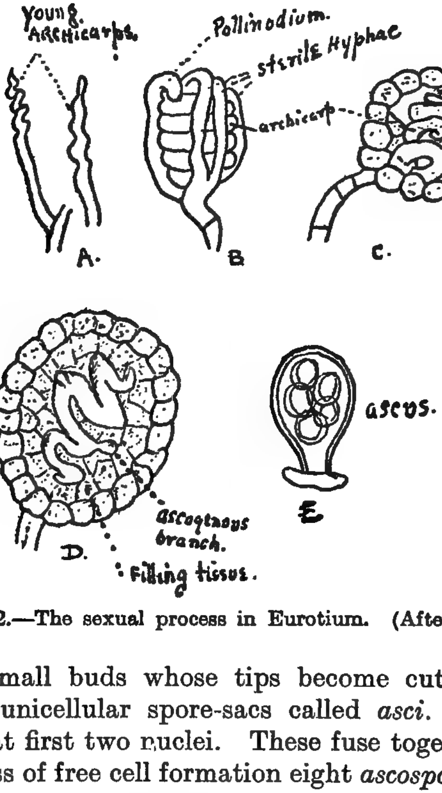


FIG. 12.—The sexual process in Eurotium. (After Lowson.)

Here we have a sudden change to a higher form of Continuity *within the Individual*, and it is to be noted that it occurs in connection with reproduction.

A more striking case is that of *Agaricus campestris*, the common mushroom, where from the fine loosely matted mycelium of the "spawn" there arises the so-called "conidiophore," or the part commonly called the mushroom. This is a stiff cylindrical column of many hyphæ closely woven together, and these spread out to form the umbrella-like top, and terminate on the radiating gills on its under surface.

It is true that Agaricus is commonly held by botanists to be so debased that it has lost all powers of sexual reproduction, and can only reproduce itself vegetatively by the spores which fall from the gills of the conidiophore; but it is our belief that such perpetual vegetative "reproduction" is impossible. For all cycles must end, and before the spores are formed there must occur a sexual act of some kind. No doubt this will be yet discovered, but it seems quite possible

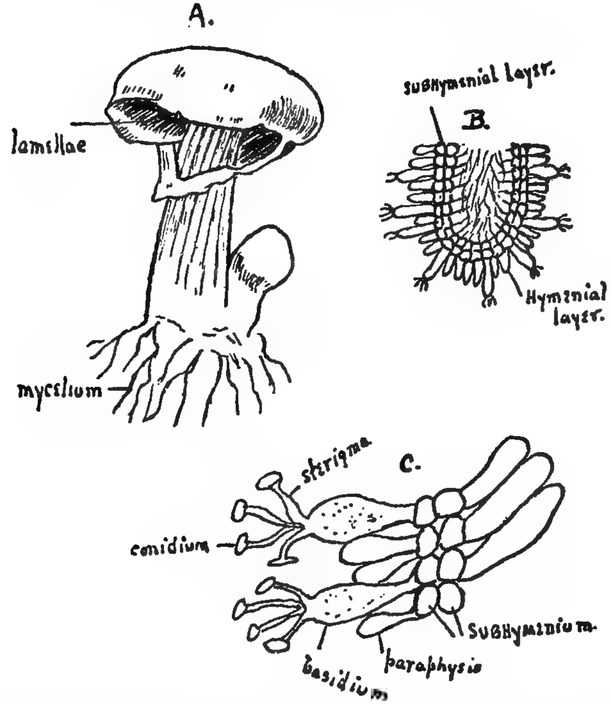


FIG. 13.—Agaricus. A, conidiophore with velum torn, showing lamellæ or gills. B, section through one of lamellæ; enlarged. C, marginal cells of lamella; further enlarged. (After Lowson.)

that an act of nuclear fusion in the terminal *basidium* on the mushroom's gill which occurs just before the formation of the spores is a sexual act.

This view will without doubt be contested, but it is pertinent to ask, What other significance can nuclear fusion have ? Why should the nuclei of two protoplasts fuse together, if the protoplasts are not terminal elements of the cycle ? The whole principle of Individual growth is cell and nuclear *division* through which elements capable of fusion are restored or reproduced. If the reader refers again to the description of the fertilisation process in Eurotium he will see that here also there is a nuclear fusion in the young *ascus*, and the question arises, Is not this the true conjugation act here, and are not the ascogenous branches or buds *pre-fertilisation* phenomena ? According to the quoted description there is first gamete-fusion, then protoplast division, and then fusion again ; a difficult sequence to comprehend. It might well be that the ascogenous buds contain the female gametes, and that the ascus contains the male and female gametes which lie together for a while before fusing. Our belief in any case is that the formation of false tissue is essentially concerned with sexual reproduction ; and it may be remarked that "terminal compression" in the shape of the multiplication of preceding vegetative continuity has clearly this significance in higher types of organism, as will be shown when we come to treat of certain Hydrozoa and Phanærogams.

CHAPTER VII

BACTERIA

It is necessary here to interpose a few remarks about a large Individual class whose characters are somewhat peculiar in that while the general habit is discontinuously multicellular, at times it is filamentous, or, possibly, cœnocytic. This class comprises what are known as Bacteria. It is to be noted, however, that the term is not used here in the wide sense in which it is sometimes applied.

Bacteria are sometimes divided into the Lower and Higher Bacteria, the former including the free unicellular microorganisms such as micrococci, bacilli, or spirilla, and the latter, filamentous or cœnocytic growths such as, for example, the Ray Fungus. But as our present purpose deals with types of living Continuity, and as truly cœnocytic Individuals form a type by themselves, we confine the term " bacterium " solely to the unicellular microorganism.

While a bacterium is essentially a unicellular organism, it does not follow that the common belief is true, namely, that it is a unicellular *Individual* ; or that when a bacterium divides it reproduces itself. It is indeed quite possible that the bacterial Individual is *multicellular*, and certain microbic growth-phenomena distinctly suggest this.

It is common knowledge that while certain types of bacteria habitually multiply in discontinuity, each germ being free and independent, others tend if undisturbed to form continuous bacterial series ; to develop, in fact, as bacterial filaments (Fig. 14).

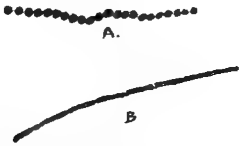


FIG. 14.—Examples of bacterial filament. A, streptococcal chain ; B, anthrax bacillus "filament."

Sometimes there are all the appearances of filamentous branching (Fig. 15).

In the figure below, the long bacillus with which the lowest branch commences is to be noted, and the suggestion it offers of the multiplication of filamentous into cœnocytic continuity. The long bacillus might be really several bacillary protoplasts within one envelope. It is such long forms, chiefly observed in old cultures, which seem to link up the "lower" with the "higher" bacteria. They are usually termed "involution forms" and regarded as degenerative in nature, but under the term are included many peculiar bacterial shapes of distinctly different kinds, and probably of different significance, and it is questionable if degeneration is reflected in most cases. Thus the "involution form" of the plague bacillus is an oval, swollen, pale structure, very different from that of the typhoid bacillus, which is like a short thin mould hypha. There seems a probability that the latter form reflects not degeneration, but the imposition of Continuity, and that, far from being one overgrown bacillus, it is equivalent to a series of bacillary protoplasts enclosed in one envelope, and not separated from each other by transverse partitions. The reverse phenomenon would be that exhibited by *Mucor mucedo* (page 62) when

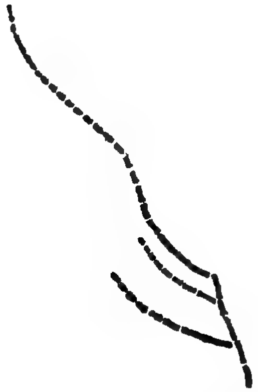


FIG. 15.—Bacillary growth from the urine of a case of bacilluria due to bacillus coli, and where under treatment the infection was disappearing. (Greatly magnified.)

it adopts a bacillary habit and grows as chains of separate cells—the " torula " condition.

Following up this idea, we might imagine the presumed bacillary cœnocyte to be of growth-cycle significance, for it appears to be the rule that an increase of Continuity *within the Individual* is an indication of the approaching formation of sexual elements. This is clearly the case in the higher Fungi, and will be shown to be equally so in the case of Continuously Zooidal Individuals.

It is true that the " lower " bacteria have not been observed to produce gametes, but that is no real objection to the supposition. It is the minute size of bacteria which makes them difficult to study, and as size after all is comparative, the typhoid bacillus may well be as complex as the motile Chlamydomonas Alga cell, which it distinctly resembles, or the anthrax bacillus be on a level with the cell of the Spirogyra filament.

Further, bacteria are known to produce " spores " at times. That is, they either become arrested and more resistent and assume a " resting-spore " condition, or what is called an " endogenous " spore is formed within the bacterial membrane. A spore is always due to environmental hostility in some form, and it is difficult to think otherwise than that in Bacteria the phenomenon is one of arrest on a road leading to gamete-formation through an immense bacterial product.

CHAPTER VIII

THE DISCONTINUOUSLY ZOOIDAL INDIVIDUAL

THE class of Individual now to be considered is probably the true successor to the Filamentous in the main road of Continuity's evolution; the sequence so far being Discontinuously Multicellular, Filamentous, Discontinuously Zooidal. It is as if we started with many separate beads, then united these in a single series, and next united many single series together in lateral continuity to form separate bead-masses on a given plan. Nature has not, of course, actually worked with already formed cells or cell-series, but, as will be shown elsewhere, has moulded the developing product of the zygote, resulting from a sexual act, on a new plan of Continuity. Thus, a zygote whose product would have been many discontinuous cells was obliged to produce this product in the form of a continuous filament, and a zygote with potential filamentous development has been obliged to have this realised as discontinuously zooidal development, at different times in past ages.

The free zooid is a true multiple of the free cell, and the filament has been a necessary link between the two. In the filament we have *serial* continuity of cells, in the zooid we have *lateral* continuity of cell-series. In the next type of Individual we shall see that we have the serial continuity of zooids, and as we go farther on the regular alternation of serial with lateral continuity will be clearly apparent. Thus, to repeat, while the Discontinuously Multicellular Individual is composed of separate, free cells, the Discontinuously Zooidal is composed of separate, free organisms made up of many cells closely united together.

These organisms are in no sense cell-colonies, but possess real tissue-continuity, and every cell performs a function for the organism of which it is a part, and which itself, though only part of an Individual, enjoys a free and independent existence.

There are, however, Individual types, composed of many separate multicellular organisms, to whom the term "discontinuously zooidal" is not applicable; the reason being that in these cases the component organisms are not "zooids," but more complex than these, representing compressed zooid-multiples. For a "zoold" has a narrower definition than a living multicellular organism, part of an Individual. It is truly such an organism, but one built on a special and simple plan, being essentially a little cylindrical tube open at one end, whose walls are composed of two layers of cells. It represents the simplest form of multicellular organism in Nature composed of true tissue. So, from now onwards, "zooid" and "zooidal" will be used to indicate a special form of cellular continuity and a special structural plan, such as exhibited by the freshwater polypite, Hydra, which has been taken as our illustrative type.

HYDRA.

The common Hydra is a minute little animal which is found with frequency in the water of ditches. In structure it is a tiny hollow cylinder of living tissue of a third or a quarter of an inch in length when its body is extended. At one end the cylindrical body is closed and a circular disc enables the organism to attach itself to twigs or other objects; but at the other, the distal end, the cavity of the tubular body communicates directly with the surrounding water by an opening which is called the mouth and is provided with marginal tentacles. These are hollow and in communication with the body-cavity or "cœlenteron," and being extensile and retractile, it is by their means that the little animal seizes its prey.

The tissues of the Hydra zooid are on the whole adapted to simple functions, consisting largely of an outer layer of cells called the ectoderm, and an inner layer, the endoderm. Between these lies a very fine structureless layer or membrane called the mesoglœa. At the same time there is wonderful cell-specialisation in the presence of stinging thread-cells here and there in the ectoderm of the tentacles, the function doubtless being the paralysing of any prey seized; and there is also a very primitive communicating "nervous system" represented by small stellate cells whose branching processes communicate, and keep one part of the body in touch with the others. These nerve-cells lie between the ectoderm and endoderm.

The Hydra zooid is only a part of the Hydra Individual, and during the Summer produces other zooids similar to itself by a process of budding or "gemmation." The budded zooid originates as a little protrusion of the body-wall enclosing a small diverticulum of the producing zooid's body-cavity. It gradually elongates, a mouth opens at its distal end, tentacles arise around the mouth, and finally the new zooid becomes detached and is free to lead an in dependentexistence and to bud like its producer. But at the commencement of Winter this discontinuous gemmation ceases, and the zooids form sexual elements. These are male and female, the former being produced in numbers

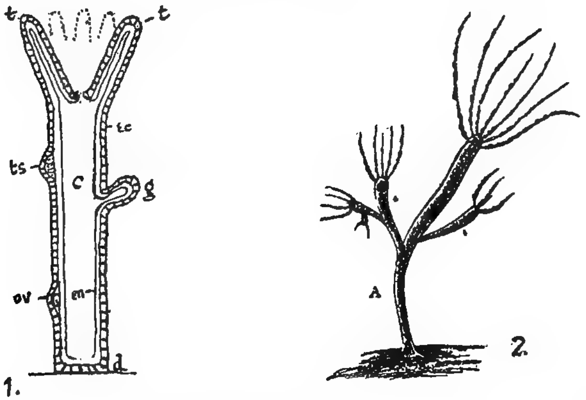


FIG. 16.—1. General plan of Hydra zooid, showing the cell-layers, and the production of a daughter-zooid by gemmation. The testis and ovary are also represented, though when these were present there would be no gemmation. *ec*, ectoderm; *en*, endoderm; *t*, tentacles; *c*, body-cavity; *d*, disc of attachment; *g*, developing budded zooid; *ts*, testis; *ov*, ovary. (Partly after Shipley and MacBride.)

2. *Hydra vulgaris*, with several budded zooids about to be detached. (Nicholson.)

by the ectoderm at a point near the distal end of the zooid in a little excrescence called the "testis," while the latter usually appear as a single ovum in a little sac nearer the proximal end of the zooid. Both spermatozoa and ovum are set free in the water and fertilisation occurs in this medium. The fertilised ovum lies in the mud till the return of warmer weather, when it proceeds to become the first zooid of a new Individual.

The formation of a new zooid by gemmation is an act of *production*, not of *reproduction*, for the zooid is a part of, or a stage in the development of the Individual; and while in a budded zooid there is a reproduction of structural plan, our belief is that each zooid represents a cyclic advance on its producer. We might say that the budded zooid carries on the cycle from where its producer temporarily halted, or that as each vegetative cell of the discontinuously multicellular Individual is a stage on the road towards the end of the cycle, so in a sense is each budded zooid, in a straight line of "descent." The compensation for the discontinuity of any growth-unit is the power of carrying the cycle to the end, or of becoming sexual, and thus each Zooid of the Hydra Individual should under favourable conditions attain to sex. But, on the other hand, the price of Continuity is Arrest, and thus it is that the great majority of the *cells* composing the zooid never become sexual, in their "descendants"; they live not for themselves, but for the good of the zooid as a whole, and their arrest enables the zooid to persist and retain its identity.

In Hydra only a certain number of cell-lines are allowed to terminate, and to do this along an interrupted path. And it is not unreasonable to suppose that it is through the cell-division involved in repeated gemmation that certain areas of a zooid finally produce sexual elements. For, in the first place, it is only through cell-growth, division, and multiplication, that sexual elements can ever appear in any cycle whatsoever. Again, nowhere, after zooidal maturity is reached, does repeated cell-division occur except at gemmation areas; elsewhere there is cell-arrest. The natural conclusion one tends to arrive at is:—

I. That a given zooid has to bud others in order to become sexual; the number depending on the "stage" the zooid represents in the cycle.

II. That the zooid's sexual organs will finally appear in what we have called gemmation-areas. It is probable, however, that gemmation is carried on with special frequency at two such areas.

The interesting fact, that if a Hydra zooid be cut in pieces each piece grows to form a new and perfect zooid, illustrates well the law that whereas Continuity produces Arrest, Discontinuity produces Release from Arrest. The matter is one of breach of Continuity, and the artificial release from cell-arrest. Continuity being severed, the cells exposed are released to multiply till the parts lacking from the original zooidal plan are restored.

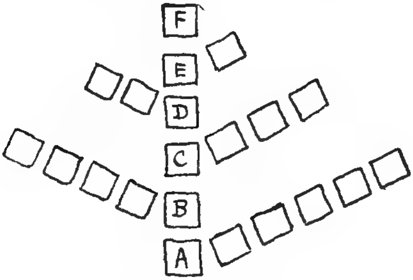


FIG. 17.—Possible zooidal progressive diminution A, an initial or intermediate zooid originates B; B originates C, and so on, till the line ends with the sexual zooid at F. The successive primary side-lines arising from the main line are represented as progressively diminishing by one zooid.

It is also to be noted that "alternation of generations" is exhibited in the Hydra cycle. There is *cellular* alternation in that asexual cells appear, and remain, as stages on the road to the final exhibition of sexual cells; and there is *zooidal* alternation in that temporarily asexual zooids become sexual in the end, and in this sense alternate with sexual zooids. It may be objected that this is not alternation of generations in the true sense, as for example in the case of the Hydrozoal colony, but in reality the cases are the same, the striking picture presented by the colony being the result of zooidal Continuity and Arrest. As, however, we shall return to this in a later chapter, we shall not dwell further on it for the present.

The question of space also prevents us from doing more than suggesting that the progressive diminution of the length of lines of cell-descent in the Discontinuously Multicellular Individual should find expression in cycles like that of Hydra's (see page 47). One aspect of this is suggested in Fig. 17.

We may close this chapter by recapitulating our theory of Continuity's evolution up to the Individual type just considered.

Our first Individual type was the Discontinuously Multicellular, and might be represented as

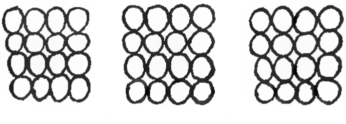
o o o o o o

o o o o o o

o o o o o o

Our second type was the Filamentous, and exhibited the simplest form of SERIAL continuity, as in the next diagram :—

In the type last considered the serial continuity of the filament is as it were multiplied into the LATERAL continuity of the independent zooid's tissues, so that the preceding diagram becomes



Thus we have our first exhibition of the alternation of Serial with Lateral Continuity in the evolution of living Individual growth-types. But it must not be supposed that Evolution has been through any existing Individuals manifesting the above forms of Continuity, for all these Individuals are at the most advanced points of "species" side-paths ; what *is* to be understood is that the main road of

Evolution has developed through a progressive intensification of Continuity similar to that which the illustrative examples given manifest. In other words, the main road of Evolution has passed through a primitive Discontinuously Multicellular to a primitive Filamentous and on to a primitive Discontinuously Zooidal type, all of which were " evanescent " ; and every living species has evolved *within a given type of Continuity.*

CHAPTER IX

THE CONTINUOUSLY ZOOIDAL INDIVIDUAL

THIS type of Individual differs from the one last considered in that its component zooids, when budded, remain attached to each other, the Individual thus taking the form of a branching zooidal "colony." In fact, it demonstrates for us the next inevitable step in the evolution of living Continuity.

This may be illustrated by the addition of one more diagram to those given on page 75.

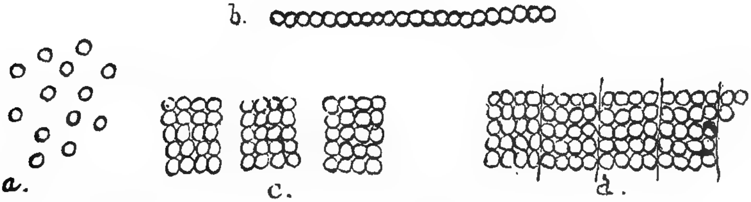


FIG. 18.—Diagram of Continuity's evolution up to the Continuously Zooidal Individual.

In the figure above, A is the Discontinuously Multicellular Individual; each cell an independent organism. B is the Filamentous Individual whose cells are united in linear or Serial continuity. C is the Discontinuously Zooidal Individual in whom the equivalents of cell-series or filaments are united in Lateral continuity to form the tissues of discontinuous and independent organisms, the zooids. D is the Continuously Zooidal Individual in whom, we may say, the separate zooids of C have been obliged to develop in Serial continuity.

In other words, the discontinuity of A is "multiplied" into the serial continuity of B, which in turn is multiplied into the lateral continuity of C. But it is to be noted that this is *cellular* continuity, and that in C the cellular discontinuity of A reappears as the discontinuity of the cell-multiple or zooid; and thus the next step in D is the evolution of serial zooidal continuity. We might say that as B is a cell-filament, so is D a zooidal filament. So it is that we can recognise in the figure an alternation of Discontinuity with Continuity, as well as (in B, C, D) an alternation of serial with lateral continuity. We shall see that this alternation holds true for our next Continuity-type.

It has already been put forward as a law that Continuity Produces Arrest; and an outstanding feature of Continuously Zooidal Individuals is *zooidal arrest.* As the development of cells in serial continuity to make a filament or " cell-colony " entails cell-arrest, so does the development of zooids in series to form a zooidal colony entail zooidal arrest. In the discontinuous Hydra, when one zooid has budded another this is set free, and the gemmation area involved may commence straightway to bud again; but in the Continuously Zooidal Individual, when one zooid has budded another the gemmation area involved is arrested for a considerable time, and it may be permanently. For the budded zooid remains attached, and it is by it that the next act of gemmation is performed, after which arrest is again imposed and further gemmation must come from the zooid last produced. Thus, as regards a given series, the process goes on till the end is reached with the production of a sexual zooid. At the same time the phenomenon of release from zooidal arrest is not uncommon, and a given gemmation area may later give rise to a second zooidal series. Perhaps the best examples of this are provided by flowering plants and trees (whose derivation, it can be shown, is clearly continuously zooidal, their special characters being the result of change to an aerial environment). In these organisms, where the stem or branch internode, or "segment," represents the ancestral zooid, a given budding-area may give rise to one branch only, or at considerable intervals of time originate several others, especially if encouragement is given by such procedures as pruning, heavy manuring, etc.

Naturally, great variation in branching habit is exhibited by existing Continuously Zooidal Individuals, but on the whole it may be said that zooidal continuity implies zooidal arrest.

On the presumption that the growth-cycle advances on through the successive zooids of a series, it is clear that sooner or later sexual zooids, or ones in whom certain cell-cycles terminate, must be produced, and when this has occurred the growing Individual will offer the picture of a branching colony composed of two classes of zooids, one apparently devoted solely to nutritional and supporting functions, and the other to reproduction. It was this picture which gave to such zooidal colonies the special credit of exhibiting "alternation of generations." But the truth is that this phenomenon, in its proper wide sense, is exhibited in all living Individuals. Every intermediate zooid in a colony starts life, so to speak, with the intention of becoming sexual, and the fact that many cells and many zooids are permanently arrested and modified and never attain to sex does not affect the true significance of the "alternation of generations." Fundamentally, it is Arrest, the product of Continuity, which brings it about that the Continuously Zooidal Individual gives a permanent exhibition of two kinds of zooids.

If we look around for examples of Continuously Zooidal Individual we find them in considerable variety amongst the Hydrozoa—one of the two classes into which the Cœlenterata are divided. All the Hydrozoa are not Continuously Zooidal Individuals, but those to whom the term is applicable are plant-like organisms inhabiting usually salt and rarely fresh water, and composed of many distinct zooids united by a branching framework, or "cœnosarc," to form a zooidal colony. While we may regard the typical growth habit as essentially equivalent to what Hydra would exhibit were its budded zooids to remain attached to each other, and while we may hazard the guess that the original primitive Continuously Zooidal type presented this appearance, the Hydrozoal colony of present and recent times produces its zooids not directly from other zooids but from the hollow tubular framework just mentioned. The significance of the cœnosarc is, however, very probably as roughly represented in the next diagram (Fig. 19); that is, it may be taken to represent the extension and narrowing of the basal or proximal parts of ancestral zooids. Thus, in Fig. 19, A shows three zooids of Hydra type remaining in continuity, while B shows them as having developed narrow tubular connection with their producers. It is from the narrow connections that we presume gemmation habitually occurred in the primitive types, as it is from the cœnosarc that new zooids are budded in modern hydrozoal colonies.

Such zooids as roughly drawn below are what is termed vegetative zooids; from their walls, as distinct from the connecting cœnosarc, they never bud other zooids, nor do they form sexual elements. Cyclically, they remain permanently arrested, and the growth-cycle advances to its termination through cœnosarc gemmation, with the result that from some distal portion of the cœnosarc a sexual zooid ultimately appears. Naturally from any part of the cœnosarc gemmation may take place and finally result in the production of sexual zooids.

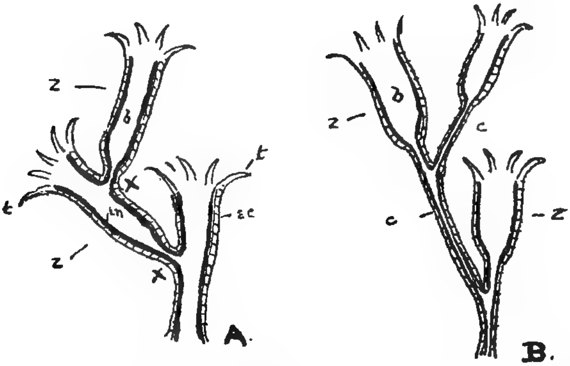


Fig. 19.—Suggested significance of the Hydrozoal colony's cœnosarc. *z*, **zooids;** *ec*, **ectoderm;** *en*, **endoderm;** *t*, **tentacles;** *b*, **body-cavity;** *c*, **cœnosarc;** x, **gemmation-areas.**

There are several subclasses of Hydrozoa, and many orders in these, for an account of which the reader is referred to biological textbooks, but for our present purpose the general plan of Continuously Zooidal growth may be taken as is represented above in Fig. 19, B.

It is to be emphasised that all Hydrozoa are not Continuously Zooidal Individuals. For example, Hydra is zooidal but discontinuous. And there are even objections to classifying all Hydrozoal colonies as Continuously Zooidal; for there are numerous examples which, while they may be so described as regards their vegetative or asexual structure, nevertheless manifest a higher form of Continuity in their sexual parts. Some Hydrozoal colonies are zooidal throughout, and their sexual organs are just zooids specially adapted for producing sexual elements, and in these types the whole colony may be said to exhibit Serial Zooidal Continuity. But there are others which, while serially zooidal in vegetative structure, exhibit in their sexual structure a " multiplication " of the serial into Lateral Continuity, with the result that the Individual is partly zooidal and partly "*megazooidal.*" This is a new term to be explained presently when we come to Individuals which are wholly "megazooidal," but it may be said here that the sexual megazooid of Hydrozoa is another example of the " terminal compression " connected with reproduction. It has already been mentioned in the case of the higher Fungi, where it results in the production of "false tissue." Just as the Continuity of the false tissue is a multiplication of that of the loose mycelium, so is the sexual megazooid's a multiplication of zooidal Continuity.

It may also be remarked that amongst Hydrozoa there are commonly included the large Individual Medusæ, or Jellyfish, which directly reproduce themselves as Medusæ. These are not in any sense Continuously Zooidal Individuals; they are wholly Megazooidal.

CHAPTER X

MEGAZOOIDAL INDIVIDUALS. THE MONO-MEGAZOOIDAL INDIVIDUALS

We may begin this chapter with a summary of the stages of the evolution of living Continuity up to Megazooidal Individuals :—

1. In the independent unicellular organism of the Discontinuous Multicellular Individual there is, we may say, Protoplasmic Continuity.

2. In the Filamentous Individual there is a multiplication of this Continuity in the attachment of single cells in linear series.

There is little doubt that the main road of Evolution has passed through a primitive form of Filamentous Continuity. It is equally probable, however, that it did not pass thence through any primitive Cœnocytic type. For though the Cœnocytic Individual has most likely evolved from some early polyprotoplastic type, its evolution has been along a side-path which has stopped dead at the false tissue of the higher Fungi.

3. Thus, passing on from Filamentous, or true cell-serial Continuity, we come to true Lateral Continuity, where the equivalents of many cell-series are compressed together in lateral Continuity to form the tissues of independent multicellular organisms. These organisms are developed typically on a simple plan, and we have reserved for them the name of "zooids." In its simplest form the zooid is a little cylindrical tube, open at the distal end, and composed of two cell-layers ; and when it leads an independent existence it forms part of the Discontinuously Zooidal Individual. It is this which represents our third stage, the independent "cell" of the first stage being here a continuous cell-multiple ; or it might be said that the

protoplasmic Continuity of stage 1 is multiplied into the cellular Continuity of the free zooid.

4. The next multiplication of Continuity exhibits itself serially. That is, we have the discontinuous zooids of stage 3 joined together in series to make the Continuously Zooidal Individual. Each zooid here is, as it were, a multiple of the cell of the Filamentous Individual: growth is in the form of a branching "zooidal filament."

5. In what we have termed the "Megazooidal Individual" Continuity is still further multiplied, and in a manner bearing out the previous statement that the evolution of living Continuity has proceeded by Serial and Lateral Alternation. For there are two main classes of Megazooidal Individual, one of which is represented by

(1) Many discontinuous organisms, each equivalent to a number of zooids fused together in Lateral Continuity during development;

while the other is composed of

(2) A number of such organisms, or many megazooids, joined in Serial Continuity.

In both cases the megazooid represents an ancestral zooidal multiple compressed in its development, or during its attempts at realisation on the ancestral plan. In addition to the two classes mentioned there is a third, in which the whole individual is represented by

(3) One large megazooid.

In other words, we have first of all separate cells; then serial cell-Continuity to form a filament or "cell-colony"; then cell-series growing in lateral Continuity to form the independent zooid; then a number of zooids united in serial Continuity to form a zooidal colony; then a number of zooidal series fused or compressed in lateral Continuity to form the separate megazooid; and then a number of megazooids united in serial Continuity to form a megazooidal colony.[1]

---

[1] Although the intensification of Continuity has been traced above from the independent protoplast, it is to be understood that this itself must be a very high multiple of the ultimate growth-unit. The Continuity of the cell is a great advance on that of the atom. Under "The Evolution of Matter" this is again referred to.

Megazooidal Individuals may be classed as follows :—

(1) The Mono-megazooidal Individual, of which our examples are the Sea-anemone and the Individual Medusa or Jellyfish (there are jellyfish which are not Individuals).
(2) The Discontinuously Megazooidal Individual, the example taken being one of the Acraspeda.
(3) The Continuously Megazooidal Individual, exemplified by the Compound Corals generally.

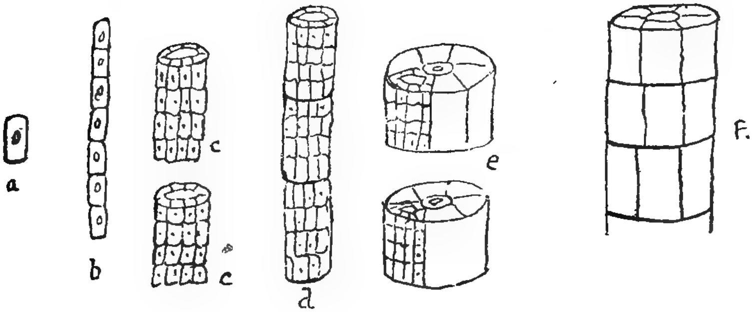


Fig. 20.—Diagram of the evolution of living Continuity, beginning with the separate cell and stopping at the megazooidal colony. *a*, a free protoplast; *b*, a cell-filament, a multiple of *a* in serial Continuity; *c*, the Continuity of *b* multiplied into the lateral Continuity of the discontinuous zooid; *d*, zooidal serial Continuity; *e*, the free megazooid, equivalent to a number of zooids compressed in lateral Continuity; F, megazooidal serial Continuity. The figures are very diagrammatic.

We shall begin by considering the Sea-anemone and the Medusa.

The Mono-megazooidal Individual of Sea-anemone Type.

The general appearance of the Sea-anemone is familiar to everyone. When its tentacles are extruded, the little animal has the form of a short broad cylinder. The mouth is a contractile opening centrally placed in the circular surface of the upper or distal end, while marginally placed are numerous strong tentacles in several rows. The base of the body acts as a disc of attachment, muscular contraction holding the organism fast to a submarine rock or shell. When the tentacles are wholly withdrawn the anemone has more the shape of a little bun, a cleft at the summit indicating the region of the mouth (Fig. 21, *a*, *b*, *c*).

Externally the Sea-anemone has the appearance of a large zooid, but its internal structure reveals no zooidal simplicity. The mouth does not lead into a simple body-cavity as in Hydra, but into an œsophagus or gullet. This passes downwards as a centrally placed tube half-way towards the base of the body, its lower end opening into a wide space, called the stomach, which in turn is in open communication with a number of chambers radially situated between the central œsophagus and the body-wall. The chambers are separated from each other by vertical septa, or "mesenteries," which pass from the body-wall of the anemone to the œsophageal tube, from the lower end of which they are continued downwards and outwards to the base of the stomach (Fig. 22).

FIG. 21.—*Actinia mesembryanthemum* (*tigrina*), a common sea-anemone. *a*, with tentacles half-extruded; *b*, with them fully extruded, and mouth visible; *c*, with tentacles withdrawn.

As in Hydra, there is an outer cell-layer of ectoderm, and an inner of endoderm, the latter lining the stomach and intermesenteric chambers. The gullet is lined with ectoderm (Fig. 22, A, B). Between these layers there is the connective tissue "mesoderm." Underneath the ectoderm there is also a layer of ganglionic nerve-cells and nerve fibres, which in lesser degree are present as well at the base of the endoderm. Certain of the septa are provided with longitudinal muscles, and it is on the free edges of the mesenteries that the reproductive organs are formed. The number of septa varies in different types of sea-anemone, though twelve is a common one—this statement referring to the "complete" septa which form the chambers; but "incomplete" septa are also present (Fig. 23, A) which do not stretch across to meet the œsophagus. The chambers of the sea-anemone are roofed over by a continuation of the cell-layers of the body-wall, but fine pores in the septa allow a measure of direct communication. The endoderm lining the chambers is well provided with cilia which maintain a circulation of the body contents. One sea-anemone, unless very rarely, comprises the whole Individual, and produces, *multiply* be it noted, both male and female sexual organs.

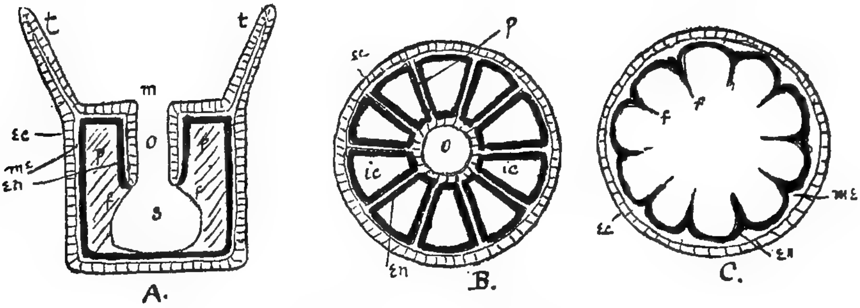


FIG. 22.—A, diagrammatic vertical section of sea-anemone drawn so as to show relations of œsophagus, stomach, septa, and mesenteries. *t*, tentacles: *m*, mouth; *o*, œsophagus; *s*, stomach; *p*, septa; and *f*, mesenteries. B. transverse section at level of œsophagus. C, similar section below the level of the lower end of the gullet. *ec*, ectoderm; *en*, endoderm; *me*, mesoderm; *o*, œsophagus; *ic*, interseptal chambers; *f*, edges of mesenteries.

Possibly these few facts regarding the structure of the Sea-anemone have already enabled the reader to recognise in the organism the multiplication of Continuously Zooidal Continuity, and that its structural plan is the logical sequel, in the ascending scale of Continuity, to that of the Continuously Zooidal Individual.

The cross-section of Adamsia, in Fig. 23, shows distinctly a plan essentially equivalent to that of a continuous "circular" series of tubular zooids whose body-walls are at times in close apposition, and at others incompletely developed. While centrally placed in the circular series, and supported by the best developed "zooidal" walls, is the short œsophagus, representing undoubtedly part of the "main-stem" of an ancestral branching zooidal system (Fig. 23, A).

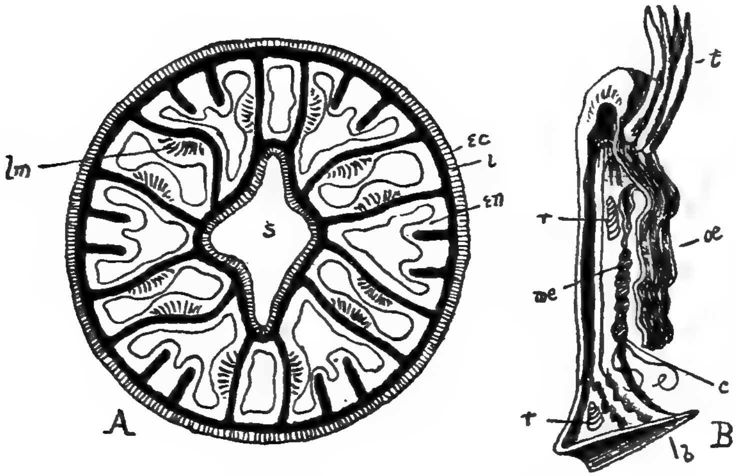


Fig. 23.—A, transverse section of a sea-anemone (Adamsia), slightly altered from O. and R. Hertwig. *ec*, the ectoderm (cross-shaded); *l*, the mesodermal layer of connective-tissue (shaded dark); *en*, the endoderm (unshaded); *lm*, cross-section of one of the longitudinal septal muscles; *s*, œsophagus. B, a segment of the body of a sea-anemone (Cereus), traversing the column from the top to the disc (after R. Hertwig): *b*, disc; *t*, tentacles; *œ*, œsophagus hanging downwards; *r*, *r*, reproductive organs attached to the faces of the mesenteries, (After Nicholson.)

As a help to make clear the nature of the Sea-anemones' Continuity let us take the following illustration, admittedly a fanciful one, but, considering that evolutionary compression has been literally a *physical compression during development*, not so extravagant as it might at first appear to be.

Let us picture a primitive Continuously Zooidal Individual to be modelled in wax, with its main-stem and lateral branches formed as hollow tubes directly communicating with each other, and the branches arising from the stem in a spiral at regular intervals as in phanærogams. If we could soften and at the same time compress the main-stem so as to produce a short wide cylinder in place of the long series of narrow cylinders, or wax " zooids " composing its length, and if we could simultaneously apply the same process to the branches, we would produce results somewhat like those drawn in the figure below (Fig. 24). That is, we would have a central short cylinder with a ring of others springing from the region of its base, and directly communicating with it in this region. And if even, lateral, compression were exercised during the process the ring of short cylinders would form a closely fitting circular series around the central tube, and give us a wax model of the fundamental plan of the Sea-anemone.

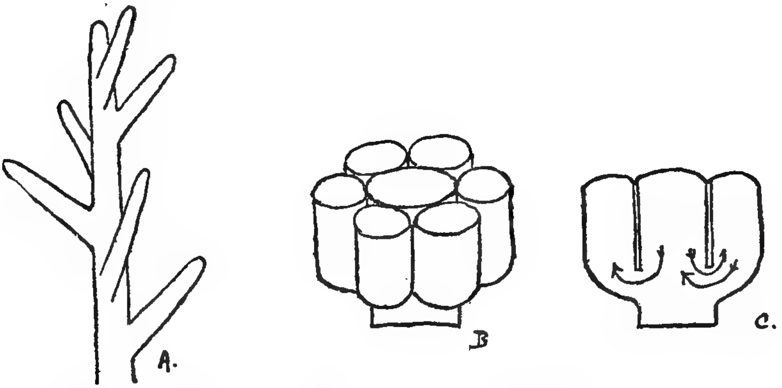


Fig. 24.—Diagram illustrating the probable derivation of the Sea-anemone's structural plan. A, hollow tubular continuously zooidal system of main-stem and branches. B, the result obtained by steady, even, serial and lateral compression in the experiment already mentioned. C, a vertical section showing how the compressed branches would communicate basally with the central cylinder. The top, or cap of the central cylinder would require to be removed to form the mouth.

The central cylinder would represent the œsophagus, whose walls would end abruptly where there was communication with the lateral cylinders; that is, below the œsophagus there would be a wide cavity bounded by the external walls of the lateral cylinders and by the base of the central one. This would represent the stomach. The hollow interiors of the surrounding cylinders would represent the intermesenteric chambers, and their contiguous walls would form the principal septa radiating from the œsophagus of the experimental megazooid (Fig. 25).

But the illustration of the wax model must not be taken too literally, for the compressed form and lateral Continuity of the earliest megazooid of Sea-anemone type must have evolved from the first development of a fertilised ovum of some primitive Continuously Zooidal type. This ovum must have had Continuously Zooidal *potentialities*, and these must have been modified (if we may so express it) as they strove to express themselves. In the evolution of the Sea-anemone type of megazooid there has been no compression of Continuously Zooidal structure *already developed*, such as has been pictured above; but, bearing this in mind, we may be allowed to use the illustration.

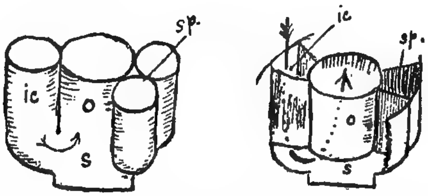


Fig. 25.—The evolutionary significance of the œsophagus (*o*), stomach (*s*), septa (*sp*), and intermesenteric chambers (*ic*), of the Sea-anemone.

Consistently with the derivation of the Sea-anemone which has been offered, and the identification of the intermesenteric chambers with ancestral zooidal body-cavities, we expect to find that when sexual organs are formed they will reflect zooidal repetition. And we are not disappointed. The reproductive organs are multiple, and are placed on the face of the mesenteries. That is, each recognisable " tube " of the megazooid produces its own sexual organs, and this fact, alone, indicates clearly that the evolution of the Sea-anemone has been on the general lines suggested. The megazooidal plan is clearly based on ancestral zooidal repetition (Fig. 26).

The Sea-anemone is an Individual. It represents all the (realisable) product of the fertilised ovum, and does not produce other megazooids by gemmation or fission, and the theory we have to offer is that the organism represents the compression in lateral Continuity, in past ages, and *during development*, of some primitive Continuously Zooidal Individual type. That Environment in certain of its most powerful aspects has all along striven to compress serial into lateral Continuity is perfectly clear, and in later chapters we shall try to show what these aspects are. But from an examination of its structure, alone, we can hardly doubt that the Sea-anemone has been derived from a Continuously Zooidal ancestry.

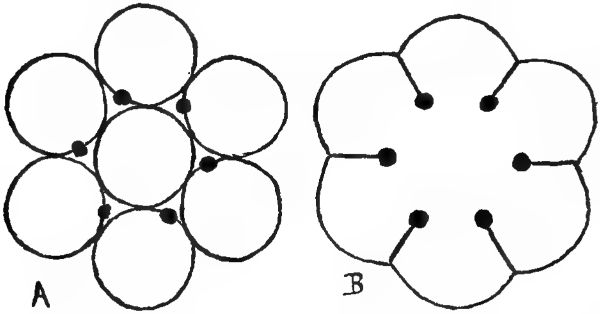


Fig. 26.—Diagram explaining the repetition of the sexual organs of the Sea-anemone. A, cross-section of a ring of zooids compressed round a central stem; the section passing through the reproductive organs of the zooids, which are presumed to be formed at a constant spot on the internal walls. On the supposition that the contiguous walls of the surrounding zooids have gone to form the septa of the anemone-megazooid, we can see how a result such as pictured in B could take place, the sexual organs appearing on the free edges of the mesenteries.

The anemonoid megazooid has not been a milestone on the road which passed on to the highest vertebrates. It represents a divergence from the main road, and one which came to a sudden stop. On the other hand, the megazooid of medusa type, about to be considered, has a structural plan which must closely resemble that of the primitive megazooid from which was derived the vertebrate segment. It is in the medusoid plan that the origin of the "cœlom" of higher types can be recognised.

The Medusiform Megazooid.

To the casual observer there would seem to be few resemblances between a jellyfish and a sea-anemone, but the fact remains that in both cases the structural plan is megazooidal and originally of Continuously Zooidal derivation. How then are the divergences in form and habit to be explained ?

The truth is that the differences depend on the different types of ancestral zooids which have been compressed in lateral Continuity. In the case of the sea-anemone the ancestral zooids have clearly been of typical cylindrical, tubular, or "vegetative" form, while in that of the jellyfish they have been of a structure whose characters reflected special adaptation for the function of reproduction.

Here lies the whole crux of the matter, and it is of the greatest importance to grasp clearly the distinction just mentioned, as in no other way can we satisfactorily explain the evolution of invertebrate and also vertebrate Segmental organisms.

But here a few words of explanation are necessary. The present chapter deals with Megazooidal *Individuals*, and we have now to consider the Mono-megazooidal of medusiform or jellyfish type ; but to do so it is necessary to hark back to the Continuously Zooidal Individual, for it is only through the reproductive structure of the zooidal colony that the derivation of the medusiform megazooid can be made clear.

As was stated on page 81, many marine zooidal colonies are zooidal throughout, the sexual elements being produced by structures which, though quite unlike the vegetative zooids in appearance, are zooids adapted for reproduction. But there are others in whom the sexual zooid is represented by a sexual megazooid of medusoid or jellyfish form in a state of imperfection or perfection, and in whom the Individual is partly zooidal and partly megazooidal. In certain colonies these sexual medusoids, or "gonophores," become separated to lead an independent existence and grow into large jellyfish which fertilise their own ova and originate new sessile zooidal colonies; but such medusoids are, of course, not megazooidal *Individuals.* Apart, however, from matters of structural detail the plans of the gonophore and of the Individual Medusa are the same, and this is also true of their derivation. It is to be understood that the immediately following remarks deal with medusiform megazooids which are *parts* of Continuously Zooidal Individuals, and which offer themselves as links between the latter and Individual Medusæ.

The Evolution of Sexual Structure in Marine Zooidal Colonies.

In these colonies the fundamental vegetative structure is the tubular zooid, and this, specially adapted and altered, is the basis of the various sexual structures exhibited. In its simplest form the sexual structure of the colony takes the form of a zooid which is not tubular nor possessed of a mouth leading to a body-cavity, but which has a globular form, has no external opening, and forms in the walls enclosing a blind protrusion of its producer's somatic cavity the sexual elements. This special sexual zooid is termed a "sporosac" (Fig. 27).

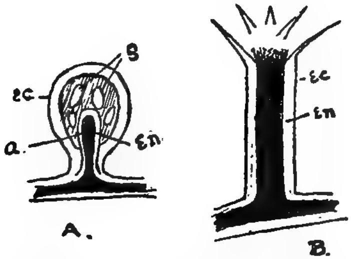


Fig. 27.—a, diagram of Hydrozoal sporosac. *a*, central hollow protrusion of the colonial "body-cavity"; *ec*, ectoderm; *en*, endoderm; *s*, sexual elements. b, diagram of a vegetative zooid for comparison. a is for all purposes like a b which has failed to form a mouth, and instead has formed sexual elements in its walls.

From some primitive Hydrozoal type which produced separate sporosacs a new type clearly evolved in which the successive sporosacs on a sexual branch suffered sufficient terminal compression during their development to form what is known as a " gonoblastidium," or a spray of sporosacs arising close to each other from a sexual stem, and enclosed in a capsule. This, in reality a manifestation of the intensification of Continuity, is the form of sexual apparatus borne by certain Hydrozoa of the present time, and is diagrammatically represented in the next figure.

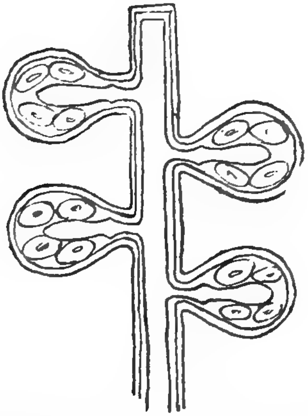


FIG. 28.—Diagram of the sporosac-gonoblastidium of the Hydrozoal colony.

But terminal compression had still further work to do, and by acting on some primitive sporosac-gonoblastidium (as this *developed*) it produced the medusiform gonophore. Elongation of the gonoblastidium stem bearing the sporosacs was not allowed to take place, but serial and lateral compression treated the whole system, as it tried to develop, roughly in the same way as they did the vegetative zooidal system which became the primitive sea-anemone. In the case of the early sea-anemone a whole potential Individual system was compressed, whereas in the medusiform gonophore only a small part of one was so affected ; but the real difference between the two cases is that in the former tubular vegetative zooids were involved, and in the latter sexual zooids of sporosac form.

Thus, the compression of the developing sporosac-gonoblastidium fused what should have otherwise become successive sporosacs, in lateral Continuity around a shortened and widened central stem whose hollow interior communicated at the base with a varying number of radiating tubes, each representing the central spade of a sporosac. Between these tubes or canals the sporosac walls developed in lateral continuity, and thus would be formed the bell or umbrella of the medusiform gonophore, whose nourishment finally called for the formation round the bell-rim of a circular canal from the ends of the radiating canals (Fig. 29).

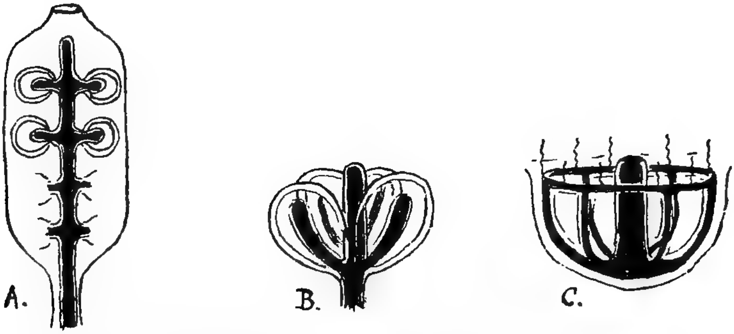


FIG. 29.—The evolution of the medusiform gonophore. A, sporosac-gonoblastidium; B, the theoretical results of compression during development of A, the results being incomplete; C, the perfect plan of the medusiform gonophore, a further development of B. B is diagrammatic of what is known as a "disguised medusoid."

There is still a higher form of sexual structure met with in Hydrozoal colonies, in the form of a gonoblastidium containing medusiform gonophores—a further intensification of Continuity, or of terminal compression. Its chief interest is in connection with terrestrial plant-evolution which is dealt with in a later chapter. It may be mentioned here, however, that in Phanærogams (Flowering Plants and Trees) we see a transition from zooidal to megazooidal Continuity parallel to that just described. In both cases the phenomenon is directly connected with the function of reproduction, and, as has already been said, we can observe a similar multiplication of Continuity, *within the Individual,* in certain humbler forms of life.

The typical, free-swimming medusiform gonophore is commonly known as a "jellyfish," in company with the truly different Individual Medusa—different not in essential plan, but in Individuality. Its two outstanding structures are the dome, umbrella, or bell, and the club-shaped "manubrium" which hangs from the concavity of this and terminates in a mouth. The bell is more or less transparent, and is largely composed of a jelly-like primitive connective tissue underlying the ectoderm. Near the rim of the bell this connective tissue is replaced by a simple form of muscular tissue which by giving rise to bell contractions causes the megazooid to move gently through the water. From the mouth at the end of the manubrium, or peduncle the alimentary tract runs to beneath the dome of the bell, at which point it divides into, or is continued as four, six, or eight narrow tubes or canals which radiate to the bell-rim as do the ribs of an open umbrella (Fig. 30, *a* and *b*).

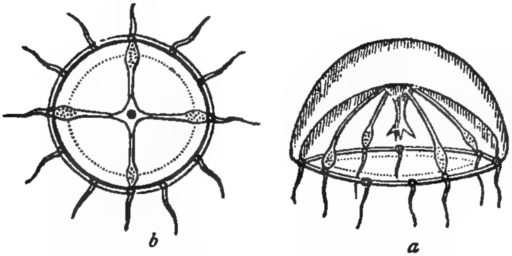


FIG. 30.—Structure of a free medusiform gonophore. *a*, Medusoid (*Thaumantias*) seen in profile, showing the central polypite, the radiating and circular gonocalycine canals, the marginal vesicles and tentacles, and the reproductive organs; *b*, the same viewed from below. The dotted line indicates the margin of the velum. (Nicholson.)

At the bell-rim the radial canals communicate with each other through a circular canal. Thus, the whole canal system is in direct communication with the mouth roughly in the same way as is the chamber system of the sea-anemone.

It is clear that such a digestive-vascular system as the gonophore's must have its fluid contents kept in circulation, and it is probable that the rhythmical contractions of the bell not only result in locomotion, but also keep the canal circulation going.

Like the sea-anemone (though only part of an Individual), the gonophore reveals its zooidal derivation by producing several sets of reproductive organs, and these arise in the expected situations. For they appear in the walls of the radiating canals—that is, in the walls enclosing what represent ancestral body-cavities or diverticula; or else they appear in the walls of the manubrium, itself equivalent to a compressed zooidal series.

At the margin of the bell tentacles are situated, and a thin veil of tissue projects inwards, the "velum," narrowing the bell-orifice after the manner of a ring-diaphragm. At the base of the velum there are an upper and lower nerve ring.

The primitive medusiform gonophore was no doubt permanently attached to the parent colony, through whom it was fed, and for this reason was not called on to form a mouth, and this form of gonophore is typical of several present-day Hydrozoa. But a higher form evolved in which a mouth was formed, and in which the bell by rhythmical contractions acted as an organ of locomotion bearing the gonophore away to lead a free existence. It is possible that occlusion of the canal in the stem attaching the gonophore to the colony may have been a cause as well as an accompaniment of strong bell-contractions and separation, as insufficient nourishment and oxygen, and the accumulation of waste products in the organism's canals, could cause the bell-contractions to begin. These could in turn, by raising pressure, cause a mouth to open, when rhythmical "respiration" and locomotion would naturally result.

We do not believe that the medusiform gonophore is a specially modified *zooid*; it is of the *sporosac* that this is true. We hold that the medusiform gonophore is equivalent to a sporosac-gonoblastidium which, as it attempted to develop, has been terminally compressed to form a *megazooid*. So far, it would seem, no attempt has been made to explain the real significance of the medusiform gonophore, but it is commonly taken for granted that as it is borne by a zooidal colony it is a glorified zooid of sorts in which the ordinary mouth-tentacles have become radial canals. There seems to be no grounds for this view, but, on the contrary, and consistently with the whole theory of the evolution of living Continuity, there is good reason to believe that the organism is megazooidal, and that the radial canals represent the blind, tubular, central spades of ancestral sporosacs which arose from a tubular stem. The radial canals, lined as they are with endoderm, have, it is suggested, a derivation parallel to that of the intermesenteric chambers of the sea-anemone; in fact, were the canals to be dilated so that they were in lateral contact with each other and with the central manubrium, the plan would be roughly that of the sea-anemone.

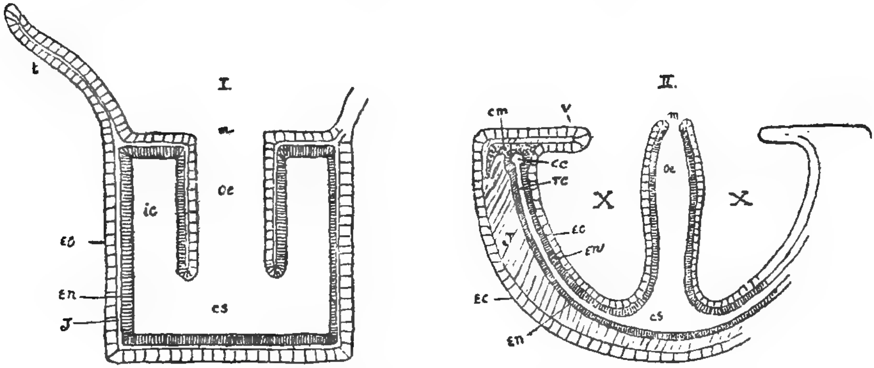


FIG. 31.—I, vertical section (very diagrammatic) of a sea-anemone, passing through two intermesenteric chambers. *m*, the mouth; *œ*, œsophagus; *cs*, cœlenteric space; *ic*, intermesenteric chambers; *ec*, ectoderm; *en*, endoderm; J, jelly tissue between these layers, and comparatively poorly developed. II, vertical section of a diagrammatic medusiform gonophore, dividing a radial canal in its length. *rc*, radial canal, corresponding to *ic* in I. *cc*, circular canal cut transversely; it has no equivalent in I. *v*, edge of velum. The other letters have the same significance as in I. The jelly tissue here is enormously developed except at *cm*, where it is represented by the circular muscle at base of the velum. Most important of all, we have the space, X, in II—a feature non-existent in I, where one layer each of ectoderm, jelly, and endoderm serves for the œsophageal tube and the inner wall of the intermesenteric chamber, *ic*.

But the radial canals are comparatively narrow, and this (consistently with our theory of sporosac-derivation) goes hand in hand with an enormous development of the jelly tissue lying between ectoderm and endoderm; and, further, the canals do not develop in contact with the manubrium, and thus at first sight the parallel derivations of anemone and gonophore are not apparent. With the help of Fig. 31 these points can be made more clear.

Now the space marked X in Fig. 31, II, is of the greatest importance, for in it we may recognise the basis, or anticipation, of what in higher living types is called the "cœlom." This will be returned to later, but it may be said that in animals classified as *Cœlomata* the "cœlom" is a space or cavity which surrounds the alimentary tract, and is contained by walls in which develop the supporting and muscular tissues, the circulatory system, and the sexual elements.

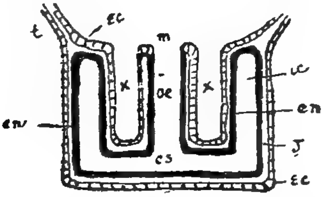


Fig. 32.—Imaginary drawing of a sea-anemone in section, with open cœlomic space like the medusoid's. Compare with Fig. 31, I.

The space X is in fact the medusoid's "open cœlom" surrounding the main alimentary tract of the manubrium; while in the walls of the space we have the jelly tissue of the bell, the forerunner of the cœlomata's muscles and connective tissues; in the radial and circular canal system the forerunners of the true circulatory system of higher types. It is also to be noted that the medusoid's sexual elements are produced on the canals in the external walls of the space, X, or on the walls of the space represented by the outer surface of the manubrium.

These suggestions, new and startling as they may appear to the reader in the face of generally held opinion, will be strongly supported when we come to higher types of living Continuity.

Had the primitive sea-anemone possessed a space like X, a section of the organism would have been presumably like Fig. 32; but in the primitive anemone's development X was uncalled for, and one layer each of ectoderm and endoderm were all that was necessary to line each side of the œsophageal walls; the ectoderm from outside growing down to line the gullet.

THE MONO-MEGAZOOIDAL INDIVIDUAL OF MEDUSOID PLAN.

The Individual Medusa.

The medusiform gonophore is, of course, only part of an Individual, and in contrast we have the real Medusæ which are complete Individuals and sexually reproduce others like themselves without intervening zooidal colony formation. Examples of such are the *Trachymedusæ*.

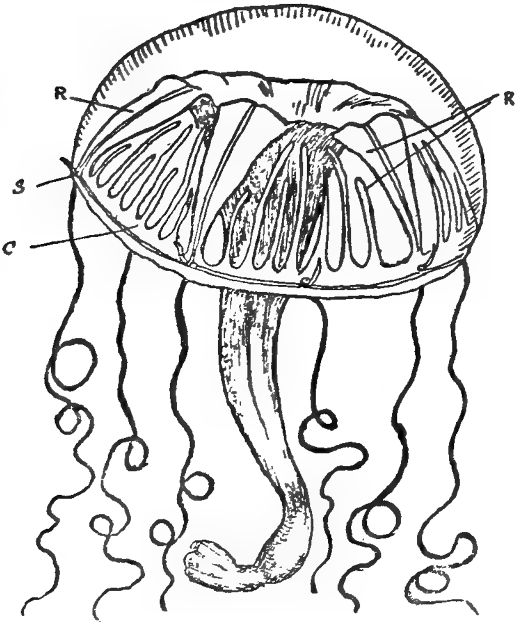


Fig. 33.—*Camarina* (*Geryonia*) *hastata*, an Individual Medusa. (After Nicholson.) R, radiating canal; C, circular canal; S, sense-organ.

The fact that the structural plan of the Medusa is practically identical to that of the free-swimming medusiform gonophore points clearly to a similar process of evolution in the past; that is, the plan is due to sporosac-gonoblastidium compression. But if so, where is the vegetative-zooidal structure which must have borne the gonoblastidium in the original ancestral type?

The most reasonable supposition seems to be that the ancestral type came to specialise in gonophore structure at the expense of the vegetative, till this became vestigial, and finally failed to develop at all. We might picture a primitive Continuously Zooidal Individual acquiring the special variation of producing only one gonophore, which developed to such a size at the expense of the colony that this became arrested. We might further suppose that the gonophore would swim away carrying with it its tiny "parent" colony, which would die off and disappear. In course of time it might well be that vegetative structure was omitted altogether in the development of the gonophore, so that this structure came to represent the Individual.

This is pure speculation, but it is reasonable to conclude that in the evolution of the Individual Medusa there has been some form of reduction leading to complete disappearance of ancestral vegetative zooidal structure.

In all medusoid organisms the dome of the bell represents the proximal end, and the remembrance of this fact is important in the study of megazooidal evolution. We might say that the "resting position" of a medusa is dome-downwards, and in fact medusæ sometimes do rest in this position at the bottom of the sea, behaving for the time being like sea-anemones.

It is true that the Medusa and the Sea-anemone are very different in appearance, but in fundamental structure they are practically the same. In both cases there has been a compression of a *developing* zooidal system to form a megazooid; an organism in no way colonial in structure though manifesting distinct repetition in its plan. But the Sea-anemone has been derived through the compression of tubular or vegetative zooids, whereas the Medusa represents the compression of sporosacs, or zooids of a special form adapted for producing sexual elements. If the manubrium of the Medusa were shorter and broader, so that the mouth was on a level with the rim of the bell, and if the radial canals were expanded sufficiently to obliterate the space, X, mentioned above, then we would have a species of Sea-anemone. The expanded canals would now be intermesenteric chambers communicating with the œsophagus, and the contiguous walls of radial canals be mesenteric plates on which the sexual organs would appear.

Thus, the Continuity of the Sea-anemone and of the Medusa is, so to speak, a multiplication of that of the zooidal colony. It is zooidal Serial Continuity transformed or compressed into Lateral Continuity, a megazooid being the result. But the two organisms mentioned are *Individual* megazooids, and there remain to be considered the two classes of Megazooidal Individual in which the growth-cycle passes through many megazooids; these being produced discontinuously in the one case, and forming a branching colony in the other.

CHAPTER XI

THE DISCONTINUOUSLY MEGAZOOIDAL INDIVIDUAL. THE CONTINUOUSLY MEGAZOOIDAL INDIVIDUAL

THE Monomegazooidal Individuals have not been milestones on Evolution's main road as, apparently, certain Polymegazooidal Individuals have been. For it would appear that a polymegazooidal Individual, or one composed of many megazooids, was the primitive cœlenterate type from which evolved the Vertebrata. The straight road of the evolution of Continuity is therefore regarded by us as passing on from the Continuously Zooidal to the Discontinuously Megazooidal Individual.

THE DISCONTINUOUSLY MEGAZOOIDAL INDIVIDUAL.

The component megazooids are here medusoid in structural plan, and enjoy an independent free-swimming existence. In the illustrative example which has been chosen it is true that there is a temporary exhibition of continuity, but as the megazooids ultimately all become discontinuous the above designation of the Individual may be taken as correct. Our example is *Aurelia,* a member of one of the main sub-divisions of the Hydrozoa which is called the *Lucernarida,* this being a zoological classification which does not take into account the question of Continuity's evolution.

In Aurelia the Individual begins life as a ciliated oval embryo, possessing a hollow interior. The embryo in time attaches itself to some underwater object and gradually takes the form shown in Fig. 34, *b* ; in fact, it becomes an attached medusoid, possessing a central manubrium with a mouth opening at the distal end, and an umbrella supporting marginal tentacles and supplied with a complete radial canal system. To this whole structure the name "Hydra-tuba" has been given.

The next stage of the Individual's development is the formation of a stolon from the base of the hydra-tuba, and from this stolon, or "runner," there arises another fixed medusoid like the first. This method of vegetative production may go on for a long time until a large colony of hydra-tubæ is formed, but a time inevitably comes when development proceeds on new lines.

The hydra-tuba grows longer, and the phenomenon of "strobilation" occurs, a series of circular grooves or indentations appearing on the tuba-walls. The grooves deepen, and the resulting prominent rings develop little lobes so that the tuba structure (now termed "scyphistoma") looks like "a pile of saucers" (Nicholson) with concave surfaces upwards. Finally the saucer-like discs are set free one by one, to develop into free-swimming medusoid gonophores which grow to a very large size. They produce sexual elements, and the fertilised ova originate new Individuals in the production of fresh colonies of hydra-tubæ (Fig. 34).

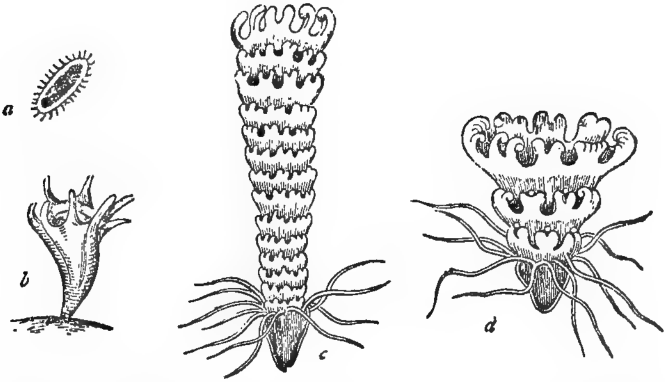


FIG. 34.—Development of *Aurelia*, one of the Acraspedote Medusæ. *a*, ciliated free-swimming embryo, or "planula"; *b*, hydra-tuba; *c*, hydra-tuba in which fission has considerably advanced, and the "strobila" stage has been reached; *d*, hydra-tuba in which the fission has proceeded still further, and a large number of the medusoids have been already detached to lead an independent existence. (Nicholson.)

The Aurelia Individual is of the greatest interest, for it will be shown later that from some such serially-medusoid type evolved the highest Segmental organisms, or Vertebrates. For the present we shall only observe that the strobila of Aurelia must "represent" the development in compressed lateral Continuity of a very large number of ancestral sporosacs in series. Thus, we might imagine a "spray" of eight sporosacs compressed as one medusiform gonophore, and a "spray" of sixty-four as going to make a succession of eight such organisms.

At the present day there are Hydrozoa which produce gonoblastidia containing not sporosacs but medusiform gonophores, which arise from the sides of the central stem; and our belief is that each gonophore here represents the compression of a laterally produced sporosac-gonoblastidium (Fig. 35, A, B). But in the case of the primitive Aurelia we are drawn to conclude that the strobila would represent the development in compression of one long unbranching stem capable of bearing very many sporosacs, which in successive multiples would form successive medusoids (Fig. 35, C, D, E). It is needless to say that the compression would be applied to the series all through its development.

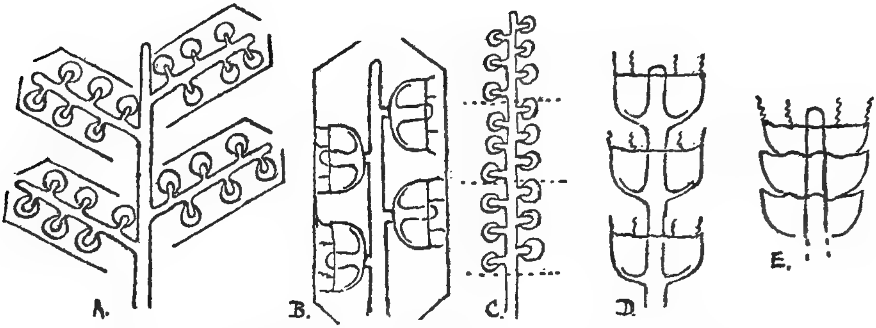


FIG. 35.—Explaining the evolution of strobilar continuity. A, B, showing how four (potential) laterally produced sporosac-gonoblastidia could by developing under compression take form as a gonoblastidium containing four medusiform gonophores (see Figs. 29, A, B, C); C, a long sporosac-bearing stem whose development under compressing influence could result in a straight series of medusiform gonophores, as pictured in D; E, the more complete compression of these in strobilar continuity.

All the development of the present-day Aurelia is clearly megazooidal, and the Individual should in time be represented solely by free-swimming gonophores. It is thus of a higher type than the Continuously Zooidal Hydrozoa which, though producing medusiform gonophores, develop as a whole zooidally.

THE CONTINUOUSLY MEGAZOOIDAL INDIVIDUAL.

This is simply a colony of megazooids produced by some form of continuous gemmation—that is, all remain attached to each other—and it is to the Compound Corals that we turn for examples (Fig. 36).

The above illustration shows a colony of megazooids produced by continuous gemmation ; a colony of compressed "zooid-multiples." And the plan of each megazooid is similar to that of the Sea-anemone. But the size of the Coral megazooid is generally very much smaller, and the organism is only part of an Individual ; while in addition it possesses a calcareous skeleton secreted by the soft parts, or formed by the calcification of the branching cœnosarc. Fig. 37, although the cross-section of a "simple" Coral, represents equally well the plan of the corallite of the Compound Coral.

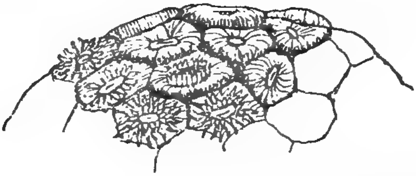


FIG. 36.—A small part of a compound coral, *Astræa pallida*. Some corallites have their tentacles extruded. (Diagrammatic, after Nicholson, after Dana.)

Thus, whereas in the Continuously Zooidal Individual we have zooidal serial Continuity, in the Continuously Megazooidal Individual we have megazooidal serial Continuity, a discontinuous Individual type intervening. In Fig. 36 the serial Continuity is not very obvious owing to the fact that the corallites successively produced grow closely together. Each is nevertheless a connecting link in some megazooidal branching series, and there is no true lateral Continuity, the corallite living practically an independent existence.

The Compound Corals undoubtedly share a common ancestry with Sea-anemones, and there are no indications that from them evolved any of the higher types. They arose off Evolution's main road, which appears to have struck onwards straight from the Discontinuously Megazooidal Individual. For this reason their mention here is brief.

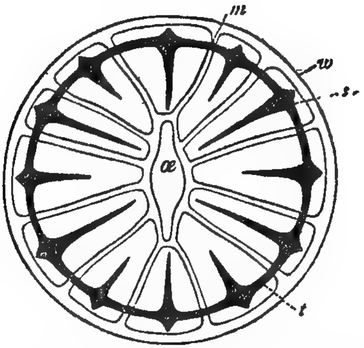


FIG. 37.—Cross-section of a simple coral. *œ*, œsophagus; *w*, body-wall; *m*, mesentery. The dark-shaded part is the calcareous skeleton), *t*, with septa, *s*, occupying intermesenteric chambers. (Nicholson.)

CHAPTER XII

THE RADIATE INDIVIDUAL

This Individual type comprises a group of marine organisms biologically termed the Echinodermata, of which familiar examples are the Starfishes and the Sea-urchins; and although they do not exemplify a further advance on the *main* road of Continuity's evolution, yet they do represent a higher form of Continuity than megazooidal and prepare us in a sense for the Segmental Individuals of the main road. In fact, it is possible to regard the Radiate as humble, or it may be depraved, Segmental Individuals for several reasons. Our brief remarks will deal with the common Starfish.

For a detailed account of this animal's structure the reader must refer to a textbook of Zoology, for we are only dealing with outstanding features.

THE organism's shape is that of a five-pointed star; the arms, comparatively short and thick, radiating outwards with their tapered points equidistant from their neighbours. The animal does not swim, but moves about at the bottom of the water by means of many protrusible tube-feet on the under surface of the arms. The mouth is in the centre of the under or ventral surface of the body, while on the upper or dorsal the anus opens. The digestive tract consists of a mouth, gullet, a pouched stomach, and beyond this a "pyloric sac," from each of whose five corners a duct arises to enter one of the arms and bifurcate into a pair of blind pouches or "pyloric cæca." Beyond the pyloric sac a straight intestine leads to the dorsally situated anus. More or less completely surrounding the alimentary tract is a true cœlomic cavity.

The Starfish has a water-vascular system, or, as it might be called, a radial canal system of a higher type than that possessed by the Medusa. It is concerned with the function of locomotion and does not communicate with the digestive tube. There is a circular canal round the gullet, and from this radiate five straight canals down the floor of the arms.

Each radial canal gives off on both sides a series of short lateral branches, which are continued into the protrusible tube-feet by whose means the animal moves slowly about; protrusion being the result of increased intra-canal pressure, assisted by special muscles and valves.

The nervous system takes the form of a circular nerve-tract immediately below the water-vascular ring just mentioned. From it radiate five nerve-cords, one down each arm below the radial water-vessel. A fine layer of nerve cells also underlies the body ectoderm generally. The reproductive organs are multiple; in the male ten testes, in the female ten ovaries, situated in pairs at the bases of the arms.

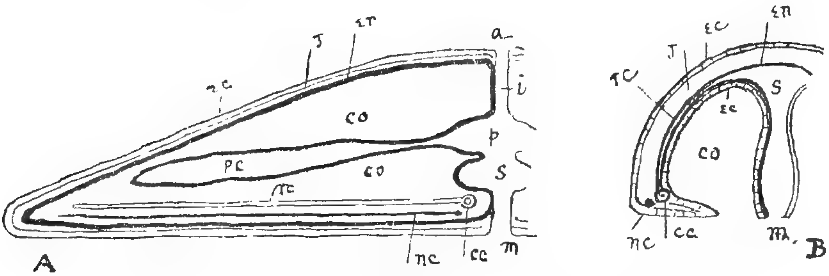


Fig. 38.—Comparing the Starfish with the Medusa. A, vertical section in the line of the arm of a Starfish. *m*, mouth; *s*, stomach; *p*, pyloric sac, giving off *pc*, pyloric cæca; *i*, intestine; *a*, anus; *j*, jelly connective tissue; *en*, endoderm; *co*, cœlom; *rc*, radial canal; *cc*, circular canal; *nc*, nerve-cord. The tube-feet arising from *rc* are not indicated. B. vertical section of a Medusa, dividing a radial canal. *m*, mouth; *s*, stomach; *rc*, radial canal, a continuation of *s*, and linked up with *cc*, circular canal; *nc*, nerve-cord; *ec*, ectoderm; *j*, jelly-tissue; *en*, endoderm.

It is difficult to classify the Echinoderm in terms of living Individual Continuity. The type we have taken, the Starfish, is clearly a higher animal form than the monomegazooidal Medusa. It presents, however, certain characters which seem to indicate some primitive medusoid ancestry.

For its body tissues are ectoderm, jelly connective tissue, and endoderm, and it has a radial water-canal system linked to a circular canal surrounding the mouth. Further, there is a repetition of reproductive organs, and in the neighbourhood of the radial canals; also one centrally placed alimentary tract, and a nerve-ring underlying the water-vascular ring.

On the other hand, in the Starfish we find a true, or closed cœlom contrasting with the "open" cœlom of the Medusa (see page 98); and the Starfish's radial canals do not connect with the digestive tract. In addition, the alimentary tract is sectioned off into special parts with special functions, and, most important of all, *ends in an excretory orifice,* or anus. Fig. 39 shows roughly the points of resemblance and difference mentioned.

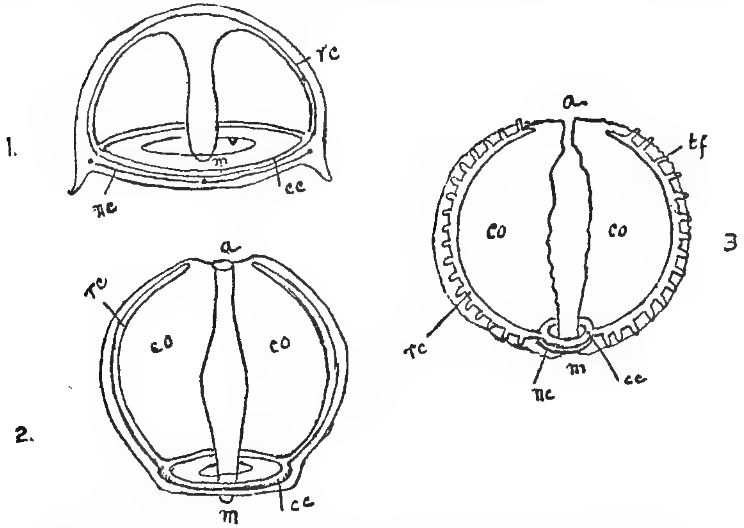


FIG. 39.—Illustrating suggested evolution of Echinoderms. 1. Medusoid plan, with "open cœlom" at *v*, the edge of the velum encircling the mouth end of the manubrium. 2. The same plan drawn with an anus opened at *a*, the radial canals, *rc*, being thus cut off from the stomach. The circular canal is drawn smaller, and the velum as encroaching on the region of the gullet. 3. The cœlom is drawn as completely closed by an encroaching velum, and the circular canal and nerve-cord encircle the gullet. By furnishing the radial canals with tube-feet the plan is made the rough one of a sea-urchin. *m*, mouth; *co*, cœlom; *cc*, circular canal; *nc*, nerve-cord; *tf*, tube-feet.

On a previous page the suggestion was made that the space between the bell and manubrium of a medusa is, so to speak, the forerunner of the true cœlom of higher types;

a suggestion to be developed further in connection with Segmental Individual evolution. And we would attribute the main peculiarities of the Starfish's structure, and that of Echinoderms generally, to two special modifications, namely, the complete closure of the ancestral medusoid "open cœlom" in the region of the velum, and the formation of an anus.

If during development such a plan as the medusoid's were modified by the opening of an anus at the dome of the bell, and, as a result, the cutting off of the radial canal system from the alimentary tract; and if at the same time the wide bell-mouth and velum of the medusoid were to develop in a contracted form, tightly enclosing the gullet-region, the circular canal and nerve-cord being relatively small rings, the fundamental plan of Echinoderms would be the result (Fig. 39).

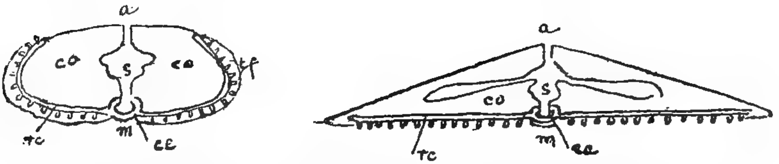


Fig. 40.—To compare with Fig. 39. A, the partially flattened plan of the sea-urchin; B, this plan drawn with the radial canals fully extended horizontally, and representing roughly the section of a Starfish. Letters as in previous figure.

A plan such as this, if compressed or flattened in development, with extension horizontally of the radial canals, would give the rough plan of the Starfish, as in Fig. 40. These figures, it is needless to say, are not offered as actual stages in development, but as illustrating how the medusoid plan is recognisable as the forerunner of the echinoderm plan.

From the fact that echinoderm larvæ are bilaterally symmetrical, and show signs of segmentation, we might reasonably conclude that the mature organism has had a serially-medusoid primitive ancestry such as can be attributed to the earthworm, and we might take the bilateral symmetry as indicating that the echinoderm had an ancestor which was free-swimming. This last suggestion is, however, doubtful, for in the evolution of the earthworm, as in that of the fish, it would appear that the new digestive opening provided was a mouth and not an anus, and that the formation of an anus at what would have otherwise been the dome end of a medusoid series would be incompatible with active locomotion of marked degree. This is, however, anticipating later chapters. What might be presumed is that a near ancestor of the echinoderm had certain powers of locomotion, and that these have been lost; more or less stationary habits and the evolution of tube-feet being later developments (Fig. 40).

CHAPTER XIII

SEGMENTAL INDIVIDUALS

The highest types of living organism are constructed on a segmental plan. They ought not, however, as is commonly done, to be regarded or talked of as having been "divided into segments"; in reality, they have been built up in segments. Their evolution has been based on the one fundamental principle ruling all Evolution, namely, The Intensification of Continuity.

We have seen that, as far as we have gone, Life can be classified in an ascending scale according to the species of Continuity it manifests, and that living evolution has been fundamentally the evolution of Continuity by a process of repeated multiplication. Up to the Continuously Megazooidal Individual the process is wonderfully reflected in existing organic types as one of alternation of serial and lateral Continuity-intensification. Thus it is that when we pass on from the Megazooidal we might expect to find a Discontinuously and then a Continuously "Hyper-megazooidal" Individual type, in both of which the "hyper-megazooid" would be equivalent to series of megazooids compressed in lateral Continuity, *during development,* to form a very complex species of growth-unit.

We do not actually find this, yet we do find a form of multiplication of megazooidal Continuity. It is what we might call "serial multiplication," or the "fusion" of the megazooids of a continuous series to form an organism which has nothing colonial in its structure. There is loss of megazooidal identity in the evolution of a higher form of growth, and we might roughly liken what happens to the fusion of a row of beads on a string to form a single rod (or several rods) in which the original beads could still be traced by external indentations. Apparently, evolutionary environmental forces, having evolved the megazooid, were obliged to abolish colonial structure in order to obtain higher complexity of function.

For the Continuously Megazooidal is the highest form of living Continuity which is truly colonial in nature, or in which distinct multicellular organisms leading practically independent existences remain attached to each other to make the Individual. But as the *lateral* fusion of zooids in the megazooid is not so complete as to leave no indications of what has happened, so the *serial* fusion of megazooids in the Segmental organism has not banished all traces of megazooidal derivation; and it is to such areas as by their traces of megazooidal boundaries indicate megazooidal derivation that the term "segments" is here applied, the organisms composed of these being called "Segmental" organisms.

But a Segmental organism is not necessarily a Segmental Individual, for the latter presents itself in two main classes; in one being composed of many separate segmental organisms, and in the other of one organism. And it is to be noted that in the former the separate organisms are not segments, but are composed of segments just as in the latter.

The two main types of Segmental Individual are therefore The Discontinuous Segmental and the Continuous Segmental.

The Discontinuous Segmental Individual we shall do no more than mention, intensely interesting as it is. There can be little doubt that it originated as a branching off from the main road of Evolution, and that it was not the ancestor of the Continuous Segmental Individuals from which man was ultimately derived. Typical present-day representatives of the class are the Aphis and Honey-bee Individuals, well known as striking examples of Alternation of generations and Parthenogenesis.

THE CONTINUOUS SEGMENTAL INDIVIDUAL.

The number and variety of Continuous Segmental Individuals in Nature are immense, including among others such diverse forms as Echinoderms (probably), Annelids, Molluscs, Ascidians, Fishes, Birds, Reptiles, and Mammals;

and as these fall into one or other of the two great divisions, Invertebrata and Vertebrata, we shall take as examples the invertebrate earthworm and the vertebrate fish. The case of the Fish, however, we shall leave to a later chapter dealing with the evolutionary factors which probably were at work in producing the ascending scale of living Continuity. In this way undue repetition will be avoided. To both the earthworm and the fish we would attribute a serially-medusoid derivation, but without the inference that the fish has evolved from any primitive invertebrate type possessing characters in any way approaching those of the worm. Our suggestion is that the vertebrates took a line of their own distinct from invertebrate segmental organisms.

THE EARTHWORM.

This familiar animal is invertebrate and typically segmental, its segmentation being truly reflected by the succession of annulations on its body surface. In all there are some 150 of these markings, and between any successive two there is a segment. External annulations, however, are not always a true guide to the number of segments in an annelid, as in the case of the Leech, in whom several annulations go to one segment. The mouth is situated at one end of the earthworm and the anus at the other, and the alimentary tract is a continuous tube running down the whole length of the cylindrical body. But between the digestive tube and the body walls there is a space, or cavity, the *cœlom*, divided by thin partitions into a series of separate chambers, one for each segment; and the true segment is all that is enclosed by two such partitions. The general plan of the worm's body might therefore be likened to a series of 150 pill-boxes gummed together end to end, with a hollow glass tube passing down centrally through all the partitions in the series. The glass tube would be the alimentary tract, each box represent a segment, and its cavity one of the cœlomic subdivisions.

The body walls enclosing the cœlom are composed of the following layers from without inwards: the cuticle (which is not cellular, but a hardened secretion); the ectoderm, which secretes the cuticle; a very thin layer of connective tissue; a layer of circular and then one of longitudinal muscles; and finally a thin layer of parietal peritoneum.

The main features of the circulatory system are a long dorsal bloodvessel running the whole length of the body, with another similar vessel running ventrally below the digestive tube, and below this a third underlying the nerve-cord. The different vessel-systems communicate in various ways, but that which is of special interest is the linking together of the dorsal and ventral vessels "by means of five pairs of loops called hearts, situated in the seventh, eighth, ninth, tenth and eleventh segments" (Shipley and MacBride).

Of equally important evolutionary significance is the nervous system of the worm. Lying above the pharynx are two suprapharyngeal ganglia, from each of which passes downwards and backwards a nerve-cord to unite to form the first ventral ganglion. The pharynx is thus surrounded by a nerve-collar or commissure connected below with the ventral nerve-cord, which is formed by the linking together of the nerve-ganglia of all segments behind the fourth; one ganglionic swelling being situated in each segment (Fig. 41).

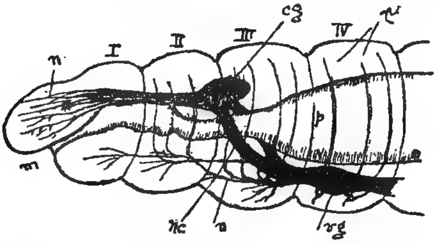


Fig. 41.—The earthworm's central nervous system. Roman numerals indicate the segments. *m*, mouth; *p*, pharynx; *cg*, the cerebral ganglia; *nc*, nerve-collar round pharynx; *vg*, first ventral ganglion of the chain which passes down through succeeding segments; *n*, nerves. (After Shipley and MacBride, after Hesse.)

In every segment except the last and the first three there is a pair of excretory organs, or "nephridia." We are not concerned with their structure, but have to note the repetition here exhibited.

As regards reproductive organs, the worm has a pair of ovaries in the thirteenth segment, and two pairs of testes in the tenth and eleventh segments.

Now our view of the earthworm is that its body has not been divided into segments, but *built up* into segments, and that these represent ancestral megazooids which under modifying force were caused to develop in close continuity; sacrificing separate identity in order to form a single segmental organism with nothing colonial in its structure. This is in the first place confirmed by the obvious repetition of the segmental unit, and, on the whole, of its contained parts. It is not suggested that ancestral megazooids gradually acquired the habit of growing closer and closer together, but that with a suddenness quite as dramatic as that suggested in the origination of the primitive sea-anemone, the primitive ancestor of the earthworm appeared. For the process must have been a sudden modification of development; and what we imagine is that a fertilised ovum, whose development under normal environmental conditions would have produced a series of medusiform megazooids, was made in past ages to develop under new conditions which inevitably modified the expected mature plan. That true megazooidal repetition potential in the fertilised ovum was modified in its attempts at realisation by forces making for closer continuity.

"But," it may be objected, "allowing that on one uniform principle we may explain the evolution of the Filamentous, the Discontinuously and Continuously Zooidal, and the corresponding Megazooidal Individual types, is there anything to support the supposition that a serially-medusoid ancestor for the annelid ever existed?" Undoubtedly there is. It is reasonable to believe that we have a present-day descendant or offshoot of such an ancestor in the interesting *Aurelia* (page 103).

At a certain stage of its development the hydra-tube (Fig. 34) is just a continuous series of developing medusoids. It is true that as they ripen they are shed distally, one by one, to live independent existences; but before this happens the "strobila" may be said to have the rough plan of a segmental organism. For the alimentary tract is one tube representing the manubria of the medusoids about to be perfected, and the future separate water-vascular systems are in continuity to form a temporary system for the whole. If therefore we imagine that a primitive type with general characters like those of Aurelia stopped at strobilation, and did not throw off its "segments" as medusoids, but that these as they matured were modified to form indivisible parts of one organism, we would have a picture of a primitive Segmental Individual.

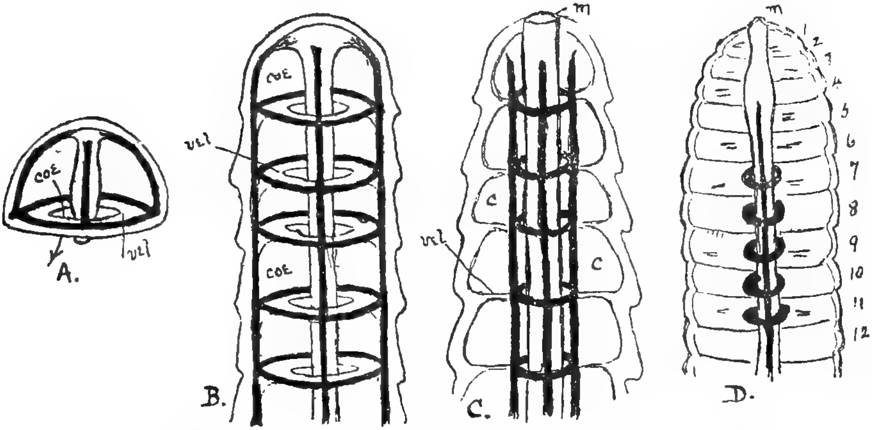


FIG. 42.—Illustrating theory of the earthworm's evolution. A, general plan of a medusoid. B, plan of imaginary series of such medusoids which by developing in close continuity have lost separate identity. C, the imaginary organism, B, with a mouth, *m*, developed at what becomes the anterior end; and with its successive circular canals encroaching, along with successive vela, to encircle closely the digestive tube. *coe*, the "open" cœlom of A, is now in C the closed coelom shut in by the encroaching velum, *vel.* D, diagrammatic plan of anterior segments of earthworm's body, showing successive subdivisions of the cœlom, the dorsal vessel, and its five hearts encircling the digestive tube. *m*, mouth; 1, 2, 3, etc., the segments. (Also see Fig. 57.)

In such a one we would expect a distinct amount of repetition of circulatory, nervous and reproductive parts or organs, and that the plan and arrangement would clearly reflect megazooidal derivation; and, if our suggestions are sound, we should recognise these features in a typical annelid like the earthworm. Our primitive segmental organism would clearly be aquatic and free-swimming, and its movements be based on ancestral medusoid bell-contractions.

With the help of some diagrams we shall make clearer the broad outlines of our hypothesis, which will be developed further when we come to the evolution of the primitive Fish.

Let us take a segment of the earthworm between the seventh and the twelfth; that is, one which contains a heart. In the muscularly contractile walls of the segment we would recognise the contractile ancestral medusoid bell. Surrounded by these walls is the cœlomic space, and this we take to represent the space between bell and manubrium in the ancestral medusoid, while the transverse septa dividing off the segments might represent medusoid vela developed closely round the alimentary tube. Down the centre of the segment runs the alimentary canal closely encircled by a heart of the worm. In the alimentary tract we recognise the ancestral medusoid manubrium, and in the heart a medusoid water-vascular circular canal.

In the mysterious Echinoderm, in the Sea-urchin for example, one comes across a parallel exhibition of the close encirclement of the digestive tube by a circular vessel; and although here the vessel is not a true water-vascular one of medusoid type, nor yet a true bloodvessel, we believe that it represents an ancestral medusoid circular canal. For it encircles the œsophagus, and from it radiate five canals which bear the protrusible tube-feet of the organism. The radial canals do not communicate with the alimentary tract as in the medusoid, and their function is in connection with locomotion; and it seems most probable that this state of affairs came about with, or as a result of, the development of an anus in the first primitive echinoderm. And in the sea-urchin this small circular canal is accompanied by a closed cœlom which we would suppose to be originally due to the closing in of the medusoid velum.

But in the primitive annelid we believe the *mouth* to have been a new feature; that is, that what we picture as the mouth end of a strobilar medusoid series took on the functions of an anus—having ancestrally acted both as entrance and exit—and that an opening developed at the convex end of the series and became the mouth; all this being during development. Also that this entailed the development of the canal system as a closed circulatory system. The causes of mouth-formation are dealt with in another chapter.

Naturally, in order to drive its contents along, such a closed circulatory system would need something new in place of ancestral bell-contractions, or in addition to the muscular segmental contractions representing these; and it may well be that the closure itself called forth the driving mechanism. For the recurring accumulation of waste-products within the closed system would stimulate contraction in the vessel-walls, and cause the development of the regularly contracting hearts of the worm. In harmony with our theory, the dorsal and ventral vessels would represent the linking up of ancestral radial canals in straight lines, *during development.*

It would seem that the primitive ancestor of the worm was not called on to develop gills as was that of the fish, hence the probable derivation of the hearts is very apparent. In the fish, however, as we shall see, we have the medusoid circular canals represented in the branchial arches, but owing to gill formation they do not surround the digestive tube as they do in the worm.

The nervous system of the earthworm can be interpreted in a similar way to the circulatory; that is, its ground plan is the same as if the circular nerve-cords in the rims of successive medusoid bells in series had their ganglia united serially to form ganglionic chains. In the earthworm, however, only one longitudinal chain has developed, but in compensation there is central nervous control. This is exercised by two large ganglionic masses united together above the pharynx and situated on the well-developed circum-pharyngeal collar mentioned and figured on page 115. It is in this nerve-collar that one can recognise the medusoid nerve-ring circling round the rim of the bell. In the medusoid the ring bears ganglia at regular intervals, and in the worm's supra-pharyngeal ganglia we seem to have these massed together at one definite spot. In medusoids the nerve-ring surrounds, at a distance, the manubrium; in echinoderms, which would seem to be of medusoid cœlenterate derivation, the nerve-ring surrounds the gullet also, though more closely; and it is consistent with our theory that in the earthworm the nerve-collar surrounds the pharynx.

In the segments posterior to the third (Fig. 41) no nerve-collars are present, but in their place, ventrally, we have what we may call ganglia of absent nerve-rings, united in series to form the ventral ganglionic chain. This system of circum-pharyngeal collar and ventral chain is peculiar to the Invertebrata, and will be referred to again in connection with the Vertebrate's nervous system.

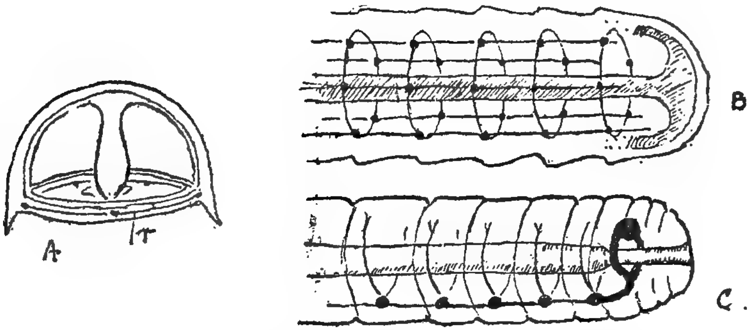


Fig. 43.—The evolution of the nervous system of the earthworm. A, diagram of medusoid nervous system. *r*, the ganglionic cord running round the rim of the bell. B, imaginary figure showing a primitive serially-medusoid organism in whom the successive nerve-cords are linked up to form several longitudinal chains. C, diagram of anterior segments of the earthworm in which, as it were, only the first nerve-ring of B is represented, and the ganglia of this occupy a dorsal position; while the succeeding rings of B are only hinted at by the presence of a ventral line of ganglia, one for each segment, and united to form a chain. (See also Fig. 62.)

Fig. 43 illustrates the suggestions made above.

With respect to the reproductive organs of the worm it may be noted that these are formed at special points in the walls of the cœlom. This is in harmony with our view that the cœlom walls are derived from ancestral medusoid bell-walls, as in these, closely applied to the radial canals, is the common position for the sexual organs of present-day medusoids.

The segments of the worm are very small and simple in comparison with those of a vertebrate like the horse.

But neither size, nor cell-content, nor complexity, has anything to do with forms of living Continuity *as forms.* Size, it would seem, but manifests the degree to which the intermediate cycle-product of the Individual is allowed or encouraged to develop as fixed cell-species which can never become sexual cell-species ; while, within a given form of Continuity endless variation is possible.

The above brief suggestions may well seem startling to the reader, but they are perfectly in harmony with our theory of Continuity's evolution. The Segmental Individual offers itself to us as a further victory of Attraction, or compressing force, over Repulsion, or separating force.

The different forms of living Continuity have originated as the fundamental Acquired Variations behind all living Evolution ; variations, be it noted, *acquired during development.* Each advance, it clearly seems, has been the result of sudden modification of a previous plan at the call of special Environmental action or influence. The hereditary plan has been altered, *as it attempted to realise itself*, by influences always making for closer and closer Continuity. The fundamental "evolution of species" has been that of the "Species of Continuity."

CHAPTER XIV

CONTROL. ARREST

SUCCESSFUL control implies the preservation of the identity of any given living system, or of its equilibrium as a whole in the face of all forces tending to disintegrate it. And this is so although the system is " internally " a scene of constant disequilibrium.

It is through a centre, or centres, of control that its equilibrium is maintained during the life of a living system; and moreover, it is through such centres that the action of Environment in moulding and adapting the product of the growth-cycle has been, and continues to be carried into effect, the centres themselves being part of the moulded product. The evolution of Control has clearly gone hand in hand with the evolution of Continuity, and thus shows itself as a species of progressive multiplication.

Every atom, we believe, retains its identity, or at a given moment exists as a definite electronic system by reason of the controlling power of its core or centre; and it would seem to follow that every plasmolecule similarly controls its component atoms. Further, in both cases we may say that as the controlling centre can both attract and repel any one of its controlled parts, so each system has an afferent and efferent nervous system of a fundamental sort. The nucleus of the cell is the multiple of the atomic or plasmolecular centre, and may be looked on as the cell's central nervous system which sends and receives messages to and from any part of the cell along molecular nerve-paths, the plasmolecular centres being, as it were, so many " nerve-ganglia " on the paths. In fact, the cell's nervous system has in command the nucleus; under this, the plasmolecule's nucleus, and under this the atoms controlling the electron. And whether the cell is discontinuous, or united with others to form a tissue, the general functions of its nucleus are the same; the balancing and harmonising of countless interreactions within the bounds of the cell, and the preservation of cell-identity or personality. Bearing this in mind, we shall now briefly summarise the successive "multiplications" of cell-control recognisable in existing individual types.

In the Discontinuously Multicellular Individual the supreme control is the nuclear control exercised in each free unicellular organism.

In the Filamentous Individual, which is really a cell-colony, the same may be said to be the case. At the same time each cell of the filament is apparently to some extent influenced by its neighbours in series, for there is the phenomenon of temporary cell-arrest. But we regard this as the result of the primitive cell continuity obtaining, or of hostile environment in the form of cell-attachment.

In Cœnocytic Individuals, such as Mucor for example, control is probably also nuclear. But here there is a closer degree of serial and a development of primitive lateral continuity, the colonial unit being not a cell but a cœnocyte. As this is composed of series of protoplasts which are not separated from each other by partitions, a certain amount of mutual control is probably exercised by the nuclei of the protoplasts. It is to be inferred that the protoplasts do not absolutely control themselves as the cells of the true filament presumably do, and that what affects one will probably affect all its companions in series.

In the Discontinuously Zooidal Individual the zooid is composed of true tissue regionally adapted to special functions. Each cell here lives not only for itself, but also for the common cell-good of the whole zooid. As the zooid is a complete cellularly continuous organism, and one requiring to coordinate the action of all its parts, we might expect some form of "supra-nuclear" control to be present; and it is no surprise to find that recently a fine network of stellate nerve-cells united by fine nervous threads has been discovered in the jelly underlying the ectoderm. By this means every cell of the zooid, while controlling its own metabolism through its nucleus, does so under the orders or influence of all the other cells, quickly collected and distributed by the nervous network.

In the typical Continuously Zooidal Individual each vegetative zooid is practically independent and its immediate control is like that of the free zooid just mentioned, though it is probable that one zooid may indirectly influence another through the cœnosarc. In the case of what we regard as terrestrial derivatives of a primitive Continuously Zooidal type—the Phanærogams—where the ancestral zooids are not discretely demarcated but develop in unbroken continuity, we expect to find some form of communicating nervous system linking these up with one another. That such a system is present there can be little doubt, but the question is, Which of the continuous tissue-systems of the plant represents it? In all probability it is the sieve-tube system, whose tubes traverse all regions of the plant, and contain running down the centre an "axis" of albuminous fluid, outside of which is a layer of un-nucleated protoplasm

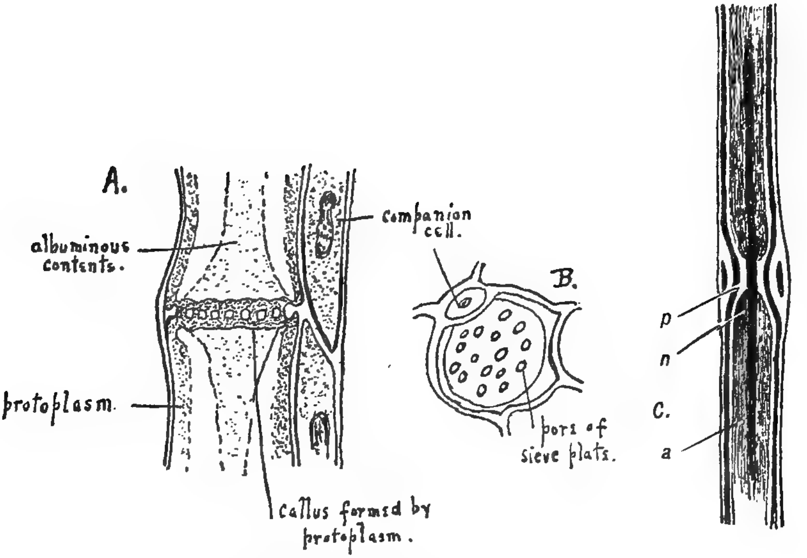


FIG. 44.—The probable nervous system of the Phanærogam. A, longitudinal section of sieve-tube in region of sieve-plate. B, sieve-plate viewed from above. C, diagrammatic "node of Ranvier" in medullated nerve-fibre. *a*, axis-cylinder; *m*, medullary sheath interrupted at node; *p*, primitive sheath thickened at node. (A, B, after Lowson; C, after Key and Retzius.)

lining the tube. The albuminous axis is usually regarded as food material, but it might well be in reality a path for nervous impulses. Closely applied to the tubes one finds certain peculiar cells called "companion cells" whose functions are unknown. It is tempting to wonder if they might not be the plant's nerve-cells. At intervals the sieve-tube is partitioned by perforated plates across which at times the protoplasmic lining spreads, thus breaking the continuity of the albuminous axis; and although we do not for a moment suggest that the medullated nerve-fibre of the vertebrate owes anything to plant-life, yet we cannot but notice a certain similarity of design in this structure. For it has a central conducting axis-cylinder surrounded by a "medullary sheath," and is partitioned at intervals by a plate, or "node of Ranvier," through which the axis-cylinder alone seems to pass. It is just possible that this may be a case of parallel design.

Turning now to the Discontinuous megazooid—an Individual as is the Sea-anemone, or part of one as is the medusiform gonophore—we meet again a diffuse communicating nervous layer bringing all parts of the organism into touch with each other. This is what we would expect, for the megazooid is equivalent to a number of zooids fused in lateral continuity round a central stem, and it is natural that the ancestral zooidal nervous layers should be linked up in continuity. At the same time the nervous layer of the megazooid is more complex than that of the zooid, as will be seen in the figure below (Fig. 45).

In medusiform organisms, however, there is in addition to the diffuse nervous system mentioned a special one whose presence is undoubtedly connected with the function of bell-contraction. For round the rim of the bell there are situated at intervals special nerve-ganglia linked together by a circular nerve-cord. Each ganglion is a little control-station governing a special section of contractile bell; and we have here the first appearance of a definite nervous system on a concentrated repeating plan, and which, moreover, is probably the basis of the nervous system of the highest forms of living Continuity. The circular nerve-cord with its ganglia is clearly for the regulation of the contractions and relaxations of the medusoid swimming-bell, so that steady locomotion and respiration may take place, the latter in the form of a regular drive of fresh contents through the canal system. Thus we might regard the circular ganglionated cord as the primitive central nervous system, for it controls circulation, respiration, and locomotion, and probably commands the action of the diffuse nervous layer which controls the actual tissue cells.

Where the Individual is, like the compound Coral, continuously megazooidal, or a colony of units on the plan of the sea-anemone, each corallite controls its own functions as does this organism. Naturally, as environmental influences, the corallites may affect each other.

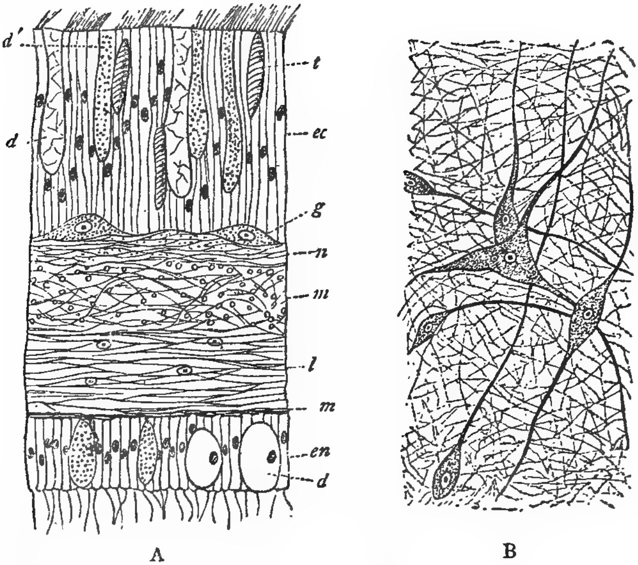


FIG. 45.—A, cross-section of sea-anemone's tissue layers (magnified), showing ganglion cells (*g*) and nerve-fibres (*n*) lying between the ectoderm (*ec*) and the mesoderm (*m*, *l*); *en*, the endoderm. B, greatly magnified view of ganglion cells and nerve-fibres. (Nicholson.)

Passing aside to the Radiate Individual, we find a " central nervous system " similar to, but more advanced than that of the medusoid, there being a circular ganglionated nerve-cord which we take to be of medusoid derivation. In addition, however, there are radial nerve-cords which pass down from the circular cord to the arms, in the starfish, or equivalent positions in the sea-urchin.

In typical Segmental organisms, equivalent to megazooidal series whose units, *in development*, have fused to form one indivisible organism, we find that as digestive and vascular systems have linked up in continuity so have the nerve-rings of ancestral megazooids. This is well seen in the humbler Segmental Individuals where megazooidal ganglia have been linked together to form a chain running the length of the animal. This is referred to in connection with the earthworm (page 120) and the evolution of the fish (page 192).

The preservation of a living system's identity is in reality the preservation of the Continuity it exhibits; therefore the Control of a living system is essentially the governing force by which it maintains this Continuity, and with this its cell-arrest. These are the two factors which allow the development of special functions all working for the preservation of identity. The control of the body is not, however, carried out by an absolutely autocratic centre. The government is constitutional, every cell has, so to speak, a vote, and the decrees which issue from the centre are, if not always in response to petition, at least criticised by the cells. Clearly the number of parties and individual interests to be satisfied is enormous, and there is never peace within the living body. One can thus see that Control has evolved not as an independent factor, but as part of an evolving balancing equation whose developing functions must inevitably influence each other.

Control cannot be separated from Arrest; in fact it implies the power to arrest, to maintain arrest, and to release from arrest. In a word, controlled growth is essentially a matter of carefully balancing arrest and release from arrest on a plan which ensures the development and preservation of the Individual's identity or personality. When this balance is lost, or when control fails, then in the part concerned there is uncontrolled or atypical growth, a subject to be mentioned later. The break-down of the central control-system entails the complete discontinuity of the Individual's parts; the loss of identity; Death.

ARREST.

It has to be noted here that arrest in the form of stoppage or retardation of growth, the direct result of hostile environment acting more or less suddenly, is not in question. We are concerned with arrest which is the result of the action of Environment as evolutionary force; arrest which first appeared as the product of Continuity, and which is under control. We might call it the arrest of the differentiated tissue or the fixed cell-species.

In all forms of living growth the cycle runs its course to end in the reproduction of one or both of the elements whose union set it going, and Arrest resulting from Continuity can in greater or less degree limit the extent of this (multiple) reproduction. It cannot, however, of itself totally prevent the reproduction. What it can do is to take a certain " amount " of the developing Individual, an amount which if left alone would theoretically become in time an enormous number of gametes, and cause this (assisted by other factors) to multiply along the side-paths of cell-evolution leading to fixed tissues. Behind all this there are, of course, the factors which have all along worked for Continuity and its intensification, and it is due to these that our own brains and bodies appear as startling phenomena in the course of sexual-element reproduction. Environment produces Continuity. Continuity produces Arrest.

The different forms of living Continuity have shown us that in all organisms composed of true tissue there is exhibited the phenomenon of cell-Arrest; the cells, in order to maintain the comparatively enduring tissue-structure, having sacrificed all hopes of becoming gametes in their future product. In compensation they are enabled to perform wonderful functions for the general good.

On the other hand, where an Individual's cells are produced in Discontinuity none should, theoretically, be arrested, and the full Individual should be all gametes. In fact, the law would seem to be that where the Individual is composed of separate free units, be these cells, zooids, or megazooids, the units in question can become sexual. It is only environmental hostility which should be able to prevent this.

Thus, the Hydra zooid's tissue cells are arrested owing to Continuity, but the zooid as a whole is unarrested owing to its Discontinuity, and can become sexual. Similarly, the vegetative zooids of the marine colony are arrested, but the colony as a whole becomes sexual. Or again, a free-swimming medusoid produces sexual elements, but in the segmental organism no elements are produced by the great majority of those continuous regions we term segments.

It is customary to call Nature prodigal in that she produces sexual elements far in excess of the number that could possibly realise new Individuals in existing conditions. She appears to be wasteful. The truth is that she is sparing, arresting in the higher living types the greater part of the developing Individual. If we take the earthworm, for example, we find that of one hundred and fifty segments only the tenth, eleventh, and thirteenth produce sexual elements ; or if we turn to a typical fish like the salmon it is clear that the huge number of ova it produces is nothing in comparison with what would be produced were all the segments to have sexual organs. So that it would appear that Nature has had to economise in producing the structural wonders of living Continuity.

While the development of a vertebrate embryo is proceeding active cell-division is no doubt general, though it is probable that many cells are from time to time temporarily stopped in the process of multiplication according to the requirements of the evolving body-plan. It is with the first divisions of the fertilised ovum that the evolution of the fixed cell-species begins. There is commencing variation. The main road of growth-cycle evolution no sooner starts than side-paths begin to branch out ; and while the main road ends in the restoration of sexual elements, the side-paths end in the arrested somatic cells. These somatic cells are not arrested in the sense that they do not grow and divide during the life of the Individual, but once their type is fixed or differentiated their division-products are true to type. Thus the fat cell in the human body becomes other fat cells, just as the starfish in the body Nature gives rise to other starfishes. In both cases this is a reflection of magnificent Control.

BREACH OF CONTINUITY.

Arrest, the product of Continuity, presents itself in another aspect besides that just considered. That is, in addition to a part of the developing Individual being arrested and modified as differentiated tissues the amount of multiplication or enlargement of these tissues is stopped or controlled by the body's governing centre. There is, as it were, a standard size for the body and its parts, and this being reached, all growth ceases, except that necessary for the repair of tissue loss.

From maturity until death tissue loss and repair are constantly going on, and we would regard tissue loss or destruction in any form as being equivalent to a breach of Continuity, and repair as being the inevitable result of the breach. This is most evident when a tissue is severed or partly removed by physical violence.

In our own bodies, if the damage be not fatal, repair sooner or later occurs, but except in a few instances there cannot be said to be restoration. Epithelium and bone are examples of such instances, but the repair of the body tissues generally is brought about by the multiplication of connective tissue cells which bind exposed surfaces together with scar-tissue. Thus, an amputated finger is not restored, but the wound heals in the manner mentioned, assisted finally by the growth of epithelium. Special organs or structures are never restored, with the outstanding exceptions of the hair and nails.

During fœtal life the case is very different. Before tissue differentiation has proceeded far it should be possible for a part removed to be restored, so that the structural plan potential in the original part is realised later on. Naturally, this is within certain limits, but the earlier the stage of development when the accident occurred the more complete ought to be the ultimate restoration; after birth, with the exceptions previously mentioned, restoration is not to be expected at all.

The removal of the developing arm of a young fœtus *in utero* may be followed by a considerable degree of restoration, but the result will not be perfect, and the new limb will probably be shortened or deformed. In such a case it is to be remembered that the fœtus enjoys a moist environment, and that probably for this reason the surface exposed after limb removal is able to replace lost tissue-cells to a degree impossible in aerial extra-uterine environment, where desiccation is hostile to growth. We may say that the watery environment of the womb makes restoration of the arm a *possibility*, and that an assistant factor would be the youth of the tissues. But why is restoration incomplete ?

A not unlikely explanation is as follows : The central control of the fœtus develops in harmony with the mass of the body-plan which it controls. When the fœtal arm was amputated the control-centre had evolved the capacity of governing the *further development* of an already formed arm, and was not perfectly adapted for controlling the formation of a new one. It may be that for this reason a certain amount of past development could not be repeated, and similarly we might judge that what prevents the restoration of the lost finger of an adult is the fact that the adult's control-centre is for the government of the mature finished plan, and not for that of the evolving plan. In addition, it is to be noted that after fœtal arm-amputation the exposed cells of the stump, whose multiplication would produce the new dwarfed limb, would be descendants of, and more maturely differentiated than the cells which originated the amputated limb in the first place. Their potentialities would, it is to be presumed, be correspondingly less.

To recapitulate. Continuity is instrumental in arresting a certain part of the developing Individual, so that this part evolves on side-lines and never originates or becomes sexual elements ; it becomes the arrested or fixed species of the somatic tissue cells. And Continuity also arrests the multiplication of the somatic cells in accordance with the needs of body equilibrium. Lastly, a breach of tissue Continuity is followed by a species of release from arrest in the form of special local cell multiplication to repair the breach. This multiplication is *under control*, local, but ultimately central, and arrest is reapplied, *also under control*, when the breach is repaired. It will be necessary to return to this in connection with abnormal growth.

In connection with the dwarfing of the restored fœtal arm an experiment which has been performed on the developing fertilised ovum of *Amphioxus* is very suggestive. If the first two cells into which the fertilised ovum divides be separated, each may develop into a complete fish, whose size, however, will only be half the size of the normally developed fish. And if the first four cells be similarly separated, four complete fish may result, each one-quarter of the normal size. On the other hand, if the first eight cells be separated from each other, no one of these can become a fish; this showing that side-path evolution has definitely begun with division into eight cells, and that the two cells which each fourth becomes have different destinies fixed for their descendants. This is clearly a matter of the commencing evolution of cell species within the developing individual.

The removal of one from the other of the first division-results of the Amphioxus fertilised ovum is just a "cell-amputation," as is also the removal of a fourth cell from its three partners; and the development potential in the removed cell is not lost, but "restored" on *a smaller scale.* And though an eighth cell cannot when removed become a fish, yet the remaining seven if left in continuity ought to make good the loss suffered, at some cost to normal mature size, in a given region. The fertilised ovum is the "primitive type" of the body's evolution, but on the evolutionary road leading to full tissue differentiation any cell is an "original type" for its "descendants," and thus we might judge that according to the amount of tissue or cell-loss, and the period of development during which it occurred, a reduced restoration would take place in the way indicated by the Amphioxus experiments.

CHAPTER XV

HEREDITY. NATURAL AND ACQUIRED VARIATIONS

The first question to be dealt with here is the Transmission of Parental Structure and Characters to the Offspring, and we shall do no more than bring forward the following broad conclusions we have arrived at; conclusions which need not be at variance with Mendelian evidence. Based on the supposition that all living *Individuals* are multicellular, our theory may be thus shortly stated:—

The zygote, or fertilised ovum, with which the living Individual starts, has latent or potential in it the lost plans or identities of the originally combining elements; and the complete Individual is all the cells which must necessarily be produced by repeated acts of division for the complete restoration or reproduction of the lost identities or plans: this in the manner, and to the (multiple) degree, possible for the Individual type in question in the absence or presence of Arrest. If we regard the growth-cycle as an enormous and complicated definite series of "reactions," it is obvious that any renewed combination of such restored or reproduced sexual elements will, all things being equal, have to result in the same multicellular product as composed the original Individual. The multicellular product, including the restored elements, represents the Individual, in all but the humblest types of Continuity where the complete Individual is a multiple of gametes, and intervening stages are evanescent. And it is such types which point to the true significance of the term Heredity, for they show us two entities fusing to reappear again in multiples after many reactions. Here there is no "transmission" of parental structure in the sense of a comparatively enduring cell-mass. There is, it is true, at any moment of "parental" development, a given number of asexual unicellular organisms, but each of these is free and independent, and disappears in its product. So that Heredity is here the reappearance or restoration of the lost gamete identity.

But in Continuously Multicellular Individuals, and notably in those of higher type, an enormous number of the cells of the developing Individual are arrested and never become, in future product, sexual cells; and it is in the arrested mass that we look for and recognise parental resemblances. Yet here also we are not dealing with a true transmission, but with a repetition of past reactions. For the somatic cell is the "fixed species" in the evolution of the growth-cycle. It represents arrested evolution on a side-path, and as in each succeeding growth-cycle evolution follows the same general lines, so do the same arrested somatic species reappear. We regard, of course, the unarrested road of development leading to the restoration of sexual elements as the main road of growth-cycle evolution.

Thus, to repeat; it does not seem correct to speak of the "transmission" of parental characters, but rather of their "reappearance" in ensuing cycles. In reality there is nothing "transmitted." It is the sexual element which is reproduced, and the Individual characters are only reflections from the arrested stages or reactions of the process of reproduction. This concisely expresses our belief.

VARIATION.

While the action of the laws of Growth results in the reappearance of the parental form in the offspring, this reappearance is never exact; there is always variation, and this is so whether the Individual be hermaphrodite or unisexual. As it is not the general rule for hermaphrodite Individuals to practise self-fertilisation, we may make the broad statement that the offspring never exactly resembles either the male or female parent, but inevitably exhibits certain characters which are peculiarly its own. As the parents are never exactly alike, this is not surprising.

On the other hand, the offspring, while inevitably varying from its parents for the reason that its development is always a perfectly fresh "experiment," may present characters distinct from those generally exhibited by the species to which it belongs.

In the first case we are dealing with the fundamental question of Predominance, and the variations may be called *Natural Variations*; in the second case the question is directly related to the action of Environment, and the variations are essentially *Acquired Variations.* This distinction is a most important one. It is, however, to be noted that the latter variations, when fixed and "transmitted," as it is clear they can be, become *characters* in the descendants of the organism first exhibiting them; and their reappearance will be subject to natural variation.

NATURAL VARIATIONS.

These might be roughly grouped in three classes.

I. The offspring inevitably varies from its parents.
II. The offspring of different parents inevitably vary from each other.
III. The successive offspring from two parents while never exactly resembling the parents, never exactly resemble each other.

Did we hold that such a thing as a unicellular *Individual* obtains in Nature, we should conclude that any variations it ever exhibited were the direct result of altered Environment; and further, that if the environment after alteration remained absolutely constant, the variations would pass on as fixed characters to the organism's descendants. Where, however, the Individual results from a sexual process of some sort, there is, the acquisition of variations apart, inevitable natural variation. For the uniting gametes have their own special potential characters (based on actual special characters), and as the Individual's somatic tissues evolve from the strife for the reproduction of both uniting elements, the characters of both parents will be exhibited by the offspring. The proportional representation will, of course, vary, and special factors can influence greatly the degree of parental resemblance as a whole. But the inevitable result always is that the offspring varies in many ways, some recognisable, some not, from both its parents.

Where the Individual type is unisexual the offspring may be said to exactly resemble one parent, and to vary from the other, in the matter of Sex. This we would regard as Natural Variation. The determination of Sex is still an obscure question, whose solution is at present being sought on Mendelian lines; but although we have as a result the ingenious Chromosome Theory, the broad significance of Unisex has not so far revealed itself. The limits of this book do not allow us to include, as was at first intended, a summary of Mendelism and the light it throws on the transmission of characters and variations, but we would state the following general conclusions of our own, which need not clash with observed Mendelian phenomena:—

In the simpler forms of living Continuity the development of the Individual ends in the restoration of both male and female elements, but in the higher forms, where Arrest is more rigid, and tissue-differentiation more complex, only one type of sexual element is reproduced. But the Individual evolves from the fusion of male and female elements, which, we may say, are equally desirous of being reproduced; and it does not seem unreasonable to suppose that while the restoration of one of these goes on to the end along the main road of cycle evolution, that of the other is diverted along the side-paths leading to the fixed somatic cell-species. Or we might suppose as an alternative, that its restoration lags behind so that it is incomplete when the body is mature. The case of the queen bee lends some colour to the latter supposition, as it would appear that by the time her true ova are formed "her" male elements are still on the road to being reproduced: hence the development of "drone-tissue." The case here is in fact suggestive of "dichogamy" in certain aspects, and it is to be noticed that the queen bee cannot be fertilised by her fresh generation of drones.

As the offspring must vary from the parents, it is obvious that the offspring of different pairs of parents cannot exactly resemble each other. But more mysterious is the variation between the successive offspring of the same parents. This cannot wholly depend on the main natural variation of Sex, for brother varies from brother, and sister from sister, as well as brother from sister. It would indeed seem probable that Acquired Variation enters considerably into the question. Even if we suppose that all the male parent's spermatozoa are equal in potentialities, and similarly all the female parent's ova, it seems clear that the modifying influences playing on the development of the zygote can never exactly repeat themselves. To mention one point alone, the relative "ages" of a fusing ovum and spermatozoon must be variable, and their respective powers of future restoration might easily be affected by an early fusion or the reverse. Again, the place of implantation in the maternal uterus varies, and the uterus as an environment for fœtal development must vary with maternal health and age. During gestation the blood of the mother, which nourishes the fœtus, must vary with the health, the habits, and the general environment of the mother, and these factors can never be the same in successive pregnancies. On the whole, it may well be that the variation of successive offspring is partly natural and partly acquired.

With respect to the plan of the Individual body, this, for the given sex, is always fundamentally the same, though capable of showing endless variation in the matter of detail. The male and female sexual element "plans" being, respectively, fundamentally always the same, it is not surprising that accidental resemblances between Individuals of widely separated stocks are often recognisable. The potential variations of the male or female element "plan" must be limited in number; but the number will be inconceivably huge, depending as it must on the ultimate particulate constitution of the basoplasm, and the endless varieties of modifying force and its mode of application. It follows, then, that when the two elements unite, the possible somatic variation of the resulting growth-cycle has, as it were, no limits. Thus, no Individual is ever exactly reproduced or repeated, though many characters may re-exhibit themselves in the offspring.

Evolution, as we have seen, can be regarded as the evolution of Continuity by multiple progression. The body is a multiple of single cells. The ovum, a single "cell," is a multiple of its plasmolecules; the plasmolecule is a multiple of its atoms, and so on. And as one female is fundamentally the same as another, so is one ovum fundamentally the same as another; differences between females are essentially matters of detail, and the same may logically be concluded with respect to ova. We can only guess at what these matters of detail may be in the case of ova;

but as the main variations in the female body, expressing themselves in terms of size, proportion, and shape, depend on the number and method of grouping of constituent cells, and on their characters and locally proportionate quantities, so we may imagine that the variations in ova depend on the size, pattern, or grouping of the ovum's plasmolecules, and on the character of these, and the locally proportionate quantities of their ultimate particles. As finer variations of the body will depend on the molecular constitution of the body-cells, so will the finer variations of the ovum depend on the ultimate plan or constitution of the ovum's plasmolecules. It must be the power of endless variation of patterns and proportions of ultimate particles which gives us the ceaseless variation of the human body.

When a fixed character, or parental variation it may be, is transmitted to the offspring, the somatic part exhibiting it may be said to remember its exhibition in the parent. There is a return to an appearance last seen in the parent. It was force of Repulsion which set free the elements whose fusion originated the offspring, and this fusion was an act of Attraction which in turn was followed by the repeated alternation of the two forces till the elements again appeared. The sexual elements lose their plans of identity to regain them, and regain them to lose them once more in a new cycle. The growth-cycle is thus truly a "repeating" reaction; it is a true cycle. It is probable that this "repetition" possessed by living basoplasm is the actual basis of what we call Memory; that perhaps Memory is based on the return to a "particulate pattern" previously exhibited. The brain cells are specially adapted to register all impressions, faint or marked, affecting the body as a whole or in its parts; and many of these impressions being repeated or almost exactly repeated, we may picture the same "patterns" recurring directly or indirectly as a result. Thus, recognition may be induced by the re-formation of a given pattern-effect, this the result of the repetition of the original cause; the cause being always Environmental Force in some aspect.

A certain sound or scent may make us recall in a flash some long-forgotten place or incident. In this case the given sound or scent, no doubt, must always produce its own proper particulate pattern-effect in the brain cells involved, and this induces or passes on into other associated pattern-effects which were the true effects of other impressions received on the occasion when the sound or scent was originally perceived. Thus, by a species of pattern evolution, in its essence a return or a reversal, a train of thought may be started which, if uninterrupted by any fresh impression, may recall a great piece of the past or break off on a side-line to quite distinct subjects.

The process, however, will be one of continuous pattern-evolution if the train of thought is uninterrupted. The point, however, to which we return is that all basoplasm has the gift of primitive memory in that it has the power of repeating particulate pattern or plan, and that this is based on the cycle of the ultimate particle—Attraction, Repulsion, Attraction. Memory is but the restoration of a previously obtaining state. If two atoms unite by attraction and then become momentarily separated by repulsion, their regained freedom is the memory of their freedom immediately before union; and if later they should unite again, their former combination is remembered. An amœba might engorge a particularly large alga cell, or enter a very hostile dry environment, and recover from either experience. On the experience being repeated the amœba could be said to remember the occasion on which it happened previously, in that, other things being equal, its controlling centre would respond in the same way as on that occasion. Further "memories" might arise during the return to normal conditions.

ACQUIRED VARIATIONS.

As variation is essentially change from a definite state or plan, its acquisition may be said to be always sudden. It is true that *recognisable* change or variation might be slow in appearing, or as a whole be gradually intensified; but such intensification would really be due to repeated sudden acquisitions of variation. Naturally, when referring to variations, people really mean recognisable variations; but in every living organism there must be countless variations which we cannot recognise; and our point is that in all cases the acquired variation is imprinted suddenly.

It is, however, to be noted that the acquired variation does develop gradually in a certain sense, for the Individual as a whole develops gradually, and the variation evolves with the Individual's cycle. This may be illustrated by our imagining a modifying force to act on the first two division-results of the zygote. In such a case we must presume that the modification produced would be a definite sudden change in the constitution or "plan" of the cells affected, or in other words, that there would be sudden acquired variation in the two cells: variation from the plan of the two cells which became the male or the female parent. But the two cells, modified as we have supposed, become an Individual, which on maturity can exhibit a recognisable somatic acquired variation as the result of the action of the modifying force mentioned; and the appearance of this variation may be called sudden. Yet it is but the original two-cell variation evolved through Individual development. As we shall see, for a modifying force to produce its best results, as expressed by variation, it must act early on the growth-cycle. It is really a recognition of this truth which makes the responsible parent pay attention to the upbringing of his child; and here, as with our illustrative example, if good results are to be expected, the modifying force must not only act early, but continue to act during further development.

The ruling Spirit of the universe acts through ENVIRONMENT (the term being used in the widest sense), and it may thus be said that it is Environmental influence which guides Evolution in all its aspects; acquired variations being the result of the action of some form of environmental force. The force acts in innumerable forms, and in its relation to a given object comes from all sources outside of this object. Thus, for example, a man's Environment may be said to be the rest of the Universe, or of the Whole of which he is a part. The modifying forces which act on his development may come as æther waves, as atmospheric pressure, as heat or cold, or through dampness or moisture, food, parental care, companionship, and in endless forms; the child's development may be affected by the geographical position of his home, by the habits of his mother, by the shape of his boots. Naturally, one distinguishes between immediate and remote environment in connection with the acquisition of variations, for it is directly acting influences which in the end are the modifying factors.

It may be remarked that some writers, while admitting the action of Environment in producing a given acquired variation, tend to limit its powers by attributing to the object affected a purposive adaptation to the altered conditions. For our own part we would agree to such purposive adaptation if it be attributed to all living organisms, for every living thing in Nature has the power to respond to external influence, and in an unscientific sense responds "purposively." For we hold that any acquired variation whatsoever must of necessity be adaptive; it represents an effect produced in response to, and therefore in harmony with, the environmental force or cause at work. The effect must be harmonious with the cause.

The acquired variation is a "character" in the organism manifesting it; it is the proper response for existence in the conditions producing it, or a response whose "purpose" is to be the true effect of the cause. Every acquired variation must be adaptive. It must be useful, it cannot be useless, *for the organism which manifests it*; that is, it cannot be useless for life in the environmental conditions which produced it.

The dwarfed and stunted plant's deformity is specially useful for life in the hostile environment which produced the deformed habit, and there is as much "purposive adaptation" exhibited here, in our opinion, as in the growth of an aerial plant-root towards a small localised collection of water. Naturally, it is only occasionally that we can recognise the cause which is at work, and this is no doubt largely due to the fact that the modifying force begins its action during the early development of the affected organism, when we cannot detect change at all. There is "purpose" in the movements of a molecule; these are adaptive in response to surrounding environmental influences; they are the effect of such causes.

The acquisition of a variation implies sudden environmental action or change. This might act directly on the organism or part concerned, or indirectly by allowing sudden response to modifying forces previously held in check. Theoretically, one organism out of a collection enjoying an *absolutely uniform environment* could not acquire variation, for all would develop in harmony with the common environment. When one organism out of a number exhibits an acquired variation, special forces must have acted on the organism during its development.

If we could only trace them back, we should find that all natural characters of living organisms were based on, or in a sense were originally acquired variations; and our reason for saying so is this: that the evolution of Life into being was itself Acquired Variation; it was variation from the previously existing Inorganic at the call of environmental forces, which were the influences from outside sources which themselves were evolving and changing. Thus, environmental action would impose sub-variations of the fundamental variation represented by Life, and these would become the stock characters of primitive types, from which in time sub-types would similarly arise, and so on.

And taking Life to be the Great Acquired Variation of the globe, we further believe that *the main stock-variations which were acquired by Life were the successive multiplications of living Continuity.* For the multiplication or intensification of a given type of Continuity into a higher form is simply a matter of the acquisition of variation at the demand of Environment.

THE TRANSMISSION OF ACQUIRED VARIATIONS.

As we shall have to speak further of Acquired Variations when dealing with "Natural Selection" and the "Origin of Species," we shall pass on to the question of their "transmission."

That acquired variations can be transmitted is hotly denied by many authorities, *but the fact alone, that cellular continuity has clearly appeared in past ages as an acquired variation imposed on cellular discontinuity, and that the various types of living cellular continuity have bred true* (*as regards their Continuity*) *to the present day,* would appear to prove decisively that acquired variations can be transmitted. But there is experimental evidence which settles the question definitely.

In this connection a most interesting paper by Prince Kropotkin may be quoted from.[1]

> "The tortoiseshell butterfly, a very common inhabitant of our gardens and fields, has been a favourite subject of such studies. It was known long since to appear in two forms, described by entomologists as *Vanessa levana* and *Vanessa prorsa,* which formerly were considered as two distinct species. Later on it was found that these two forms were merely two different broods of the same species. The *levana* form, which is orange brown, with blackish brown spots on the upper side of the wings, lives through the Winter as a chrysalis, to appear as a butterfly in the spring ; while the eggs of the *prorsa* form, which has black wings with a white transverse band, are laid in Spring and it issues as a butterfly only late in the Summer. It was

---

[1] Inherited Variation in Animals. Prince Kropotkin. "The Nineteenth Century and After," Nov. 1915.

natural, therefore, to suppose that the differences in the colours and markings of the two broods had something to do with the temperature under which their pupæ had lived ; and as early as 1864 Dorfmeister proved that the two forms of the tortoiseshell butterfly (as well as an intermediate form occasionally met with) could be obtained by rearing their pupæ in different conditions of temperature."

That is, definite variations were produced as a result of change in environment. But a point of special importance is that there is a special period in development when the application of the modifying force produces a maximum effect, as expressed in visible variation. Thus, Merrifield found, after many years of experimenting, that " it is in the larval stage that the life-habits and mass of the two phases are as a rule determined, but in the pupal stage the facies may be affected and even transformed."[1]

Now, when the modifying force is applied to the growing larva it affects all its cells ; some at particular stages on the road to reproduce the sexual cells from which they originated, and others which are evolving on side-paths to become mature somatic cell-species. Both types of cell are " becoming " ; in the one case they will become in their final product sexual elements, in the other differentiated tissue cells ; and the action of the modifying force is to influence subtly the process of " becoming," so that when this ends, and all have " become," there is modification of constitution or identity. As regards the *Acquisition* of the variation, it is clear that the modifying force must act during development if results are to be expected, and it is obvious that the earlier its action on the product of the fertilised ovum the more marked will be the results. The force is unable to affect to a recognisable extent the finally evolved fixed tissue cells of the mature insect ; to produce visible effects it must act on the " primitive ancestors " of these cells in the evolving Individual.

This is not difficult to understand, but the problem of the TRANSMISSION of acquired variations is less simple.

In the paper quoted we find that it was discovered by Professor Fischer that the modification produced by a modified

---

[1] Inherited Variation in Animals. Prince Kropotkin. "The Nineteenth Century and After," Nov. 1915.

environment could be "transmitted to the next generation even though that generation was brought up under the normal conditions of life."

Two explanations of how this could come about are mentioned by Prince Kropotkin as coming from Professor Plate: "It may be that the modification of the body cells was transmitted to the germ cells; and it may be also, as Weismann suggested, that we have here a case of direct action of the abnormal temperature upon the germ cells." Our own conclusion is that neither of these suggestions hits the truth. As will be gathered from what we have already suggested, our view is that as the modifying force must act during development in order to *impose* acquired variations, or must act on a developing mass of cells whose destinies are diverging—in the one case to somatic fixity, in the other to reproductive finality—there is what we might call a parallel evolution of variation from the point of application of the force. In the one case we get the recognisable variation of the somatic tissue; in the other there must be the unrecognisable variation of the independent sexual element. These two forms of variation must be quite different, but when it is remembered that when the sexual element combines with another to evolve a new Individual the growth-cycle is repeated, and the evolution of somatic tissues occurs again on the same fundamental lines, we can see how, *certain things being given*, the somatic variations can reappear in the offspring. The fixed tissue cell belongs to one cell-species, the sexual element to another; the evolution of the former is on a divergent line, while that of the latter is on a cycle-path which ends in return to the start.

The fertilised ovum we have regarded as the "primordial type" from which evolves the Individual on main and side-lines, and the latter begin to branch out after the first few division acts, as may be gathered from the *Amphioxus* experiments mentioned on page 132. For if the first two cells produced by cleavage be separated, each can develop into a complete fish, though of half the normal size; while the separation of the first four cells can likewise give rise to four complete fishes, each, however, of one-fourth the normal size. But the first *eight* cells are unable to develop independently. Thus we can see that a modifying force acting on the Amphioxus fertilised ovum, or the first two or four division-results, really acts on a "primitive type," whereas at a later stage of development it acts on already differentiating types; and we should naturally suppose that if an acquired variation were to be *exactly* "reproduced" in the offspring, the modifying force would have to commence its action on the "primitive type" cell.

If this were to be called X, with the power of becoming somatic tissues, S, and also X once more, then it is clear that a force commencing its action on the first mentioned X could, by continued action during development, cause the appearance of modified somatic tissues, Sm, and of modified sexual elements, Xm. The fertilisation of one Xm by another would, other things being equal, result in an offspring with somatic tissues modified as Sm.

On the other hand, we might suppose that if the modifying force commenced its action on already differentiating early cells, the actual tissue variations produced could not be faithfully "reproduced" in the offspring. For if the parental variations were Sn, and Xn, their evolution would have to start from the beginning of the offspring's cycle, and not from the point at which in the parental cycle the modifying force commenced its action. The offspring's variation might be So, and Xo.

In a word, we suppose that important as the early application of modifying force is for the *acquisition* of variation, it is an even more important condition for the *reappearance* of the variation in the offspring.

It would appear, however, that, at times, for the successful reappearance of an acquired variation the modifying force must also continue its action till the organism produces its sexual elements, or right on to the end of the growth-cycle. At least this was proved to be so in experiments with the transmission of colour modification in the Colorado Beetle, as mentioned in Prince Kropotkin's paper.

The main points to which we return are:—

That the Acquired Variation is the result of Environmental action.

That Environment produces its results by action on the early developing Individual and altering the realisation of its potentialities.

That in certain circumstances Acquired Variations can reappear in the offspring as " characters."

That the different forms of living Continuity in the world are clear examples of past " transmissible " environmental modification.

That Life itself appeared as an acquired variation, and the successive forms of living Continuity as the basic " subvariations " of living evolution.

That the Living was a modification of the Inorganic, and that at successive periods living Continuity was multiplied or intensified into higher and higher forms by environmental modification. That each type of living Continuity was so modified in certain numbers, the remainder passing down their arrested Continuity as fundamental character.

CHAPTER XVI

THE EVOLUTION OF CONTINUITY

WHILE Evolution, in the widest sense, is based on the fundamental principles of Attraction and Repulsion, it has in the case of living matter two distinct aspects which must be clearly recognised if confusion is to be avoided. These may be defined as :—

I. THE EVOLUTION OF THE DIFFERENT TYPES OF LIVING CONTINUITY.

II. THE EVOLUTION OF DIFFERENT SPECIES WITHIN EACH CONTINUITY-TYPE.

The distinction is of the greatest importance, but its non-recognition has been universal and has increased the complexity of a most difficult problem. For though at the present day the principle of Evolution has been placed on an immovable basis, the method of the process, and the laws involved, have so far not been clearly demonstrated. As a result the main road of Evolution appears to be interrupted by unbridgeable gaps. But with the recognition that Evolution is primarily the evolution of CONTINUITY, the whole subject becomes illuminated, and this whether it deals with cells or cell-multiples, Individuals or species. The present and immediately succeeding chapters deal with Continuity's evolution, the Origin of Species being considered separately in later pages.

With respect to Evolution generally, there is one suggestion which it is desirable to make before going any farther, and that is that what we may call the " main road " of Evolution, leading to man, has probably not passed through any living organisms, past or present, of which we are cognisant.

We may feel quite certain of this as regards the organisms existing at the present day, for these are one and all at the advanced ends of special evolutionary side-paths; and although any given one exhibits the *same form of Continuity* as did the primitive type from which it evolved, yet the organism in question has evolved the peculiar characters of its "species," different from those of the primitive type.

We cannot be so positive regarding extinct organisms known to us only through fossil remains, for it is possible that among them there might be some "mileposts" on Evolution's main road. But the probability of this being so seems small. For in the first place, as we shall see, the main road has evidently run in a watery environment right up to Segmental Continuity, and this entitles us to put aside the fossils of *land organisms* whose Continuity is lower than segmental; while marine fossils of Continuity lower than segmental are strikingly similar to organisms existing at the present time, and there is reason to believe that most if not all were highly evolved members of fixed species at the ends of evolutionary side-paths. In our opinion the same is probably the case as regards extinct organisms of segmental Continuity, whether these enjoyed an aqueous or terrestrial environment.

The "testimony of the rocks" does not offer us the key to the problem of living Evolution. But the present-day living world in its successive types of Continuity offers us a story the headings of whose chapters are distinctly legible. The geological record is at the best most imperfect, and although one could classify in an ascending scale of Continuity the fossils which have been discovered, one could only do so through a study of existing types. The key is offered by Life itself, and not by its past traces.

We have no exact knowledge of the state of the world when Life first appeared, or of the real manner of the world's evolution to a solid planetary condition, but there can be little doubt that the latter process has been essentially one of the INTENSIFICATION OF CONTINUITY. This is not only consistent with our own theory but also with what is called the "nebular hypothesis" of the earth's origin. For this hypothesis supposes that in inconceivably remote times diffuse nebulæ, or gaseous clouds, became heavenly bodies by a process of condensation; that our sun represents the still incandescent nucleus of an immense condensed nebula, and that this in the process of contraction threw off outer rings which broke up and fused so as to originate the planetary system over which the sun still exercises nuclear control. This theory is perfectly in keeping with that of the universal sway of Attraction and Repulsion, for it involves a condensation due to attraction, a splitting off due to repulsion, and the mutual attraction of parts or quantities repelled. The "nebular" has, however, been discarded for the "meteoric" hypothesis, which attributes the earth's formation to the collision and fusion of meteoritic particles; the Many uniting to form the Continuity of the One. In any case it is universally accepted that this globe was once a plastic molten mass, and that its present comparatively solid state has been due to cooling and contraction; in other words, there has been a steady intensification of Continuity controlled by central attraction.

At an early stage of the process the condensation of aqueous vapour would come to form the first seas, their formation being in fact another example of intensification of Continuity.

The first Life must have appeared as a special condensation phenomenon, or as a special intensification of inorganic Continuity. We may presume this from the high complexity of the living molecule; from the fact that in an evolving world of inorganic molecules whose atomic constitution was, and is, numerically simple, a certain type was formed whose Continuity was equivalent to a multiple of the inorganic molecule's. By some special process equivalent in its results to mutual attraction, atoms with inorganic molecule-forming potentialities were united or brought together to form the "mega-molecule" of primitive living matter; and as the earliest forms of life of which we have any traces undoubtedly enjoyed a watery environment, and as without water in some form life is impossible, it is certain that Life originated in an aqueous environment.

On this supposition Life originated as The Great Variation of the Inorganic, and as a stage onwards in the evolution of Continuity. Life evolved into being, as well as evolved in the generally accepted sense after having appeared. What the first form of life was like we can only guess; possibly an ultramicroscopic molecule spontaneously generated in a cooling warm moist environment, the further multiplication of Continuity resulting in the primitive unicellular organism.

If the surrounding environment of primitive Life was aqueous, and if at later dates Life appeared in terrestrial or aerial environment where, however, *water had to be obtainable,* it is clear that at given periods certain types forsook watery for aerial surroundings, or were obliged to live in the latter. And here we return to a most important point, namely, that *with respect to types of living Continuity the waters of the globe at the present day reflect the straight road of living evolution*; that is, we find in them Individual forms which in the ascending scale of Continuity clearly indicate the course of the main road traversed by Evolution in the past. This road ran in a watery environment from the first living organism right up to the Segmental Individual.

The highest forms of Segmental Individual are terrestrial, and the very highest is Man himself; and as we shall see, it is practically certain that the main road leading to Man had reached segmental Continuity before it left the water for the land. Further, it is most probable that all *terrestrial* Individuals of Continuity lower than segmental have sprung from primitive watery types of a Continuity similar to that which they exhibit, and not from land types of lower Continuity.

It is true that we can arrange existing and extinct *land* organisms in groups which successively exhibit the intensification of Continuity, but the series is an incomplete one and in no way supports a suggestion that there was a *terrestrial* main road as well as an aqueous one. The waters of the globe have been the reservoir or storehouse of primitive types from which the earth has been stocked at various times. It is clear that terrestrial Individuals have in the past evolved strange new forms; the case of the whale is an example of such evolution; but it is most unlikely that any land-Individual has ever multiplied its Continuity into a higher form. It is to be understood, naturally, that at different periods different species of a given Continuity-type have acted as "primitive types" for special lines of terrestrial evolution. This becomes obvious in the case of Phanærogams, and also as regards terrestrial segmental Individuals. The centipede and Man have clearly originated at different periods from distinct aqueous segmental species.

Our views might be put in tabular form (p. 152). In the table the terrestrial organisms are represented as having sprung directly from the main road, but it is possible that some of their aqueous primitive types occupied places in the aqueous side-lines. This we believe to be the case as regards terrestrial Continuously Zooidal Individuals.

The left column, identical with the middle column of lost primitive types *as regards Continuity*, is in complete existence in the sea at the present day. The types in the right column, of land organisms, at present existing, do not make a complete chain. There is no gradual transition, but a leap from one form of Continuity to the next, or from each link of the chain to the next; but this is regular in the left column, whereas in the right one the chain, really a false chain, is wanting in many links.

This provides us with an explanation of the great gaps in the chain of Evolution which are so puzzling; for Evolution being fundamentally the evolution of Continuity by multiplication, the complexity of each succeeding type is increased at a bound. *Natura non facit saltum* is clearly untrue.

We must remember that, apart from accidental preservation in a fossil state, no organism is preserved except through its descendants. Many of its characters may not be preserved at all, owing to evolution, or it may be, devolution. This is the price demanded by DISCONTINUITY. For just as the discontinuous unicellular organism is an evanescent stage in the evolution of a discontinuously multicellular Individual cycle and vanishes into the further stages it "becomes," so in the larger cycle of Natural Evolution the discontinuous Individual itself disappears as an evanescent stage in the production of other Individuals. The actual road of evolution which has been traversed is always wiped out unless some special factor intervenes to preserve it; and this is true of side-roads as well as of the main road. Under natural conditions the only record is the form last produced.

This law, however, in no way interferes with the preservation of the main types of Continuity, for special factors

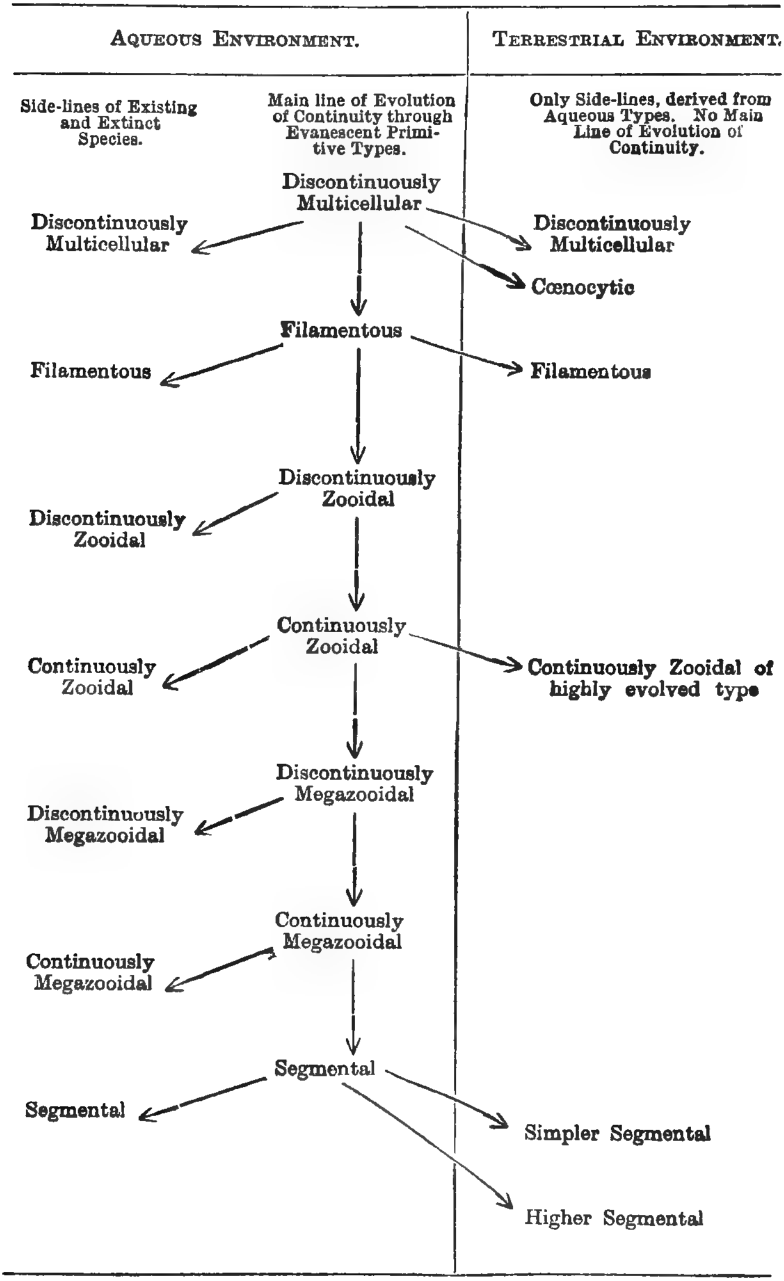

AQUEOUS ENVIRONMENT.
TERRESTRIAL ENVIRONMENT.
Side-lines of Existing and Extinct Species.
Main line of Evolution of Continuity through Evanescent Primitive Types.
Only Side-lines, derived from Aqueous Types. No Main Line of Evolution of Continuity.
Discontinuously Multicellular
Discontinuously Multicellular
Discontinuously Multicellular
Cœnocytic
Filamentous
Filamentous
Filamentous
Discontinuously Zooidal
Discontinuously Zooidal
Continuously Zooidal
Continuously Zooidal
Continuously Zooidal of highly evolved type
Discontinuously Megazooidal
Discontinuously Megazooidal
Continuously Megazooidal
Continuously Megazooidal
Segmental
Segmental
Simpler Segmental
Higher Segmental

FIG. 46.

have interfered to fix and preserve them for us up to the present time, a small proportion only of each new Continuity-type having been allowed to disappear in the origination of higher forms. The remaining proportion has suffered permanent arrest as *regards Continuity*, and further evolution has been a species of differentiation within the given Continuity-type. In fact, we may say that the arrested types of Continuity are the " fixed tissue cells " of the living body of Nature. The forces which produced each form of living Continuity have down to the present maintained it, any variation occurring being that of subordinate character.

It is obvious that each new form of living Continuity must have appeared suddenly. From discontinuity to continuity there is a sudden step, and the basis of Continuity's evolution has been a species of multiplication. What we have to bear in mind is that all down the ages force of Attraction, as force working for continuity or compression, has been acting, and continues to act, in opposition to that of Repulsion, which works for decompression and discontinuity; and that from time to time the former force has been able to dominate to an extent allowing it to compress still further the results of its previous action. These repeated intensifications of Continuity took place, however, countless years ago on plastic evolving primitive types, and affected a limited number, or what we might call the " main stem " of each Continuity group. The destiny of a certain number of organisms of a given new Continuity was to develop along an evolutionary road whose feature was the repeated multiplication of Continuity, much as the evolution of certain cell-lines of a developing Segmental Individual is along a main road leading to cycle-termination, or sexual elements.

The parallel between the evolution of the Individual cycle and the evolution of the body of Nature is by no means far-fetched, for in both cases surely the same fundamental laws must be at work. And as we can perceive that the arrest and differentiation of the human body's somatic cells is for the maintenance of the body's personality during life, and for its future reproduction, and that they reflect a state of equilibrium or balance, so may we take it that the fixation of Continuity types which occurred in past ages has been, and still is a necessity for the proper evolution of the main road on which Continuity has been repeatedly multiplied. On all hands there is the process of Give and Take, of self-sacrifice and self-preservation; and as the cycle-career of the somatic cell has been sacrificed for the successful evolution of certain cell-lines towards sexual-element formation, so have the arrested forms of living Continuity been sacrificed in order that the remainder might advance on the main road of evolutionary destiny. This has been the inevitable result of Nature's efforts towards equilibrium, themselves inevitable; remembering which, we may say it has been necessary for Nature's equilibrium.

Environment in the special aspect of evolutionary forces has worked to produce, maintain, and multiply Continuity, and even when, as in the Discontinuously Zooidal Individual, the built-up units composing the Individual remain separate and free, the matter is one of definite accomplishment rather than of defeat. For the Continuity is an advance on that of the preceding type and is a monument to definite results obtained. It is a matter of arrest on a side-path. Environment, it is true, still continues to work for discontinuity, but it is a losing game. With the death of the Individual she shatters a given personality, but only to see it reproduced again. Force of Attraction inevitably dominates force of Repulsion. The manner in which Environment appears to have acted as a uniter and compressor will be suggested in the next chapter, and also when dealing with Symmetry.

While new species of plants and animals have doubtless still to appear in this world, it does not seem probable that any existing types of Continuity are destined to be multiplied into higher ones. In any case it is difficult to see how the highest form, segmental, could be *multiplied*; it might be further *intensified*, traces of segmentation might disappear, but this would almost certainly involve, in man at any rate, loss of function, and be a matter of devolution. We have families and multiples of families of human beings respectively developing in relative continuity, but a "super-Individual" equivalent to several Individuals united together is inconceivable.

No doubt there have been cases of degeneration during the process of living evolution, and it may be that a given form of Continuity has at times been reduced to a lower one, but such an occurrence would surely be exceptional, for on every hand we can see that Attraction is the dominant force, and higher and higher Continuity its goal.

All these conjectures apart, the fact remains that we have the simplest known living type—the Discontinuously Multicellular—and all its successive multiplications, with us at the present time. This certainly shows that from the earliest ages the different forms of Continuity have remained arrested as regards their Continuity. Thus the world contains such diverse living types as amœbæ, fungi, free zooids, zooidal colonies, medusæ, corals, and vertebrates; only a certain proportion of each newly evolved form of Continuity having been permitted to evolve to a higher form.

The multiplication of living Continuity has not, however, been a process of moulding on new lines the already existing Individual, but of the *developing* Individual. For example, no actually existing series of primitive zooids was compressed to form the primitive sea-anemone—just as we know that no already formed terminal plant-shoots are compressed to form the plant flower; but serial zooidal potentialities were compressed in their attempts at realisation, so that the megazooid resulted. Our conclusion is that the multiplication of living Continuity has been due to compressing environmental force which acted on the first division-results of the zygote, or fertilised ovum, and all their subsequent product. Thus, the first megazooids of sea-anemone form would appear all at once, and we may picture with what comparative suddenness a stretch of primæval sea-bed would become studded over with a perfectly new living type, complete in structure from the first. Clearly a gap in the road of evolution would be the result of this sudden leap to a higher form of Continuity. In a similar way we may picture the sudden appearance of filamentous Continuity, that of the tissues of the primitive discontinuous zooid, that of the zooidal colony, or that of megazooids in series; the last leading to primitive segmental Continuity and, like all the preceding forms, taking shape in a watery environment. But no similar evolution of Continuity has taken place on dry land. The different forms of Continuity which have appeared there have, we believe, been separately derived from parallel aqueous types. The Continuity exhibited by terrestrial Individuals has been evolved in a watery environment, and minor special terrestrial characters are terrestrial modifications within each form of Continuity.

In a rough way we might picture the process as having been somewhat as follows:—

A. From a primitive Discontinuously Multicellular stock, whose environment was aqueous, a certain number of Individuals developed in Filamentous Continuity; the rest breeding true through succeeding ages, and their further evolution being only that of Discontinuously Multicellular Species. From time to time the land would probably obtain "primitive types" from the fixed Discontinuously Multicellular class. Even on land, however, the environment would be largely aqueous.

B. At some period a certain number of Filamentous Individuals would develop with the multiplied Continuity of the Discontinuously Zooidal Individual, while the rest continued to breed true as Filamentous Individuals, their further evolution being that of species. Probably from these would be obtained at a later date freshwater filamentous types.

C. The evolution of Continuity would then, still in an aqueous environment, pass on to the Continuously Zooidal Individual type in a certain proportion, while in another it would remain arrested to preserve for us at the present day the free zooid; that of Hydra being a modern species. It is most unlikely that any primitive *terrestrial* Discontinuously Zooidal Individual was ever derived from an aqueous type.

D. Still in oceanic environment, the primitive Continuously Zooidal form would then pass on into the Discontinuously Megazooidal, and also continue to breed Individuals whose Continuity did not change to a higher form; and from these, at varying periods, we believe that the original types of the higher terrestrial plants, existing and extinct, were derived.

E. From the primitive Discontinuously Megazooidal would come the Continuously Megazooidal type, as well as all the different species of the former, extinct and existing. There is no evidence that any terrestrial Discontinuously Megazooidal Individuals ever obtained.

F. The highest form of Continuity would then be reached by the compression of primitive Continuously Megazooidal Continuity into primitive Segmental in one direction, while in another Megazooidal Continuity remained fixed to evolve species. None of these apparently ever supplied the earth with stock.

G. It seems clear that from the primitive marine segmental type (or types it may be) many segmental " sub-types " evolved greatly differing in size and characters ; and it is probable that from these were separately derived the chief original terrestrial forms of segmental Individual. Thus, the centipede is segmental, and so also is the bird, but it seems unlikely that these share one common *terrestrial* primitive ancestry or derivation. Each has been derived from a distinct aqueous type, and the common ancestor was probably megazooidal.

In the above summary the Cœnocytic and Radiate Individuals are not included, as these have not evolved on the main road of Continuity-multiplication.

CHAPTER XVII

THE EVOLUTION OF CONTINUITY (*continued*)

WHILE the geological record does not supply the key to the evolution of living Continuity, yet it throws valuable light on the subject.

The part of the earth in which we are interested is the "crust," and lies superficially to the crystalline or Archæan rocks, regarding whose origin geologists are still uncertain, and which contain no traces of past life in any form. The crust of the globe is composed of more or less distinct rock layers or *strata* which have been successively deposited through inconceivable stretches of time, and which contain evidences of past life in the shape of fossil forms or casts of plants and animals.

These *strata* from below upwards are divided into four great sections, namely, the Palæozoic or Primary, the Mesozoic or Secondary, the Cainozoic or Tertiary, and the Post-Tertiary or Quarternary; the adjectives being also used to denote the periods of geological time during which the rock-systems were being deposited and the living types represented in their fossils flourished. Each section is further divided into systems of *strata* or *formations*. The following table shows the sections and systems; the numerous *strata* not being included:—

SECTIONS.	SYSTEMS.	NATURE OF ROCKS.
Post-Tertiary	Recent. Pleistocene or Glacial	**Sand, gravel, clay**
Tertiary	Pliocene Miocene Oligocene Eocene	**Sands, gravels, clays, marls, limestones**
Secondary or Mesozoic	Cretaceous	**Limestone, chalk, sands**
	Jurassic	**Limestone, sands, clays**
	Triassic	**Marls, sandstones, limestone**

Sections.	Systems.	Nature of Rocks.
Primary or Palæozoic	Permian	Sands, limestone, slate
	Carboniferous	Coal, limestones
	Devonian	Old red sandstone
	Silurian	Sands, gravel, shale, slate
	Cambrian	
Archæan	Archæan	Granites, schists

Sandstone, limestone, and chalk strata have been laid down at the bottom of the sea, or on the beds of inland lakes, during immense periods of time, and have been derived from the siliceous skeletons and calcareous shells of endless generations of marine organisms. Shales and slates, which are practically indurated muds, have also been deposited under water, but presumably shallow water at the mouths of rivers and estuaries. The origin of coal measures from palæozoic vegetation is common knowledge.

There is clear proof that from time to time in the past there have been great elevations of the sea-bed above water level, alternating with subsidences, for we find the Devonian old red sandstone of submarine origin followed by the carboniferous system representing ages of terrestrial plant-life, and this in turn followed by the submarine deposition of sands, limestone and chalk. Elevation has alternated with subsidence. Our knowledge of the forms of life abounding in past ages is gathered from the fossils found in the various strata, and it is noteworthy that from below upwards there is an increasing complexity of type. In certain layers new organisms suddenly appear as if their evolution had been a sudden process, while others plentiful in lower strata may completely be wanting.

But, while this is so, we do not find the successive Continuity-types appearing with successive strata. On the contrary, we find that as far back as the Silurian period segmental Individuals were in existence. In the Silurian rocks fossils have been discovered of Algæ, Hydrozoa, Corals, Starfish, Crustaceans, Brachiopods, Cephalopods, Insects, and Fishes. That is, at this comparatively "early age" *all the forms of living Continuity had evolved.* If we accept the Cambrian system as the first of the earth's crust, we would naturally conclude that evolution was a more rapid process when the world was younger than in later ages;

but it may well be that the Archæan rocks represent many strata which have been crushed out of recognisability and which may have contained fossils showing the progressive evolution of living Continuity.

Be this as it may, there can be little doubt that, as a matter of acquired variation, transmissible be it noted, each new form of living Continuity must have appeared suddenly.

To repeat ; as *regards the fundamental forms of Continuity we have advanced nothing since the Silurian period.* During the time that the presumed first strata of the globe were forming, the highest form of Continuity known to us, the Segmental, had already evolved. As has been said, however, the Archæan rocks may represent many " lost " strata.

It can hardly be doubted that the factor at work in the formation of the successive types of Continuity has been a *compressing* agency. It has been Force of Attraction acting in special ways. For it is necessary to point out that Force of Attraction does not solely imply either the attraction of one entity to another, or the mutual attraction of two entities. The force is essentially directly attracting in its action, it is true, but it may indirectly produce the compression of objects not directly affected.

If we turn, for example, to the evolution of the *megazooid* of sea-anemone form (page 88, Figs. 24, 25) we must attribute the results produced to *steady vertical and lateral pressure* on all the development of a zygote which originally possessed branching continuously zooidal potentialities. And the pressure must have been constantly applied. In fact, the compressing agency which produced the different forms of living Continuity must have acted evenly and constantly from age to age. It is not implied that the degree of compression which produced filamentous Continuity was the same as that which produced the megazooid, but that variations in the degree constantly and inexorably conformed to natural laws.

The only attracting and compressing force to which we can attribute constant action according to Law ; which could compress evenly in vertical and lateral directions ; which could originate the successive forms of Continuity and maintain them after formation, appears to us to be the attraction force which caused the first formation of this globe, and its progressive contraction and solidification: the force, in fact, which caused, we believe, Life itself to originate. *This force is Terrestrial Attraction, or Gravity.*

When we realise that owing to terrestrial attraction the electronic Continuity of the atom, the atomic Continuity of the inorganic molecule, and the higher atomic Continuity of the living molecule were successively realised, and that Life, once called into being, had to continue its existence and multiply in presence of the constantly acting force, we can see how the first form of living Continuity would inevitably come to be multiplied again and again.

All the forms of living Continuity evolved in *aqueous environment*, and Gravity would act in two main ways as the compressor of developing living systems.

(1) Directly; by pulling the system against the earth's surface.

(2) Indirectly; in the form of WATER-PRESSURE.

The question of relative densities of a living entity and its watery environment would, in the absence of means of locomotion, decide whether the entity sank to the bottom, remained suspended, or floated to the surface, and therefore the degree of water-pressure to which it would be subjected. Did it sink, it would be subjected to direct force of Gravity plus the pressure of overlying and surrounding water, whose weight, apart from the added one of superincumbent atmosphere, would always be the measure of its attraction to the earth. Naturally, were the entity to move habitually under the water, new pressure factors would appear.

Now water-pressure varies according to the depth of the water, but at a given depth it is constant, and it is clear that the results of compression obtained at one depth would be more marked at a greater one. One has only to postulate that it is the Individual's development from the zygote which has been compressed, to realise how the progressive multiplication of living Continuity could take place.

We do not suggest that water-pressure was the only factor at work; for example, the temperature and salinity of the water, and the food of the developing organism, could all affect the density of its cells; while light, as a factor pulling away from the earth would enter into the question.

But, though it is possible that without the aid of water-pressure cells might have developed in serial filamentous continuity, nevertheless it is difficult to see how the progressive multiplication of Continuity in the manner which has occurred could have taken place in the absence of water-pressure.

One cannot, in fact, resist the impression that compression during *development* has been the constant process in the evolution of the different forms of living Continuity. In no other way, it is suggested, could the structural plan of the sea-anemone or the medusoid be explained, nor the intensified Continuity of the segmental Individuals. And regarding this compression to be but an indirect result of the action of everywhere-obtaining terrestrial attraction (attracted water being the compressor of our theory), we are consistently recognising the work of one factor all up the scale. The force which binds the electrons in the atomic whole, binds the atoms of the molecule ; the molecules of the mass ; mass to mass ; and in binding masses of water to the earth has compressed into existence the primitive protoplast and all succeeding forms of Continuity.

We cannot pretend to explain the actual way in which water-pressure produced its results, but we get some hints from the structural plans of the Individual types.

If primitive Filamentous Continuity appeared as an acquired variation in a discontinuously multicellular Individual type, and was due to compression during development, it is clear that rest under the body of compressing water would be a necessity. This could only occur if the zygote about to develop as a filament were of greater density than the water. This might well represent the initial acquired variation, and be due itself to increased water-pressure ; an agency such as a strong current carrying the fertilised ovum to depths where the pressure by diminishing volume increased density.

Be this as it may, if it be given that a fertilised ovum, or zygote, with discontinuously multicellular potentialities, were dense enough to remain at the bottom under unusual water-pressure, then its development as a filament might be expected for the following reasons : The zygote's density, and the water-pressure would make for rest *in situ* of the zygote and its division results, and conceivably for attachment. The result of attachment would presumably be proximal cell-arrest, with distal cell-multiplication and serial growth. But there is reason to suppose that as cell succeeded cell there would be a slight diminution in density, with a resultant slight pull towards the surface of the water. Light-attraction might also act by stimulating distal growth and drawing the filament towards the surface.

This supposed diminution in density is not fanciful, for it obviously occurs in the development of present-day algæ such as Spirogyra, whose zygote develops in underwater attachment, and whose filament floats to the surface. Another example is the bladder-wrack, which, attached to some rock or stone, strains towards the surface when submerged; diminishing density here taking the special form of air-floats. Hydrozoal colonies, and stalked crinoids, are other examples of organisms whose zygotes are denser than the water, and in whose development diminishing density may be presumed from the fact that growth is upwards and away from attachment. Naturally, in the sudden evolution of filamentous growth we presume a very faint diminution of density with extension; just sufficient to cause upward growth in face of even lateral water-pressure.

In the evolution of the zooid we have to presume that a fertilised ovum, or its equivalent, with *filamentous* potentialities, came to develop in water-pressure conditions severe enough to institute a higher form of Continuity; the result being, on the whole, as if several beginnings of branching filaments were squeezed together, as they grew, into a little mass by water-pressure. If the multiplying cells of such a mass regularly diminished in density, a spherical form, then a pear-shaped one, and finally a cylindrical form, could result, as accompaniments of upward growth. Another result of gradual diminution in cell-density could be the formation of a hollow interior in the mass.

In this connection it may be noted that if a liquid heavier than water—chloroform, for example—be placed in small amount under water, it takes the form of one or more discrete flattened globes. Gravity and overlying pressure try to spread the chloroform out as a film on the bottom, but lateral water-pressure resists. The density of the chloroform is, however, such that a drop under water cannot assume a spherical form. A drop of oil, on the other hand, suspended in an emulsion, is spherical, its suspension and shape indicating an even balance of pressure forces on all sides.

Now a cell-mass, whose cells were all of the same density and heavier than water, would under water-pressure develop as a spread-out mat and not as a spherical mass. But if a slight diminution in density went hand in hand with cell-multiplication a spherical shape would almost certainly be the result. And if there was basal attachment to the bottom, the pull outwards and upwards due to diminishing density would cause the formation of a hollow interior in the sphere, in the presence of surrounding water-pressure. As cell-multiplication proceeded, gradually progressing diminution of density would, in presence of lateral water-pressure, cause the sphere to elongate into a pear-shape, and finally into the shape of a cylinder, and it is on these lines that it is suggested that the zooid evolved. The budded Hydra zooid, it may be noted, starts as a little hollow bud which becomes pear-shaped, and then elongates into a cylindrical form, a mouth opening distally from within outwards. The last fact lends a little colour to the supposition that the distal mouth of the new primitive zooid appeared when the cells of the distal end of the cylinder were of such low density that upward pull, assisted, it may be, by internal pressure of fluid contents, caused a cell separation or break which became the mouth. Pressure outside and inside the cylinder would then be equal and the tubular form be maintained. The elongation of the tube would also tend to cease, for a diminution of density sufficient to cause the outbreak of a mouth would make for the discontinuity of further cells produced. It may be that here we have the explanation of the discrete, or laterally discontinuous tentacles round the mouths of typical zooids, and these may have at first appeared as final zooidal attempts at elongation ; diminished density having made them stream upwards as separate cell-strings, still attached, however, round the mouth of the zooid. Thus, this would make gradual diminution of cell density not only a chief factor in determining the shape of the zooid, but also its proportionate length. It would explain how further growth had to be through gemmation, equilibrium of personality of the first zooid having been attained.

The following diagrams are intended to illustrate some of the points above suggested.

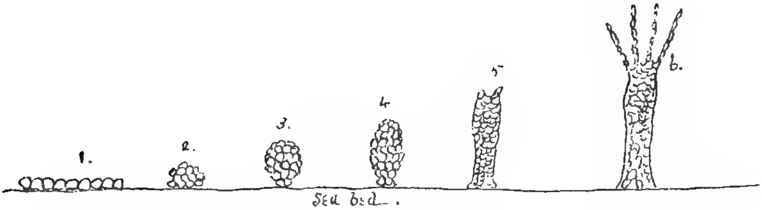


Fig. 47.—Illustrating the possible manner of evolution of the tubular zooid. 1. Showing how a growing mass of cells of similar density would, if the cells were of higher specific gravity than the covering water, grow along the bottom as a flat mass. 2. Showing that if each cell produced gradually diminished in density the cell-mass would as it grew gradually take a spherical shape in presence of water-pressure, to become hollow in time as in 3. The cell-mass is attached to the bottom. 4. As growth proceeded diminishing cell density would cause the sphere to elongate upwards towards the surface; and a point would be reached, as in 5, when the cells of the distal end of the tube would give way owing to the upward pull, possibly assisted by increasing internal pressure in the tube, and a mouth be formed. Further growth would be from the margins of the mouth, and owing to still diminishing cell-density would be in the form of discrete series of cells, or primitive tentacles, 6.

It is natural to suppose that any daughter-zooid budded by a "parent"-zooid would as a whole be of lower density than its producer, for it would originate from cells of lower density than the first cells of the parent; and it may be that the final discontinuity of parent and daughter, as exemplified in Hydra, was originally due mainly to the pull upwards of the lighter budded zooid.

In Continuously Zooidal Individuals, the zooids remain attached, and there is zooidal arrest. It is not easy to imagine how this new Continuity-variation came about, but it may be noted that in modern zooidal colonies there is a branching cœnosarc from which gemmation takes place, and that a tough horny periderm is usually present, giving the colony at times a coralline appearance. Permanent attachment of the zooids might have originated as a result of the formation of horny periderm which defeated the forces working for zooidal discontinuity; though the formation itself might well be a result of attachment and immobility connected with questions of relative density. As regards the Discontinuous Megazooid of anemonoid form in a preceding chapter its structural plan has been shown to be attributable to the compression of potential branching zooidal plan during development (pages 87–90), and it need only be remarked that our theory is that water-pressure was the factor at work: it being presumed that a fertilised ovum with continuously zooidal potentialities came to develop in heavier pressure conditions than those which evolved the ancestral type.

The medusiform gonophore, which appears suddenly after a considerable amount of continuously zooidal growth and not directly from a fertilised ovum, is more difficult to explain. Yet it is clearly a spray of sporosacs which has been compressed in its development to form a sexual megazooid, and it is reasonable to suppose that its formation would indicate a special compressibility, perhaps related to an increasing density and a plasticity connected with approaching cycle-termination. In the Continuously Megazooidal Corals, on the other hand, where the coralline plan is that of the anemone, the continuity displayed is probably the result of megazooidal density and attachment, which in turn were factors in the deposition of the coralline skeleton binding all the megazooids together.

The manner in which water-pressure could have evolved Segmental Continuity will be mentioned presently in connection with the evolution of the primitive Fish; active movement in the presence of water-pressure being in this case a factor of special importance.

But it has been taken for granted that some factor intervened to place fertilised ova, or conjugated gametes, in conditions where water-pressure greater than the habitual obtained. And we have this factor in SEGREGATION.

Segregation acts in many guises, but it has been instrumental in the origination not only of the different types of Continuity, but also of the different species within each type.

Attraction inevitably induces Repulsion, and Aggregation invariably ends in Segregation.

Segregation frequently reflects environmental hostility in a near or immediate form, and it is through this that atoms, molecules, the products of cell-division, and Individuals separate from each other to come under the action of different modifying forces. For example, the segregation occurring on the splitting up of a molecule results in momentarily segregated atoms encountering new affinities. And the segregation of cell-division during development entails that the future product of a division-result appears in the young Individual in a definite region where special cell-characters are necessarily acquired and maintained. This is the segregation through whose help are evolved the different cell-species of the body.

At the same time, Environment may act as a segregator in the form of suddenly acting physical force. It may set up natural barriers which have the same effect as removal to a distant environment, or it may actually carry potential Individuals to places far distant from the habitat of the original stock, where special influences mould the development on new lines. The wind, water currents, birds and animals frequently act as transporters of potential Individuals, but the periodical alternation of elevation and subsidence of the ocean-bed has without doubt been one of the most important segregating factors in past evolution. By the process of elevation a marine stock could be brought to acquire terrestrial characters, while through subsidence of a stretch of the ocean-bed a given organic type could be caused to develop in depths where increased water-pressure would proceed to multiply previous Continuity. Multiplication of numbers would itself lead to segregation and the invasion of new environments.

In many different ways, therefore, Segregation would lead to the invasion of new environments where greater water-pressure obtained, and where Continuity could be further multiplied, *during development.*

It has already been pointed out that the discreteness of the various strata of the earth's crust, and the sudden appearance, and occasionally disappearance, of certain fossil forms in given strata, are indications of alternating elevation and subsidence of the ocean's bed in the distant past. That elevation could bring about the evolution of a new terrestrial type from a previously existing marine one.

But the successive strata of the earth's crust do not reveal to us in fossil forms any regular multiplications of Continuity, and for the simple reason that as early as the Silurian Period the main forms of living Continuity had already evolved. It is difficult to believe otherwise than that the Archæan rocks were once stratified, and that the alternate processes of elevation and subsidence kept occurring during immense stretches of time long before the Silurian Period. It is indeed quite possible that as many strata preceded the Silurian Period as have followed it.

A little thought makes it clear that immense stretches of time would be necessary for the evolution of the different forms of Segmental Continuity, alone, which we know existed in the Silurian Period; and if we add to this the time which must have been necessary for the evolution of the Continuity-types lower than segmental, and the then existing species within these types, we may conclude that Life obtained on the globe at least as long before the Silurian Period as from that Period to the present day.

CHAPTER XVIII

THE EVOLUTION OF PHANÆROGAMS

The suggestion that there has been no continuous road of *terrestrial* evolution in the past, that the ocean has been the great factory and storehouse from which at long intervals the earth received its primitive types, *each with established and fixed Continuity,* and that these were the originators of great subdivisions of the terrestrial animal and vegetable kingdoms, will no doubt not meet with general acceptance. And especially may this be anticipated with respect to the main subdivisions of the vegetable kingdom. For here an enormous amount of work has been done which would appear to negative our suggestion.

Botanical classification divides the plant world into :—

(1) Thallophytes (bacteria, algæ, fungi).
(2) Bryophytes (liverworts and mosses).
(3) Pteridophytes (ferns, horsetails, clubmosses).
(4) Gymnosperms (pines, yews, conifers generally).
Phanærogams, Angiosperms (flowering plants and trees).

The prevailing view is to the effect that all these types of vegetable growth are more or less closely related to each other through primitive plant-forms which flourished terrestrially in the past, and of which we have little or no record ; that plant evolution has followed many divergent paths which, however, if they could be retraced, would lead to a vanished main road of terrestrial plant-evolution. Our dissent from this view is based on the broad principle of The Evolution of Continuity, and admittedly not on deep botanical knowledge. This chapter, however, is mainly devoted to showing that one class of plant, the Phanærogam, came suddenly into existence, not through derivation from any previously existing *terrestrial* plant-form, but from a *marine type* of already fixed Continuity. If this can be shown to have happened with the Phanærogams, it may also reasonably have occurred with respect to Pteridophytes and Bryophytes.

Regarding the question solely in the light of Continuity-evolution, we may conclude that the Algæ and Fungi have originally a discontinuously multicellular derivation, rather than that they share a common primitive filamentous ancestry.

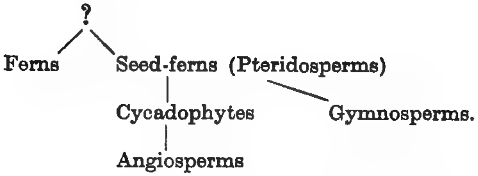
It is difficult to say anything about the Moss's evolution, because we cannot classify the Moss's Continuity. The protonema of the Moss is of filamentous Continuity, but the plant arising from it is clearly of a higher form.

In Pteridophytes, for example in the Fern, and especially in the Horsetail, we would detect direct derivation from a water-inhabiting continuously zooidal type (or types), and not evolution from the Bryophytes. There are no signs, past or present, suggesting that Ferns have descended from Mosses, though much work has been done to prove that they have done so. Professor Scott, in "The Evolution of Plants," adopts the view that the Fern has an algoid ancestry in which there was an alternation of generations as in the brown alga, Dictyota; that a water-inhabiting plant bearing spores was followed by one of identical appearance bearing gametes; and that the fern plant corresponds to the former. He suggests that aerial environment improved the sporophyte, while need for water as a means for fertilisation dwarfed and altered the gametophyte into the form of a prothallus; a process of degeneration.

While recognising the high authority of Professor Scott, we venture to suggest that alternation of generations is not a safe guide in tracing the evolution of terrestrial organisms, but that we should rather turn to examine the *species of Continuity* the organism in question exhibits. Our belief is that the Fern Individual has a marine continuously zooidal derivation, and that the forerunners of the fern plant and its prothallus were not similar but quite different, just as a branching zooidal colony differs from its gonophore. There is, however, no known type of zooidal colony which confirms our belief though from the graptolite fossils it is clear that there existed in the earliest ages zooidal colonies with a plan totally different from existing ones, and peculiarly suggestive of fern structure.

THE EVOLUTION OF PHANÆROGAMS.

At the present time the tendency is to picture the evolution of flowering plants and trees somewhat as follows :—



That is, the Angiosperms are supposed to have been derived as an offshoot from the disappearing Cycadophytes ; these from the Seed-ferns, which in turn are held to have sprung from a common stock with the Ferns. The Gymnosperms are thought to be possibly the result of side-evolution from the Seed-ferns. We would suggest a different derivation for the Angiosperms and Gymnosperms, not inferring that there is no relationship of any sort between the Angiosperm and the Cycadophyte, but that the two plant-types are not linked closely or distantly to any *terrestrial* evolutionary road. The distinct continuously zooidal primitive types from which it is suggested the Cycadophytes, Angiosperms, and Gymnosperms were derived would exhibit many homologies, and it is through these that we are led to recognise a terrestrial evolutionary relationship which does not really exist.

Marine zooidal colonies of the present day have been derived from primitive types which existed long ages ago, and it is from some such early types that we presume the primitive Phanærogams were derived. Further, we would suggest that in the typical Phanærogams there are evident clear signs of the past zooidal derivation.

First of all there is the general form or plan of the flowering plant, with stem and branches, which are usually cylindrical in shape and roughly circular in section. At fairly regular intervals a leaf arises from the stem or branch, and in the axil of the leaf is situated a bud which can grow to become a new branch. The region between any two successive leaves or buds is known as an internode, and the stem or branch is but a continuous series of internodes.

In the branching plan of the Phanærogam we would recognise the similar plan of the zooidal colony, and in the repetition of the internodes the repetition of zooidal structure in the marine colony. In fact, we believe that the internode is the plant "*zooid,*" and that the plant stem or branch represents a continuous series of ancestral zooids as modified by aerial conditions, having been made to develop in such close Continuity that separate identity has been lost and internal structure completely changed. But though the flowering plant is not a zooidal *colony*, yet each "zooid" has the power of behaving in certain respects as a separate unit, being able to originate another by process of gemmation so that a continuous series results. This alone points irresistibly to the zooidal derivation of the Phanærogam.

But this is not all. For while we hold that the internodes are the terrestrial representatives of the nutritive and supporting zooids of Hydrozoal colonies, we further suggest that the flower-structure of the former are homologous with the fructifications of the latter in certain aspects. For the marine zooidal colonies of the present time have, like Phanærogams, their cones and flowers. Here it is necessary to turn our attention to the reproductive organs of zooidal colonies.

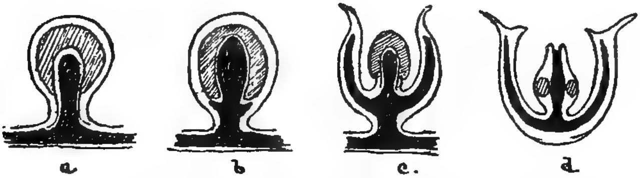


FIG. 48.—Diagram of different forms of sexual structure in marine zooidal colonies. *a*, sporosac; *b*, disguised medusoid; *c*, attached medusiform gonophore; *d*, free-swimming medusiform gonophore. (After Nicholson.)

On an earlier page we have noted that the reproductive "zooids" (so-called) of hydrozoal colonies differ entirely in appearance from the vegetative or true zooids. And the reproductive structure may be comparatively simple in design, or the reverse. There are four typical forms of sexual apparatus met with, all these, though distinctly differing, originating as hollow buds or protrusions of ectoderm and endoderm from the colonial cœnosarc.[1]

On page 94 the evolutionary significance of these four forms has already been mentioned, and the fact pointed out that the medusiform gonophore is not a zooid but a megazooid.

Marine colonies of the present day are, it is true, highly evolved, yet we may believe that in fundamental plan they do not differ from their primitive types; and our theory suggests that in the marine sporosac and medusiform gonophore we have the key to Phanærogam evolution; that from a past type of zooidal colony bearing sporosacs came one of the two divisions of Phanærogams, and from a type bearing medusiform gonophores came the other. In a word, that the marine gonoblastidium (Fig. 28, page 93) which bears sporosacs is homologous with the Gymnosperm cone, and similarly, to an extent which will presently be mentioned, that the attached medusiform gonophore is homologous with the Angiosperm flower.

If the vegetative "zooids" or internodes of the Gymnosperm do really represent ancestral vegetative zooids, we expect to find confirmation in the Gymnosperm's reproductive structure, and the next figure shows that we do find it (Fig. 49).

Naturally, the adaptation of our hypothetical primitive zooidal colony to aerial conditions, and the increased complexity this would involve, would tend to obscure the Gymnosperm's derivation; but with the clear indications of continuously zooidal derivation offered by the repeating internodes of the vegetative part of the plant it is difficult not to recognise in the pine-cone the terrestrial counterpart of the hydrozoal sporosac-gonoblastidium. In the carpel and stamen we would recognise the central spade of the sporosac. It is not unreasonable to suppose that the dryness of aerial conditions would involve the disappearance of the sporosac-walls, and produce a pre-terminal arrest which left a megaspore and microspore in place of ovum and spermatozoon; a certain amount of further cell-division being necessary for the actual production of sexual elements. In the Calamite cone (Fig. 49, G) one also seems to recognise

---

[1] See "Megazooidal Individuals," pages 92–98.

the hydrozoal sporosac-gonoblastidium, and it is our belief that the Calamites were also of Continuously Zooidal derivation.

And this suggested derivation of Gymnosperms is supported by the case of the Angiosperms.

There would seem to be clear geological evidence that the Angiosperms appeared on this globe suddenly. Gymnosperms have flourished since Palæozoic times, as their fossils plainly show, but the first evidence of Angiosperms is in the Cretaceous strata of Mesozoic times, where their fossils are met with in great variety.

But, as has been already said, it is most improbable that the Angiosperms have been derived from Cycadophytes, Gymnosperms, or any preceding *terrestrial* plant-types ; the truth would seem to be that they were a fresh stock derived from the sea or lakes which ages before had supplied the Gymnosperms. However, during the ages which passed from the appearance of the Gymnosperms to that of the Angiosperms, the Hydrozoal type which supplied the former plants had been itself evolving ; and doing so in one special direction. It had now come to be represented in part by a type in which the reproductive structure was much more

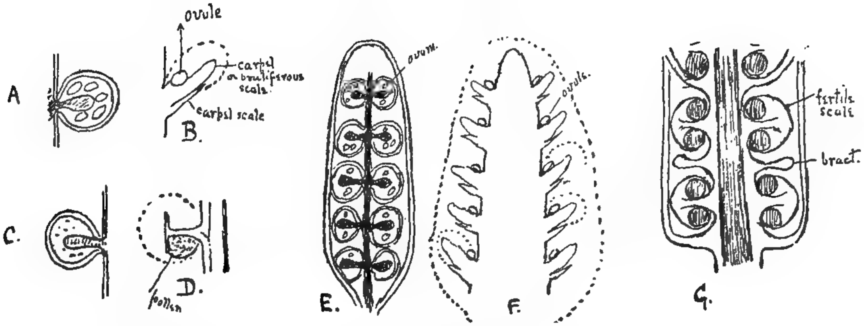


Fig. 49.—Suggested derivation of the Gymnosperm cone from the Hydrozoal sporosac-gonoblastidium. A, hydrozoal sporosac, containing sexual elements. B, ovule, carpel, and scale of female pine-cone. C, stamen and pollen-sac of male pine-cone. D, female gonoblastidium with successions of sporosacs. E, female pine-cone with successions of ovules, carpels and scales ; diagrammatic. F, longitudinal section of part of cone of a Calamite. (Fig. F, after Scott.)

complex than previously, taking the form of a sexual *megazooid.* So that when members of this type came to develop and multiply in aerial conditions as the first Angiosperms, the sexual structure took a form differing greatly from that of the Gymnosperms.

Now it has been shown on page 94 how the medusiform gonophore evolved from the sporosac-gonoblastidium, as the result of terminal compression during development in aqueous environment, so that if we can show that the Angiosperm flower has its homologies with the medusiform gonophore in a convincing way, the conclusion that the Angiosperms were a fresh stock derived from the sea is tempting. Any resemblances they have to Gymnosperms would thus not indicate terrestrial derivation from these plants, but only separate derivation from two distinct kinds of marine continuously zooidal type at a great interval of time.

The fact that during given past periods the same organic types flourished at far distant parts of the globe, as is proved by the fossils found, would seem to have a simple explanation, namely, that at a given depth a world-wide distribution of a marine stock would obtain in the sea during long ages, and that the elevation of the ocean bed to form dry land in a given period would supply at different parts of the globe a common primitive stock for adaptation to aerial conditions. Thus, through the subsidence of the land Palæozoic vegetation largely disappeared, and when in the Mesozoic period fresh upheavals of land occurred they bore with them at different parts of the globe a fresh marine zooidal type which became a new form of plant-life.

This marine type, it is suggested, possessed attached medusiform gonophores, and in several primitive forms became the first Angiosperms. It is unnecessary to say that the origination of the Angiosperm would be due to *development* in the new environmental conditions.

The attached medusoids of hydrozoa known to us are of considerable variety, but they are all alike in being composed of a bell manubrium, and radiating canals (usually four, six, or eight in number). The canals communicate with the cavity of the manubrium, and are linked together by a circular canal running round the rim of the bell. The attached gonophores are usually unisexual, and the sexual elements are produced in two special situations: either on the walls of the radiating canals, or on those of the manubrium (Fig. 50).

If we picture a medusoid with female elements on the manubrium and male elements on the canals, we cannot fail to see that its plan might stand for that of a typical Angiosperm flower. And when it is remembered that the vegetative part of the Angiosperm shows signs of ancestral zooidal repetition, and that the typical flower is terminally compressed to form a species of megazooid in a similar way as is the hydrozoal medusoid gonophore, we feel that the resemblance is no matter of chance but reflects derivation.

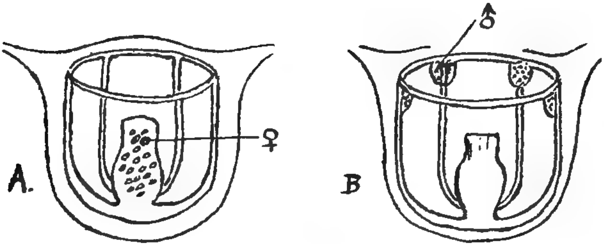


FIG. 50.—Diagram showing the site of production of sexual elements in medusoid gonophores. In A, on the walls of the manubrium; in B, in those of the radiating canals near the rim of the bell.

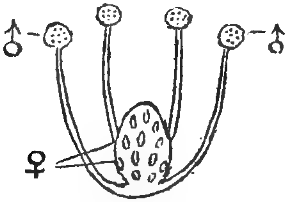


FIG. 51.—The significance of the Angiosperm flower.

We would not expect the ancestral medusoid bell to be represented in the plant flower, for this organ was adapted for locomotion in a watery medium, and for rhythmic respiration and water-vascular circulation; but we should expect that the structures which bore the sexual elements in the gonophore would persist in some form. Thus it is we would account for the presence and discreteness of the flower's stamens, representatives of the ancestral medusoid gonophore's radiating canals. As in the Gymnosperm, we could attribute the presence of pollen grains on the stamens —that is, instead of spermatozoa—to arrest induced by aerial desiccation.

It will be noticed that in the plan above the canals surround the manubrium with its female elements just as do the stamens the gynæcium in the typical hypogynous flower.

The flower perianth would seem to belong really to the vegetative part of the plant, as regards derivation; and the petals and sepals to be modified leaves successively given off by compressed, or "un-decompressed," internodes in the flower stem immediately below the sexual parts proper (Fig. 52).

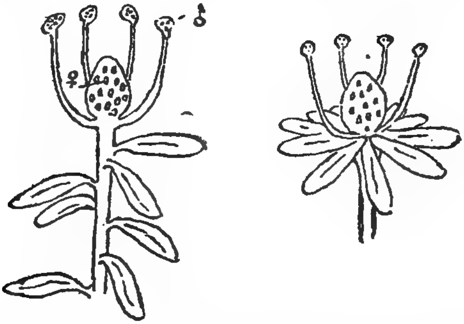


FIG. 52.—To show the significance of the perianth.

With the appreciation that the Angiosperm is continuously zooidal in derivation; that the first continuously zooidal organisms were undoubtedly formed in the sea; and taking into account the homologies which have been put forward, it seems very probable that the Angiosperms were a fresh implantation on land from the great marine storehouse, and did not evolve from any preceding terrestrial plant-types as is commonly believed. Our theory explains the strange gaps existing between one terrestrial plant type and its predecessor and successor, and is in harmony with the principle of the Evolution of Continuity. Separate zooids in continuous series have in aerial environment developed as a straight stem, whose buds and leaves alone remain to indicate what has happened; while, as regards sexual structure, parts necessary for life in watery environment have disappeared, or been altered in aerial environment, but the original plan has remained intact.

To repeat. In watery environment, from the single sporosac came the sporosac "raceme" or gonoblastidium; from this evolved the medusiform gonophore; and finally, from this last, the gonoblastidium containing many medusoid gonophores. The four primitive Hydrozoal types distinguished by the mentioned forms of sexual structure appeared in the sea at long intervals of time, we may believe; and each one, it seems almost certain, stocked the land at long

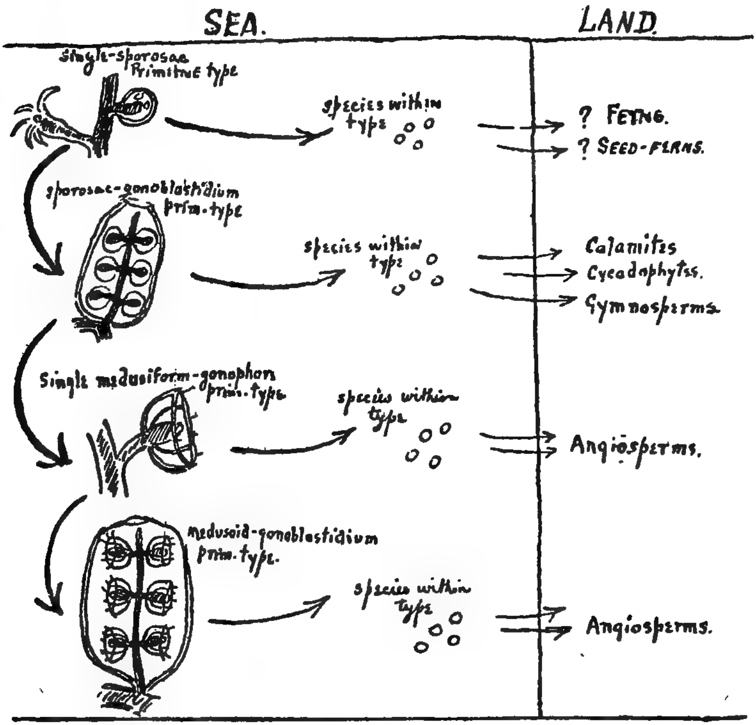


FIG. 53.—Suggested scheme of plant evolution.

distant periods with a new primitive form of terrestrial plant-life.

It is true that it is difficult to do more than guess the plant type which was derived from the single sporosac primitive hydrozoon, though it may have been possibly the Ferns with their little sporangia; but we feel surer in concluding that coniferous plants generally have been derived from a hydrozoal type or types bearing sporosac-gonoblastidia.

The Angiosperms we hold to have appeared at a much later date, *because their marine primitive type was much later in its evolution.* Its distinguishing feature was the attached medusiform gonophore, and this, it is suggested, finds representation in the flower of the present-day Angiosperm. The medusoid-containing gonoblastidium would logically be represented in the Angiosperm flower raceme.

Fig. 53 is a rough outline diagram of our theory of plant evolution.

CHAPTER XIX

THE EVOLUTION OF THE VERTEBRATE

THE megazooidal precursor of the primitive segmental type through which the highest segmental organisms evolved must not only have exhibited serial megazooidal repetition, but must also have possessed strong locomotive powers. And if we turn to the megazooidal types known to us we find that the only ones distinctly motile are medusoid in plan. It is through these that we can explain the evolution of the present-day typical Fish, and thus picture the evolution of the primitive piscine type from which, without doubt, sprang the higher vertebrates.

It is clear that an organism like the Fish could not have evolved from a primitive type in which *one medusa* composed the Individual; we have to imagine a type in which the Individual would be represented by a *series of medusoids*; for a series must be presumed in order to account for the Fish's segmental repetition. Now the only existing medusoid Individuals in whom there is anything approaching a serial medusoid plan are certain members of the Siphonophora and of the Acraspeda, and it is the latter which throw light on our subject.

There are two classes of Acraspedote Individual. One is represented by a single large Medusa, and for this reason can be put on one side; but the other develops as a great number of medusiform gonophores which are successively set free from the distal end of a long developing series. This class has been already considered under the name of Discontinuously Megazooidal Individual (page 103), with *Aurelia* as the example, and the reader is requested to refer to the description already given.

It is the strobila which interests us, as it represents a long series of medusoids developing in close continuity.

It is true that in Aurelia they all end by becoming discontinuous, but it requires no great effort of imagination to picture a primitive type in which the successive medusiform parts of the strobila did not separate, but were obliged to develop in close continuity, so that a series of interdependent segments was the result. Such development in close continuity would in fact produce a primitive piscine organism; and we propose to try to show how a mouth, gills, brain and cord, and closed circulatory system, such as possessed by the typical Fish, would be almost *inevitable consequence.* It cannot be emphasised too strongly that the primitive Fish must have originated suddenly, and that its mature plan was the result of forces moulding and guiding on new lines the *development* of a fertilised ovum originally serially-medusoid in its potentialities. Thus we are not to picture the modification of a strobilar plan already realised, but the moulding, on new lines, of developing tissue whose original idea was to realise a strobilar plan.

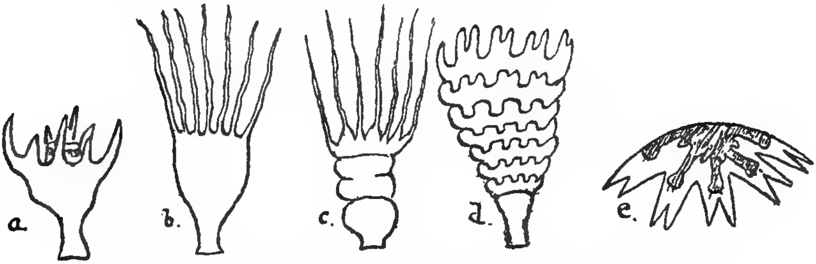


Fig. 54.—The development of *Aurelia.* *a*, Scyphistoma; *b*, further stage; *c*, strobilation begins; *d*, strobila; *e*, free-swimming Ephyra. (After Claus.)

The umbrella or bell of a medusoid is not only a locomotive but also a respiratory organ. In humbler forms of aquatic life the digestive is also the respiratory system, as in the Hydra zooid, where the body-cavity not only receives food for digestion but also oxygenated water for respiration; but in a medusoid, equivalent to a number of zooids united closely in lateral Continuity, there is necessarily more specialisation. For the somatic cavity, while a simple tube to begin with, expands to form a dilatation from which radiate the nectocalycine canals to join the circular canal in the rim of the bell. In this way the digestive canal is continued as a water-vascular system. The canals, in fact, act as primitive bloodvessels in that they convey to all parts of the organism oxygen for respiration, in addition to nutritive substances from the digestive cavity proper.

In all probability bell contractions and relaxations are the chief agencies in maintaining a proper canal circulation, the former causing the expulsion of fluid bearing impurities, and the latter causing an inflow of fresh water bearing oxygen and food. The regularly recurring accumulation of waste-products no doubt stimulate the nerve-ganglia in the bell-rim to call for bell-contraction, and thus it is that in the free-swimming medusoid there appears for the first time in the ascending scale of types rhythmic respiration due to muscular action.

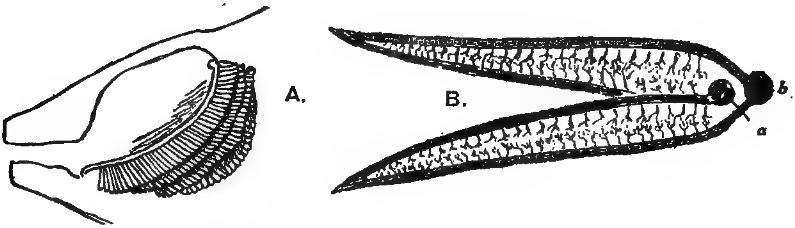


FIG. 55.—A, diagram of the gills on the left side of a typical Fish. B, diagram of a pair of laminæ. *a*, the artery which gives off little branches which are linked up through capillaries with the little venules leading to the vein, *b*. (After Nicholson.)

In the typical Fish this bell-contraction is represented by gill-contraction, and when we examine the vascular anatomy of the Fish's respiratory system we get some light on the mode of evolution followed. It is not to be supposed that the head of the Fish represents an ancestral medusoid; in reality it represents an ancestral *series* terminally compressed so that the segments are indistinguishable; the result of development while moving forward in the face of water-pressure, and reflected in the formation of the brain-mass, as will be shown.

It is common knowledge that the Fish breathes by admitting water into its mouth and then forcing it past the gills to escape at the gill-slits; the capillaries in the mucous membrane of the laminæ of the gills absorbing oxygen from the water as it passes through, and giving up carbonic acid.

The Fish's heart drives the venous blood of the general circulation through the branchial arteries (*a* in figure) to the gill capillaries, where, having got rid of its carbonic acid, it absorbs oxygen and returns through the branchial veins (*b*) to the aorta. The branchial circulation is thus to all purposes composed of a number of vascular rings, usually four, each formed by the junction of a right and left arching bloodvessel, the points of junction being the arterial bulb and the aorta (Fig. 56).

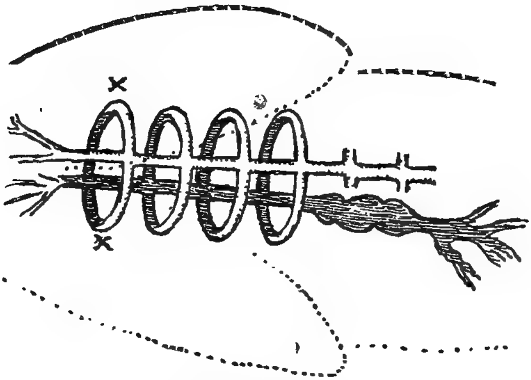


Fig. 56.—Diagram of the branchial circulation of the typical Fish. The venous part of the system is shaded, including the arterial bulb. The capillaries would link up the shaded with the unshaded half of each ring at x.

Consistently with our theory that the Fish has evolved from a primitive "serio-medusoid" organism, we recognise in the branchial rings ancestral medusoid canal repetition; each ring representing, as it were, the circular canal which runs round the rim of the medusoid bell. Derivatively, the rings are in the Fish what the loop-hearts are in the Worm (page 117), though the Vertebrate and the Invertebrate have evolved on quite separate paths from their primitive serio-medusoid types. So, taking Fig. 57, A, to represent the plan of the medusoid canal system, a series of such systems joined up together through the intensification of megazooidal serial Continuity would give a diagrammatic canal-plan such as is drawn in Fig. 57, B.

In humbler forms of segmental Individual, for example, in some Annelids (from which, however, the Fish has not evolved), circulatory arch repetition is very regular down the length of the animal, as is shown in C above.

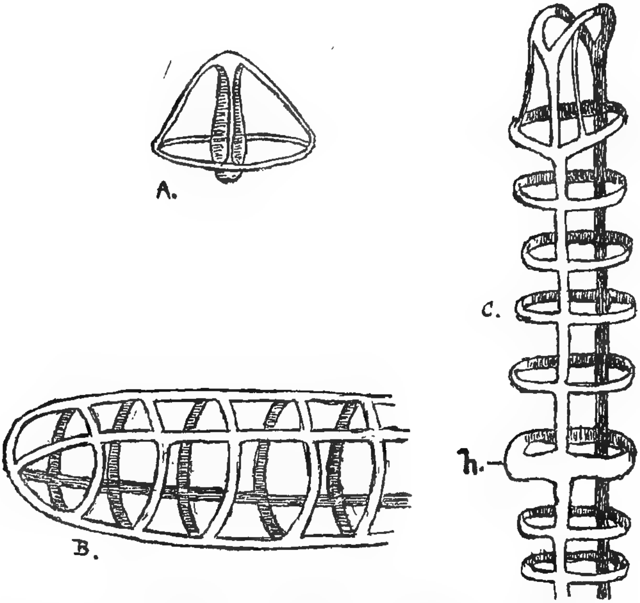


FIG. 57.—A, diagram of circulation of a medusa; B, the result of linking up a series of forms like A (leaving out the manubrium); C, diagram of the circulation of Saenuris, an Annelid, for comparison; *h*, heart.

But in a medusoid the canal system is continuous with the digestive tube, and communicates through this with the mouth of the organism; whereas in the Fish, while the respiratory circulation is in close touch with part of the digestive tract, all the bloodvessels are completely shut off from this. And here we come to the crux of the question. The medusoid has one opening which acts both as mouth and anus, whereas in the primitive Fish an additional opening to that at the end of a series of medusoids inevitably had to be formed. This new opening became the mouth of the organism.

In segmental organisms the mouth develops at what is termed the anterior end of the body; that is, at the end where the controlling nerve-centre develops, and which habitually leads the way when the organism responds to a source of attraction by moving towards it. The nerve-centre itself, a mass of nerve-ganglia compressed together, takes form as the result of terminal segmental compression during development, this in turn being caused by resistance encountered in movement under water-pressure.

Now, in our hypothetical primitive serio-medusoid type it is clear that bell-contractions would be the means employed for active locomotion, and the convex end of the series would be that which led the way during movement. A developing embryo, therefore, which started life with serio-medusoid potentialities, would inherit, so to speak, this method of movement, and as a result its developing serial segments would from the first encounter end-on resistance at what we may call its convex extremity. Hence, at this extremity terminal compression would be a feature of development, and with it the massing of ganglia to form a brain. Thus, while the mouth forms at the anterior end where the brain takes shape, the brain forms at the end of the organism, which for ancestral reasons has to lead the way during movement.

The development of a series of medusoids in such close continuity as to become segments would produce an embryonic organism of a long, somewhat tubular shape, whose walls, representing a continuity of medusoid bells, would have the power of muscular contraction. Down the centre of the body, suspended in the cœlomic space, equivalent to the successive spaces between ancestral medusoid bells and manubrial structure, would run an alimentary tube. This would represent the development in continuity of the manubria of successive medusoids.

The "inherited" opening of this tube would be at the posterior or "concave" end of the organism (Fig. 58).

Such an organism as that drawn below could never take shape, given motile powers and ever-present water-pressure.

In the first place, forward movement in water-pressure conditions would inevitably mould the body on stream-lines (see Fig. 68, in chapter on Symmetry), and cause a tapering of form towards the posterior end. But, more important than this, the systems of digestion, respiration, and circulation, suitable for a single medusoid, would never suffice for a long series of medusoidally derived segments. The medusoid's mouth is also its anus, and the stomach and canals can be filled and emptied through the one opening, but it is clear that one long manubrium with one terminal orifice could never admit the nourishment necessary for a long series of segments, nor allow the escape of impurities; especially so when it is remembered that the whole series of linked-up canal systems would only communicate with the digestive tube by the radial canals of the terminal leading segment (Fig. 59, A). Further, the development of tapering form would reduce the manubrial orifice to a minimum.

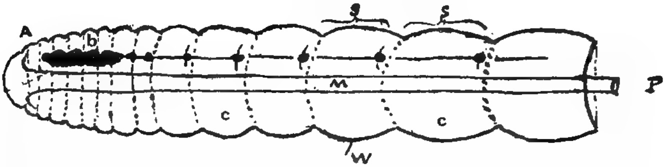


Fig. 58.—Diagram in connection with mouth formation in the primitive Fish. Showing how the "inherited" mouth would be at the posterior end of the developing organism, special factors apart. A, anterior end with terminally compressed developing segments and mouth; *b*, brain mass; *w*, contractile walls, the segments, *s*, of which represent ancestral medusoid bells; *c*, cœlom; *m*, digestive tract, whose one *inherited* opening is at the concave posterior end, P. This diagram is not offered as a developmental stage.

Our conclusion is that the inherited manubrial orifice became, or developed as, the anus of the primitive Fish.

It is to be remembered that the primitive Fish must have evolved suddenly; that a fertilised ovum with "strobilar" potentialities must have been so acted on during its development that new characters appeared all at once. Thus, during its development, the elongating embryonic mass would be compressed in close segmental Continuity, and as it moved with its convex end leading there would come into play powerful physical forces. There would be a moulding of the developing and plastic, not of the mature and rigid. There would not be a narrowing and tapering of an already formed Fish-like structure, nor of an already formed manubrial orifice, but a moulding of form and orifice *during development*. As serio-medusoid potentialities tried to realise themselves the new plan would be made to evolve, and modification, once started, would itself be active in causing further modification.

For example, the commencing tapering of body form and the narrowing of the inherited orifice of the digestive tube would result in the accumulation of impurities, which in turn would induce strong contractions of the body-wall segments. And these contractions would raise the pressure in the cœlom and in its contained digestive tube. We can thus not unreasonably picture the rise of pressure in the digestive tube (increased by the insufficient size of the outlet at the posterior end), resulting in a breach in the tube walls and the body-walls at the junction of certain developing segments. That is, the very need for oxygen would bring about gill-formation. In addition, the same internal pressure might result in the formation of a new opening at the anterior end of the organism, whose alimentary tract would now have a mouth as well as an anus; though it is possible that the mouth was formed not by positive pressure from within during body-wall contraction, but by external water-resistance on the anterior end during movement, assisted by internal negative pressure during body-wall relaxation: was pushed and sucked in, and not pushed out. At the same time, the compression of the anterior developing segments would be going on, a nerve-centre taking shape, and all the modifications occurring which would exert a mutual balancing influence while evolving to become new characters.

The formation of the mouth and gill-slits or branchial clefts of the developing embryo would have important results. For in the first place the muscular relaxation of the walls of the anterior segments would suck in water at the new mouth-opening, and this water would pass but a short distance down the alimentary tract to escape at the gill-slits. The escape would be assisted by the muscular contraction following relaxation. In the second place, the formation of an anterior mouth would bring about the closure of the developing circulatory system.

This system in a continuous medusoid series would be the linked-up canal-systems of the successive medusoids, and would only communicate with the manubrial tube in the convexity of the anterior terminal medusoid-segment, and it seems clear that the formation of a mouth at this spot would cut off the terminal communicating radial canals from the digestive tube, and leave the embryo with a developing *closed vascular system.* This can be made clearer in the next figure (Fig. 59).

It may well be that terminal compression of the leading segments would assist in closing the circulatory system; and it also occurs to one that this factor might assist in the formation of gill-clefts, the compressed developing anterior segments exercising specially strong contractions on the digestive tube and cœlom in their neighbourhood.

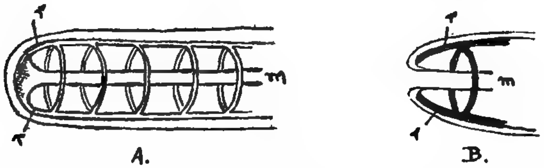


FIG. 59.—A, diagram of "circulatory system" of imaginary serio-medusoid organism, showing how the manubrial digestive tube would only communicate with the linked-up canal-systems at the anterior extremity. B, showing how the formation of an anterior mouth could cut off the radial canals. *m, m,* the digestive tube; *r, r,* the radial canals at anterior end of the organism.

This apart, however, the point to which we return is that the formation of an anterior mouth would *close the developing vascular system,* and that the indrawn water of respiration would of necessity *pass over and not through the primitive branchial vascular rings* (Fig. 60).

But simple branchial loops, such as in the diagram, would not offer a sufficiently large surface for the absorption of the oxygen passing over them, and it is quite probable that the gas itself would directly stimulate vascular branching and the formation of branchial capillaries. This alone, however, would not suffice for the needs of the developing organism, for not only would oxygen have to be absorbed in large quantity, but it would have to be carried to the tissues of the segments anterior and posterior to the gill-clefts. Moreover, impurities in the closed circulation would have to be borne to the branchial vessels for excretion. Thus a circulation of the contents of the closed vessel-system would be called for. No doubt the developing primitive Fish would help to maintain a circulation in its vessels by serial body-wall contractions, but this means would be insufficient and spasmodic. The organism would develop a heart.

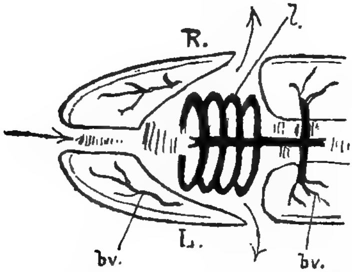


FIG. 60.—Formation of mouth, and gill-clefts, of primitive Fish. R, L, right and left sides of head which represents many compressed segments, whose circular and longitudinal canals have become *bv*, bloodvessels of a closed circulation. The powerful contractions of posterior R and L are supposed to have caused dilatation of the digestive tube and finally breaches at the site of the arrows. The branchial loops, *l*, represent ancestral circular canals, *across* which, instead of *through* which (as in medusoids) the respiratory water passes. Posterior to them is the representative of an ancestral circular canal adapted for tissue nourishment. The figure is ultra-diagrammatic.

We seem to get a hint of the acting causes behind heart formation from the free-swimming medusoid, for it would appear that the regularly recurring accumulation of waste-products, carbonic acid, etc., in the medusoid canal system is the exciting cause of the bell-contractions, and it is reasonable to suppose that the same factor in the *closed* vessel-system of the developing primitive Fish would produce parallel results. These can be recognised in the regular gill-contractions, but as we have seen that gill action alone could not supply the Fish with oxygen, it may well be that the accumulation of impurities within the closed vessels brought on recurring contractions of part of the vessels themselves. The primitive heart, and the arterial pulse, would on this supposition originate as wave-like "convulsive" spasms of the walls of part of the vessel system, the spasms being the result of waste-product accumulation, and recurring regularly owing to the regularly recurring accumulation of waste-products.

In a similar way, it may be remarked, we might account for the first beats of the human fœtal heart; for, as development proceeds, the maternal circulation alone is insufficient for the removal of the impurities and poisons of fœtal metabolism, and these substances may well directly force the fœtal circulation to evolve its own driving powers. It is to be noted that when the mother's excretory functions fail to act properly spasmodic contractions of her muscular system, in the form of eclampsic convulsions, can occur.

With respect to the systemic circulation of the Fish we would detect in the main branches arising from the main venous and arterial trunks ancestral megazooidal circular canals.

So far we have tried to show how the primitive Fish's respiratory and circulatory systems would evolve, an anterior mouth being formed at the same time; and if our theory is reasonable it should help to explain the evolution of the Fish's nervous system.

In *Invertebrate* segmental organisms, such as the earthworm, it has been shown (page 120) that terminal compression provided a primitive form of brain by bringing together the ganglia of successive anterior segments; while posteriorly the ganglia of successive uncompressed segments formed for the animal a ganglionic chain or primitive cord. The anterior ganglionic mass is situated above the mouth, or dorsally, but the chain runs ventrally or below the alimentary canal, a connecting nerve-collar encircling the œsophagus.

On the other hand, in *Vertebrates* the brain and spinal cord occupy a dorsal position, and when it is presumed that the vertebrates have evolved from some primitive invertebrate type this change in the position of the cord is clearly a very puzzling matter.

The theory of Gaskell is at the present time generally held to explain satisfactorily how the invertebrate ventral cord came to take a dorsal position, being roughly to the effect that in some primitive invertebrate type, possessing annelid characters, the nerve-ganglia composing the ventral chain increased in size and grew upwards so as to surround or encase the overlying alimentary canal, the lumen of this finally becoming the ventricles of the brain and the central canal of the cord. Also that in place of the original digestive canal a new one was formed underneath the cord.

We cannot pretend to find this theory in any way satisfactory, and it is here suggested that there lies at hand a much simpler one, and one completely in harmony with the theory of the evolution of Continuity.

There is more reason to believe that vertebrates have not evolved from any annelid type, or one possessing a ventral chain and œsophageal collar ; and that the primitive Fish evolved on a line of its own from a special continuously medusoid type, while the annelids did the same from another. *Our firm belief is that the Vertebrates sprang suddenly into existence with the primitive Fish*, and that the spinal cord was dorsal from the start. That an inherited alimentary canal should come to take on the duties of a spinal central canal, as Gaskell's theory suggests, is, to say the least, improbable. It would be a sudden modification of a kind which completely ignored the inheritance of function and plan. Did we entertain the suggestion as possible, it could only be by picturing it as occurring during development ; but we would ask how a new alimentary tract could be formed from developing tissues whose potentialities had been decided in simpler living types countless ages before.

It is true that we can recognise the evolution of the closed vascular system of the vertebrate from the hollow tubular interiors of ancestral sporosacs, but this is a different question altogether, for it is a harmonious evolution by steps which are the repeated multiplications of Continuity. We can see how the digestive cavity of the zooid was multiplied in the medusoid into a digestive cavity with thin radial branches, whose contents bearing oxygen and nourishment, and necessitating circulation, were a primitive blood of sorts just as the canals were primitive bloodvessels communicating with the stomach cavity. The development in continuity of successive medusoid canal systems, and the cutting these off from communication with the digestive canal resulted in the closed circulation of the segmental organism. But this is, we might say, inevitable evolution.

But Gaskell's theory pictures a nervous system (which had evolved harmoniously with the digestive and other systems of the body it governed) as suddenly overgrowing and practically obliterating the all-important alimentary tract on which its own normal development depended. This might occur as uncontrolled growth, or as a nervous neoplasm, but not as a modification, inevitable, and necessary for evolutionary advance. We cannot believe that Nature could make a new alimentary tract where no inherited alimentary tissues or potentialities were present.

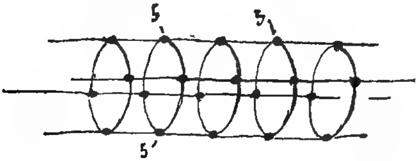


Fig. 61.—The evolution of the segmental nerve-chain. *g*, the ganglia of successive medusoid rings linked together.

A simple explanation of the dorsal position of the vertebrate cord offers itself through the theory that Vertebrates and organisms of Annelid type, while both of medusoid ancestry, evolved on separate lines from the beginning. In a word, it is to the effect that the method followed in the " linking up " in continuity of the developing representatives of successive medusoidal ganglia has differed in the two cases.

The nerve-ganglia of a medusoid are situated in the bell-rim, and the linking up of the successive ganglia in a continuous medusoid series would make a number of longitudinal ganglionic chains, as in Fig. 61.

This we take to be the basic plan on which depended alike the evolution of the Annelid and the Vertebrate. In a medusoid the ganglionic ring in the bell-rim surrounds the manubrium near the mouth, and in a continuous medusoid series the continuous manubrial tube or gut would be surrounded by all the successive nerve-rings.

In the evolution of the Annelid type we can thus account for the circum-pharyngeal nerve-collar, and would conclude that this alone remains to represent the ancestral nerve-rings in complete circle. Dorsally on the nerve-collar terminal compression has massed together several ganglia to form a primitive brain, while ventrally a smaller ganglionic mass obtains as a "sub-brain." Posteriorly to this the nerve-rings are only represented by one ganglionic mass for each segment, plus the nerves given off laterally, and the linking up of these ventral ganglia has given the ventral cord.

In the primitive Vertebrate the same state of affairs could, we may say, have possibly resulted. But here terminal compression massed together a greater number of ganglia to form a dorsal brain, the ancestral nerve-rings altogether failing to surround the alimentary tract as rings or collars, but being represented by the right and left cranial nerves. Posteriorly to the brain the nerve-rings were represented by a ganglion mass with lateral nerves in each segment, but these developed *from the first* dorsally. The next figure illustrates our suggestions.

It seems clear that terminal compression was the chief factor at work in the evolution of the Vertebrate brain; the *developing* evolving type habitually presenting its anterior segments towards sources of attraction as it moved to them in the face of water resistance. That the compressed brain-mass is bilaterally symmetrical, as is also the spinal cord, is a matter to be dealt with in the chapter on Symmetry, being essentially connected with the demand by attraction-sources for undeviating movement-response, or for the correction of deviation. But it may be noted here that such a demand would call for the representation in the central nervous tract of two ancestral ganglionic chains, such as are roughly drawn in Fig. 62, I. Further, the call for a motor and sensory tract on each side of the body would be inevitable, and this inclines one to suppose that the vertebrate brain and cord represent, so to speak, four ancestral ganglionic chains which have developed in close lateral continuity, and in a dorsal position.

As we have said, a few pages back, we cannot accept Gaskell's theory of the derivation of the vertebrate brain ventricles and spinal canal from an enclosed alimentary tract; and if our own theory respecting the evolution of brain and cord be consistently applied we are driven to suggest that the ventricles and canal arose as follows:—

The development in dorsal lateral continuity of the four ancestral ganglionic chains involved their enclosing a dorsally situated ancestral medusoid radial canal-system in all its length as this developed (see Fig. 59, A, upper *r*). When the usual position of nerve-ganglia in the rim of the medusoid bell is remembered, this supposition does not seem unnatural, and is much less fanciful than that which would make a ventrally situated nervous system grow round and almost obliterate an alimentary tract of long pedigree. The fact that in the developing Amphioxus the neural canal temporarily communicates posteriorly with the

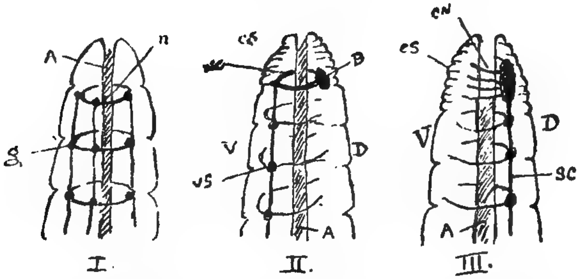


Fig. 62.—The significance of the plans of the Vertebrate and Invertebrate nervous systems. I. Imaginary serially medusoid organism with successive nerve-rings surrounding the alimentary tract; their ganglia being linked together in parallel lines. This may be taken to stand for the inherited nervous potentialities of the developing primitive Invertebrate and Vertebrate alike. *n*, nerve-rings; *g*, ganglia; A, alimentary canal. II. How the plan in I was realised in the primitive Invertebrate. D, dorsal, V, ventral surfaces; CS compressed anterior segments; B, primitive brain; NC, nerve-collar surrounding œsophagus; VG, ventral ganglia which with their nerves alone represent the nerve-rings of I. III. How the plan in I was realised in the primitive Vertebrate. CN, cranial nerves, representatives of N in I; SC, spinal cord, dorsally placed, otherwise of similar significance to the ventral chain in II, the nerve-rings being represented by the spinal nerves passing out to right and left. The other letters same as in II.

alimentary tract does not lend real support to Gaskell's theory, in our opinion. In fact, we believe that the phenomena of early development are not safe guides to the derivation of mature structure. Thus, for example, in the same case of Amphioxus, the cœlom is usually described as arising from the developing alimentary tract in the form of two outgrowths or protrusions. Our belief, as already clearly stated, is that in no living organism can the cœlom be regarded as having been derived in the evolutionary sense from alimentary structure; and the most we are entitled to say is that in the developing Amphioxus there is at first a common cavity from which is formed both cœlom and alimentary tract. It is not suggested that the study of early development is not of the greatest value in the case of different species *within a given type of Continuity*, but our suggestion is that where the question is the evolution of a given type of Continuity from a lower one the comparison of mature structure is the safer guide.

As regards the Vertebrate alimentary tract, this we believe represents ancestral medusoid manubria united in serial continuity; in harmony with the explanations already given of the evolution of the vascular and nervous systems. The abdominal cavity, or cœlomic space, in which the digestive tract is loosely suspended, would thus be equivalent to a number of medusoid "open cœloms" merged in serial continuity (see page 186); the "open cœlom" being the space obtaining between the medusoid's manubrium and inner bell-surface. The significance of the true cœlom has already been mentioned in connection with the earthworm and the echinoderm.

CHAPTER XX

THE EVOLUTION OF THE ATYPICAL FISH

THE typical Fish's characters are largely the result of the active locomotive powers possessed by its developing primitive type. But there exists at the present time what may be called the "atypical Fish," and its structural plan would seem to indicate that the primitive type from which it evolved had no motile powers. Examples of atypical Fish are presented by the *Mollusca* generally, but it is in the class called *Cephalopods* that we get the clearest hints as to the way this type of organism evolved.

Although possessing no vertebral column, and for this reason biologically classified as an Invertebrate, the Cephalopod shows no signs of having been derived from primitive Annelid invertebrate stock. In fact, though invertebrate, the Cephalopod probably has a closer relationship to the typical Fish than to the Annelid. Our supposition is that, like the typical Fish, the Cephalopod has been derived from a primitive serially-medusoid form of Continuity, and that the absence of locomotive powers in this ancestral type resulted in the evolution of characters greatly different from those of the typical Fish.

The serially-medusoid type from which it has been suggested came the typical Fish, moved along actively with its convex end leading, and thus it was that in the evolving Fish the head, mouth, and brain took form in this, so to speak, potential region; while the potentially concave end developed a tapering form, and the inherited alimentary opening became the anus. All this was due to movement during development, in face of constant water-pressure, and with the convex end leading.

But if the ancestral serially-medusoid type had not been free-swimming, but had lived attached to the bottom of the sea, can we picture what structural segmental plan would have resulted when development under compression took place ? With the help of the modern cuttlefish we can, to a certain extent.

Let us start, then, with our primitive serially-medusoid type, noting that it was not motile, but most probably attached to the sea-bed at its convex extremity. This requires no stretch of imagination, for in the developing *Aurelia* (Fig. 54) we have practically such an organism. If a fertilised ovum, with developmental potentialities of a strobilar kind, such as Aurelia possesses, were obliged to develop under strong pressure conditions, the Cephalopod's plan would, it is suggested, be the result. In the absence of movement with convex developing end leading there would be no terminal compression of this region as in typical Fish evolution ; but the *concave* end would be the one to suffer compression. For as the strobilar plan tried to realise itself through growth towards the surface of the water, the potentially *concave* end would be subjected to overlying and surrounding water-pressure, and it would be this region which would be terminally compressed in its development. In other words, a head would take shape at what would represent the tail end in the evolving typical Fish (Fig. 63).

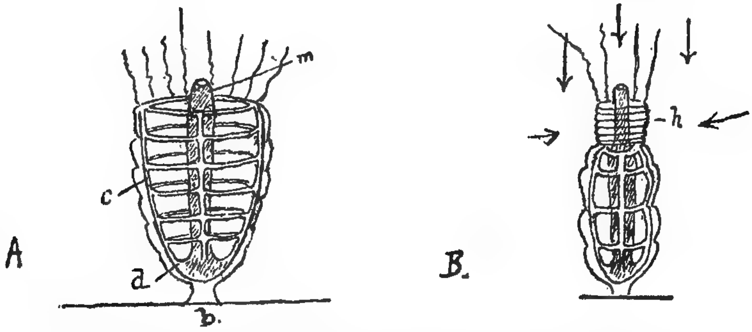


FIG. 63.—Terminal compression in the evolving atypical Fish. A, the inherited developmental potentialities of the fertilised ovum which was caused to develop under special pressure conditions. The figure is virtually a "strobila," anchored to the sea-bed at *b*. *m*, the digestive tube of manubrial derivation, communicating with the water-vascular system, *c*, at *d*. Terminal compression during development, as indicated by the arrows, could, other results apart, give the result shown in B.

The terminally compressed segments would take the form of a solid tissue mass surrounding the distal part of the digestive tube with its inherited opening. There would be a narrowing of the tube in the compressed region, and at the same time the nerve ganglia of successive compressed segments would develop in close continuity to form a primitive brain. Terminal compression would also probably provide strong thick tentacles representing growth from the several compressed segments forming the head (Fig. 64).

But all parts of the new type would be evolving in their development at the same time—an impossible thing to describe or figure—and this is where our difficulty comes in. For while the parts mentioned would be taking shape, others would be evolving in their company, moreover influenced by them and influencing them. While the head and narrow gullet were forming, accompanying alimentary, respiratory, and circulatory novelties would be developing. As a mass of solid tissues, the developing head would not rhythmically contract, but below it there would be taking shape a sac-like body whose walls would contract in a wave-like manner—a gift from ancestral medusoid bells. These

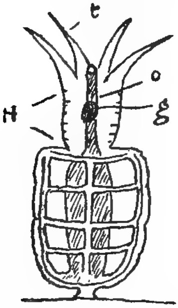


FIG. 64.—Terminal compression in the evolving atypical Fish. The diagram does not, of course, represent an actual stage of evolution, but is merely meant to show how inherited potentialities would be affected by pressure in their attempts at realisation. H, the head-region, with narrow œsophagus, *o*, passing through it. H is composed of several compressed segments, whose successive nerve-ganglia are compressed to form *g*, the compound ganglion or primitive brain. Below the head is a comparatively uncompressed body with wide digestive tract, drawn as communicating at the convex base with the water-vascular system.

contractions would be stopped sharply at the junction of body-sac and head; and the fluid contents between the digestive tube and body-walls, being unable under pressure to escape because of the obstructing head, would force an opening by which to issue. The most likely spot to give way would be where the body joined the head, for here the pressure would be greatest. As a result of the breach, seawater would then pass in and out to circulate round the digestive tube suspended in the cœlomic cavity (Fig. 65). That is, we suppose the same forces to have been at work in the formation of the developing primitive Cephalopod's gill-clefts as in the case of the evolving Fish; the difference being that the clefts took shape at what we might call the opposite ends of the ancestral medusoid-series.

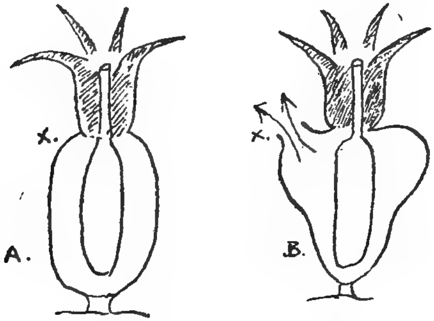


FIG. 65.—The evolution of the Cephalopod's gill-cleft. Showing how, as development proceeded, the body-wall contractions, by acting on the fluid contents of the body-sac, would cause a rupture in the region indicated as X. A represents the state of relaxation; B, the effects of contraction.

As in the case of the evolving primitive Fish, the vascular system of the Cephalopod would be ancestral water-vascular canal systems which had been cut off in their development from all communication with the alimentary tube; and in the region of the gill-cleft the indrawn oxygenated water would stimulate representatives of ancestral circular canals to act as branchial loops, and to form the fine capillaries of primitive gills.

In the primitive Fish a mouth had to take form which communicated with the gill-clefts; the inherited alimentary orifice developing as the anus. In the primitive Cephalopod the inherited orifice developed as the mouth, and it was the anus which appeared as the new alimentary opening, and it communicated with the gill-cleft. It is difficult to say what forces caused the formation of the anus, but no doubt they were pressure forces, possibly the result of peristaltic or contractile movement of the developing gut, and it may be partly due to body-wall contractions, and the outflow of water at the gill-cleft. In any case, the current of the escaping water would doubtless cause the terminal part of the alimentary tube to develop with the anus presenting towards the gill-cleft, the excreta being thus carried outside with the water of expiration. This is what we presume from the anatomy of the present-day Cephalopod in the next figure.

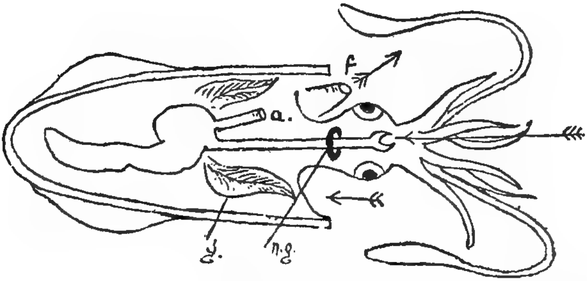


Fig. 66.—Plan of a typical Cephalopod. (After Nicholson.) The notes beneath will help to explain the figure.

“ The body in the Cephalopods is bilaterally symmetrical, and the cephalic region (prosoma) is conspicuously marked out, and is separated from the visceral region (metasoma) which is enclosed in the mantle. The mantle cavity is situated on the under side of the body, when the animal is placed in its natural position. The head is very distinct, bearing a pair of large globular eyes, and having the mouth in its centre. The mouth is surrounded by a circle of eight, ten, or more long muscular processes or arms which are generally provided with rows of stalked or sessile suckers. . . . In all the Decapod, and in some of the Octopod forms, the sides of the body are produced into muscular expansions or fins with which the animal swims head foremost. In all the Cephalopods, also, the lateral margins of the foot (‘ epipodia ’) are either placed in apposition (Nautilus) or are actually united (Cuttlefishes) in such a manner as to form a muscular tube known as the ‘ funnel.’

> "The funnel (Fig. 66, *f*), is placed on the lower surface of the body, with its anterior extremity projecting beyond the mantle, while it opens behind into the pallial chamber. It serves for the elimination of the water which has been used in respiration, and the outgoing currents also carry with them the excretions of the kidneys and of the ink-sac, together with the fæces. By the contractions of the mantle, the water contained in the pallial sac can also be driven through the funnel in a succession of jets, driving the animal backwards through the water. . . . The circulatory organs consist of a central ventricle, into which the aerated blood from the gills is poured by two laterally placed auricles developed on the branchial veins where they leave the branchiæ. . . . The respiratory organs are in the form of two (Cuttlefishes) or four (Nautilus) plume-like gills, placed symmetrically on the sides of the body within the pallial sac . . . the necessary respiratory currents are maintained by the alternate contractions and expansions of the muscular walls of the mantle-sac. In each expansion the water finds its way into the pallial chamber by the opening between the rim of the mantle and the neck; and in each contraction it is expelled through the tube of the funnel, which is so constructed as to allow of the egress but to prevent the ingress of the water. The central nervous system consists of the three normal pairs of ganglia . . . but these are aggregated to form an œsophageal collar (Fig. 66, *ng*). . . . The great œsophageal nerve-collar is protected by a cartilaginous plate which foreshadows the cranium of the Vertebrata. . . ." (Nicholson.)

It will be noticed that most Cephalopods are able to move forwards by the action of lateral fin-fringes, but that when alarmed or desiring to move with speed they move in a backward direction by ejecting water strongly from the mantle sac. In the latter case the advancing end of the animal is that which in the typical Fish has become the anterior; and the fact that backward movement is more efficient than forward in the Cephalopod, and also the method of the movement's production, clearly reflect the serial-medusoid derivation of the organism. The ejection of water through the funnel is due to "wall-contractions" which represent ancestral serial-medusoid contractions, and, as in the case of medusoids, the mechanism of locomotion is here also that of respiration. In the common Octopus backward movement is also obtained by additional means representing ancestral bell-contractions; for the organism expands and contracts the fringe which bears the tentacles, these being drawn behind the head to be thrown forwards immediately afterwards.

The mantle-sac of the Cephalopod is equivalent to the cœlom or abdominal cavity of the typical Fish, in that both represent the space enclosed by a continuous series of medusoid walls; the viscera lying suspended as we would expect a continuous manubrial structure to be in a medusoid series. We have suggested that in contrast with the primitive Fish the primitive Cephalopod evolved from a stationary or attached type of strobilar plan, and we have to presume that on full development the organism became humbly motile. This might well have happened as a result of gill-formation, and the strain on the organism's "moorings" during the expulsion of respiratory water.

The Cephalopod could never hope to evolve rapid continuous movement like that of the typical Fish, for it evolved two separate locomotive mechanisms, which acted in opposite directions. It did its best with fin-fringes, assisted by grasping tentacles, to develop forward movement, but the contractions necessary for respiration of the walls of the mantle-sac have more or less defeated its purpose. It may be remarked that in the typical Fish we find the water current of expiration trying to defeat voluntary movement in a different way; for if the Fish desires to remain motionless, or to move backwards, it has to counteract the forward drive of gill-contraction. This can be well observed in the case of a stationary goldfish in a glass globe.

The main road of Evolution leading to Man has not passed through any primitive Cephalopod type, but through one whose features were roughly those of the present-day typical Fish. And it is well here to repeat that the truth seems to be that *no living organism in this world represents an actual past type on the main road of Evolution.* In the light of the CONTINUITY they exhibit we can clearly recognise through known organisms what the outstanding features of the main road have been, but the actual road has been wiped out. Moreover, the side-roads have also been wiped out; and as Man is all that remains to represent the main road, so is a given animal or plant species all that remains of the actual side-road leading to it. The road of the Evolution of Continuity has, however, been preserved to the present day. Side-path evolution has been a matter of modification or variation within a given Continuity-type; and each new form of Continuity which evolved suddenly in the past has remained arrested to produce its appropriate species, with the exception of such representatives as were destined to carry on the main road of Evolution through the further multiplication of Continuity.

The foregoing conjectures are very superficial, but the intention has simply been to outline the Evolution of living Continuity; to make clear the fundamental principles of Evolution, and to show how *there must be "gaps"* in the evolutionary record.

CHAPTER XXI

THE EVOLUTION OF MATTER

It would be easier to speculate regarding its evolution if one were aware of the ultimate nature of Matter; but even without this knowledge there are distinct indications that what is termed "Matter" has evolved into being, and that its evolution has been based on the intensification of Continuity.

Any hypothesis that can be put forward regarding the nature of Matter must clearly include one concerning the nature of Matter's "antithesis"—Force; but this is a question equally obscure. Our own inclination is to regard Matter as a Force manifestation, or as Force in a special aspect.

The outstanding characters of Matter are form, weight, and visibility, whereas what we designate as Force is formless, intangible, and invisible Power, perceptible by us only through its effects; and our perception of Matter's character is nothing else than the reception of Force-impressions of various sorts by the Matter which we *are*. Thus, as far as we are concerned as living beings, Force would be non-existent but for Matter, and Matter non-existent but for Force. On the whole, though it does not take us very far, it might be said that Force is the power to produce perceptible effects, and that these can only be perceived by Matter, and through Matter, which is possibly Force in a special aspect.

It might be said that if this is so, then Force is Matter in a special aspect; but the question is, Did Force originate from Matter, or Matter from Force? It is reasonable to conclude that Force did not originate from Matter; for if we give the former an ultimate material nature it is clear that it must be ultimately particulate; and for the preservation of the identity of the ultimate particle, and for its movement on given lines, Force would be absolutely necessary. On the other hand, if one pictures Matter as having been derived from Force there is no such difficulty. Our real difficulty is in conceiving Force or Power in the absence of Matter, or before Matter evolved; and it is only possible to try to imagine vaguely Force as the Force of Attraction, and in "pre-creation" days sustaining some all-containing system of equilibrium and unity.

Our speculative theory is that the All-containing cycle started from such a non-material state of unity and attraction, and that the cycle itself could only start its course through the transformation of attractive into repulsive force, with as a result disequilibrium, separation, and division. There would be a chaos of Force, and a shattering of previously obtaining oneness to its utmost limits. This shattering, however, we suppose to have been followed by the first step towards the restoration of lost oneness through the re-induction of Force of Attraction; that is, the lost equilibrium immediately began to be regained through a gradually evolving dominance of Attraction. This belief is based on the revelation of all natural growth-cycles, where we can recognise that Attraction induces Repulsion, and vice versa, but all with the inevitable end that Attraction gains the victory.

And our next supposition is also based on the revelation of natural law. For as we can trace the constant battle between Attraction and Repulsion, and the dominance of the former force, in the evolution of living Continuity, so we might picture the first victory of Attraction over Repulsion to take the form of inconceivably small "force-systems" which, like the original all-containing System, would have distinct and complete identity of personality.

Repulsion would keep apart, and prevent the coalescence of these "ultimate particles," or "potential force-units," but their actual existence would indicate a victory for Attraction. The particles would be insulated in the sense that Force of Attraction would prevent their dissolution, while Force of Repulsion would for the time being prevent their aggregation into larger systems.

This is to picture the ultimate particle of Matter as a force system, bound in attraction round some mysterious force-centre. The particle would have definite quantity and size, and as a repellible or attractable unit could be said to have weight. In other words, through the binding and "insulation" of an infinitesimally small "amount" of kinetic force the phenomenon of Matter may have first appeared.

If, then, we suppose that the first act of "Creation" was the formation of this bound force-system through the commencing substitution of Force of Attraction for chaos-producing Repulsion, the rest of our theory puts a smaller strain on the imagination. For the alternating mutual induction of Attraction and Repulsion—the former force maintaining and increasing its dominance in the process—could result in the aggregation of ultimate particles into larger systems, as well as the separation or independence of these systems. Thus, the discontinuity of the ultimate particle could be followed by the first form of particulate Continuity. These multiparticulate systems might be capable of disintegration as the result of special action of Force of Repulsion, and their component particles set free; but re-formation would keep pace with disintegration, and the loss of one identity go towards the formation of another—possibly one of higher Continuity. In any case, by the steady multiplication of Continuity we could account for the evolution of more and more complex systems up through the atomic to the living segmental.

At the present day the atom is regarded as being a system of ultimate particles to which the name *electrons* has been given. But atoms are clearly of different fixed species, and if the electron is truly ultimate, it follows that the special characters of atoms must depend on the quantities and "arrangement" of component electrons; that is, on the form of Continuity obtaining.

For the atoms of the different elements are distinguishable by one marked feature This is their "atomic weight." The atomic weight of an element is the weight of its atom as compared with that of an atom of Hydrogen, taken as 1. So the different species of elements are the different species of atoms, and these vary fundamentally in the matter of weight, or in the degree in which they are attracted towards the earth's centre.

We know that the earth was once a molten inorganic mass; that it was derived from the evolving sun; and that the sun probably took shape through the condensation of some enormous diffuse "nebula"; and we are led to wonder at what stage of the evolution of the solar system the elements evolved. Had all the known elements evolved before this globe took shape, or before the crust of the earth began to form? We do not know, but it seems clear that *some* elements had already evolved when the earth was still molten; for the spectroscope reveals that the sun, of which the earth is a fragment, has, although it is still molten or incandescent, certain known elements in its substance; for example, Hydrogen, Iron, and Sodium. It may well be that further cooling, condensation, or compression have to take place before the sun can evolve the elements of high atomic weight. And perhaps towards the centre of the comparatively cold earth the evolution of elements of higher atomic weight than any known to us is at present going on, or is to take place, as the result of increasing contraction or condensation.

On the whole it is reasonable to suppose that a pre-elemental stage of evolution once obtained, and that the known elements evolved through the Intensification of Continuity; and we get a certain measure of support for this presumption from what is known as the Periodic Law, or the Law of Octaves (Fig. 67).

This law is to the effect that if the elements be arranged in the ascending order of their atomic weights, any given element in the series is found to resemble the eighth, sixteenth, twenty-fourth, etc., succeeding it, or preceding it; the resemblance being that of general properties, and also in the matter of highest oxides and hydrides. The following table, taken from Bloxham's "Chemistry," shows this.

One cannot but feel that this table is a species of key to the evolution of the elements, if we could but use it aright. But in spite of our inability to do so, we can see in it indications of past elemental evolution through some form of Continuity intensification. If we take increasing atomic weight to reflect higher and higher Continuity, the heaviest elements would be those last evolved, and as the

GROUP ..	0	1	2	3	4	5	6	7	8
Highest Hydrogen Compounds	—	RH	RH_2	RH_3	RH_4	RH_3	RH_2	RH	—
Highest Oxygen Compounds	—	R_2O	RO, or R_2O_2	R_2O_3	RO_2, or R_2O_4	R_2O_5	RO_3 or R_2O_6	R_2O_7	—
SERIES 1	—	Hydrogen H 1	—	—	—	—	—	—	Helium He 4
2	Helium He 4	Lithium Li 7	Beryllium Be 9	Boron B 11	Carbon C 12	Nitrogen N 14	Oxygen O 16	Fluorine F 19	Neon Ne 20
3	Neon Ne 20	Sodium Na 23	Magnesium Mg 24	Aluminium Al 27	Silicon Si 28	Phosphorus P 31	Sulphur S 32	Chlorine Cl 35·5	Argon A 40
4	Argon A 40	Potassium K 39	Calcium Ca 40	Scandium Sc 44	Titanium Ti 48	Vanadium V 51	Chromium Cr 52	Manganese Mn 55	Iron. Fe 56 Cobalt. Co 59 Nickel. Ni 59 Copper. Cu 64
5	—	Copper Cu 64	Zinc Zn 65	Gallium Ga 70	Germanium Ge 72	Arsenic As 75	Selenium Se 79	Bromide Br 80	Krypton Kr 83
6	Krypton Kr 83	Rubidium Rb 85	Strontium Sr 88	Yttrium Y 89	Zirconium Zr 91	Niobium Nb 93	Molybdenum Mo 96	—	Ruthenium. Ru 102 Rhodium. Rh 103 Palladium. Pd 106 Silver. Ag 108
7	—	Silver Ag 108	Cadmium Cd 112	Indium In 115	Tin Sn 119	Antimony Sb 120	Tellurium Te 128	Iodine I 127	Xenon Xe 130
8	Xenon Xe 130	Cæsium Cs 133	Barium Ba 137	Lanthanum La 139	Cerium Ce 140	Tantalum Ta 181	Tungsten W 184	—	Osmium. Os 191 Iridium. Ir 193 Platinum. Pt 195 Gold. Au 197
9	—	Gold Au 197	Mercury Hg 201	Thallium Tl 204	Lead Pb 207	Bismuth Bi 208	—	—	Niton Nt 222
10	Niton Nt 222	—	Radium Ra 226	—	Thorium Th 232	—	Uranium U 238	—	—

FIG. 67.

result of a process of condensation or aggregation due to the steady action of Force of Attraction.

Several possibilities suggest themselves.

I. That no element evolved from a preceding one in the table, but that each case came from some primitive element-type which has disappeared. That the known elements are fixed species at the ends of side-paths.

II. That each element did actually evolve from some preceding one in the list.

III. That each *group* (vertical series in the table) indicates, or is a special line of, past evolution.

IV. That in the ascending order of their atomic weights the elements represent links in a past evolutionary line.

It may be noted with respect to the third possibility that Lithium can be obtained from Copper in group 1; and Thorium and Zirconium can be made to produce Carbon in group 4. But, on the other hand, Radium can give rise to Helium, and Thorium to Helium, in both cases to an element of a different group.

It is not unreasonable to conclude that the recurring similarity of characters in every eighth element is based on some recurring similarity of atomic internal plan or arrangement. There is, so to speak, a repeating cycle of general characters. This is indicated in the matter of the hydrides, for in a given series of eight elements the difference in hydrogen combination increases to its highest in the fourth element, and then decreases by regular steps till the eighth is reached, whose highest hydride is the same as that of the first element of the series. In a different way the oxides also indicate a character cycle which may well be based on a repetition of internal atomic plan. Experiments which have been made with floating magnets of various numbers, and all of similar polarity, give distinct colour to the supposition. For when controlled by a bar magnet of opposite polarity, held above the water, the floating magnets take most interesting arrangements according to their numbers; and if the numbers are steadily increased, past arrangements reappear on a larger scale.

The Periodic Law would certainly seem to indicate that the elements have evolved, and that a feature of this evolution has been the larger and larger aggregation of electrons composing atoms. The plan on which the electrons became aggregated would seem, however, to decide elemental character, and the character-repetition of the Periodic Law may well indicate a repetition of internal plan whose basic principle is the multiplication of Continuity through addition.

CHAPTER XXII

THE ORIGIN OF SPECIES

This chapter deals with the origin of sub-species *within the different classes or fundamental Species of living Continuity.* The latter question has already been considered, and the conclusion has been suggested that the fundamental Species did not originate through any process of Natural Selection in the Darwinian sense, but was a matter of direct modification during development, at the hands of Environment; a process of repeated compression, assisted by the factor of Segregation in its various forms. And we would likewise attribute the origination of sub-species to the same fundamental cause, namely, environmental action. Each new type of living Continuity first appeared as an *acquired* variation from established plan, and it is our belief that sub-species have originated in the same manner.

It must be emphasised that the variation to which we would attribute the origin of sub-species was not "from whatever cause arising" (Darwin), but was *acquired*; acquired from Environment. And the acquisition must have been sudden. *Natura non facit saltum* is clearly untrue, as the gaps between the successive Continuity-types show, and it is difficult not to believe that any variation concerned in the origination of sub-species must have been suddenly acquired or imposed. Thus, if we were to accept Darwin's supposition of slow and gradual change during great stretches of time, it would only be in the sense that the final result had been gradually attained as the sum of very many suddenly acquired variations imposed at intervals.

At the present day Darwin's theory of Natural Selection, although not wholly satisfactory, holds the field, and its only rival may be said to be the Mutation Theory of De Vries.

It is clear that behind all Darwin's theory was the crossing of selected Individuals as practised by man in originating new varieties; and that accepting it as certain that in Nature new species must have originated in variation, he had to solve the problem of how Nature could similarly select Individuals possessing given variations, so that interbreeding could take place without interference from Individuals not possessing the variations.

As it was imperative that the Individuals possessing the variations should survive, it seemed inevitable to him that those not possessing the variations should be destroyed or weeded out, or removed in some way.

He felt that he had the key to the whole problem in his hands when he recognised that of any type of Individual born only a small portion could survive owing to the "struggle for existence." For he had only to suppose that the variations in question were peculiarly favourable for the perpetuation of the species to account for the destruction or disappearance of the Individuals not possessing these variations. The survivors were in his words "the fittest," the non-survivors the "unfit." The Natural Selection was thus obtained by weeding out all but the specially fit, whose fitness was the possession of variations peculiarly suitable for continued existence.

There is here an intermingling of truth and fallacy which is difficult to disentangle, and yet the fallacy can be clearly discerned.

But it is not our purpose to do more here than give a bare outline of our own theory regarding sub-species origination, and this is done in the form of the following propositions which, incidentally, show where the weak points are in Darwin's great theory.

The propositions are:—

The fundamental factor in sub-species origination has been Environment. This it is which in innumerable forms has modified development so that transmissible variation has resulted. It has produced the Acquired Variation. Life itself first appeared as Variation at the call of, or by the force of Environment, and all the variations of Life appeared through the influence of the same factor.

The acquired variation is not "from whatever cause proceeding"; it is distinct from the natural variation present in every offspring the result of fusion of distinct male and female elements. It is direct modification, and harmonious with the modifying force or forces.

Any acquired variation must be peculiarly favourable for the life of the organism possessing it, or eminently suitable for life in the environmental conditions which produced the variation; but not for the continued existence of the species generally, and without regard to environment.

Environment varies between extreme hostility and extreme friendliness, and it is clear that in its innumerable forms it can destroy, hinder, or push on development. But whether an Individual is weeded out or perishes, or survives to wax great and multiply, is not owing to the absence or presence of variations peculiarly favourable for the preservation of the species as a whole, but is fundamentally a question of environmental fitness.

It is wrong to classify living *Individuals* as Fit and Unfit. The adjectives should have an environmental application. The matter is one of Fit and Unfit environments. The first life on this globe must have sprung into being as the fittest response to the environmental forces which produced it. But these forces being themselves variable in nature and action, developing multiplying Life must have harmoniously responded to their influence by exhibiting acquired variation. In fact, no sooner can Life have originated than Environment must have begun to weed it out as well as have continued to encourage it.

The Bible parable of the Sower illustrates our meaning well. The seed was all fit to begin with, but its fate depended on the nature of the environment into which it fell. That which fell into good ground and sprang up an hundredfold was initially no better than that which fell upon stony ground, or amongst thorns. The fitness or unfitness was the environment's. "Those on whom the tower of Siloam fell" were no worse than their neighbours; they had the misfortune to enter a hostile environment.

Man, it is true, can select and cross Individuals possessing transmissible variations, and in this way fix new varieties; but man here only acts as a selector of *Individuals,* and it is not really his selection which produces the new varieties.

His interference only results in the production of one hundred per cent. pure-breds as compared with a smaller but equally inevitable number in Mendelian proportions. And he cannot prevent a certain proportion of the true-breds (showing the variation) from appearing, even if he try by intercrossing with Individuals not possessing it to delete the variation. Mendel's experiments with the tall and dwarf sweet-pea plants exemplifies this point. It seems clear that Individual selection is not necessary for the *preservation* of the transmissible variation, but that the use of the process is to increase the percentage of "preserveds."

Environment imprints the variation and preserves it.

Darwin pictured a selection or segregation of *Individuals* possessing a given variation "from whatever cause proceeding"; the segregation being in essence a weeding out of the Individuals not possessing the variation. The more reasonable proposition would seem to us to be that Environment selected or segrated developing Individuals of normal developmental potentiality in order to imprint the variations; or, to put it better, so that the developing Individuals came under the play of new environmental forces which imposed the variation; the variation being a harmonious response to the new environment's influence.

In a word, Environment used Segregation of Individuals (*in posse*) in order to produce acquired variation.

Like Man, Environment has clearly segregated at times Individuals possessing a variation, but as has been pointed out, this has not been necessary for the preservation of the variation, though assisting "numerically" in its preservation.

The survival of the fittest is only the survival of the hereditarily normal in suitable environment; though, of course, one capable of producing variation. The struggle for existence only reflects the law that nothing is gained, or thrives, without some corresponding loss or sacrifice in surrounding Nature; and also that the potentially fit becomes the unfit when forced to develop in hostile environment. At the basis of things, Nature has not worked by means of tragedies, but in spite of them. Tragedies are taken into account, and have their influence in the universal balance, but the ruling principle is the survival of the normal in suitable environment.

It is clear that if selection of Individuals has not been the basic factor in the origination of species as the preserver of transmissible variation, we must look for some other form of selection. This offers itself in the Segregation or the Growth-cycle.

For the growth-cycle begins with an act of attraction or "aggregation" between two sexual elements with a resulting temporary loss of identities, and ends in the restoration and segregation of the elements once more. And just as the fused elements inevitably segregate at the end of the cycle, so do the characters potential in them segregate cleanly in Individual descendants. It is true that a crossing over of characters takes place on Mendelian lines, but, as experiment has clearly shown, intercrossing by itself cannot delete a character. Thus, it is the selection or segregation of the growth-cycle, and not that of Individuals, which preserves the transmissible variation as a fixed character. Our main argument may thus be summed up in the following way: All characters have *originated* as acquired variation under the influence of Environment. Life itself originated as an example of such variation.

Experiment has clearly shown that acquired variations can be transmitted, and when this happens they become characters. But apart from this, there is clear evidence that each succeeding form of living Continuity appeared as an acquired variation of ancestral plan, which has been preserved through countless years to the present day.

Environment, which has moulded all characters, has itself been always evolving, and by acting in innumerable ways has produced the innumerable variations of Life.

Environment has been the one and only *producer* of new characters, and growth-cycle segregation has been the factor which has all along worked for their preservation. Naturally, the persistence of the environmental forces which produced a new character would, of itself, cause the reappearance of the character in the offspring, if not add to character's intensity.

Individual segregation to new environment, or the equivalent, the imposition of new environmental conditions, would be necessary for the production of acquired variation; but natural selection would not at all be necessary for the preservation of the acquired variation. By its action in insuring the fullest percentage of true-breds it could, however, on occasion, help to preserve a new species in certain conditions of the struggle for existence.

In the Mutation Theory, to which reference has been made, De Vries holds that new species originate through sudden change and not by gradual transformation. The sudden changes he calls "mutations," and his belief is that all simple characters have originated in them. The commonly termed "sport" is an example of an organism exhibiting mutations.

In our opinion the mutation can only be acquired variation, and if this be accepted, then our theory is in fundamental agreement with that of De Vries. For our view is that all simple characters of plants and animals have *originated* as acquired variations.

Clearly, the natural variation, or "fluctuation," exhibited in the transmission of fixed hereditary characters is quite distinct from acquired variation, and being in no sense a matter of modification, cannot be held to have any influence in the origination of new species.

CHAPTER XXIII

THE EVOLUTION OF SYMMETRY

The subject of Symmetry is a very wide one, including as it does symmetry of Form, of Power, of Time, and of Numbers ; but what we are concerned with is the evolution of Symmetry of Form in cellularly-continuous organisms. It is symmetry of form accompanying Continuity.

There is, it is true, a symmetry of form which may accompany Discontinuity, in the sense that free and independent organisms could be symmetrical with each other. Thus, the measurements of one fish could, in all directions, be exactly those of another. This, however, we may put on one side as of no interest ; our attention being taken up with the fact that the fish, an organism built up of many cells in close continuity, is itself bilaterally symmetrical.

It is quite clear that symmetry of form need not be the accompaniment of Continuity, for just as a very asymmetrical house may be built up with a number of similar bricks, so might the union of many cells result in an asymmetrical organism. In fact, we may say that asymmetry of form would be the inevitable accompaniment of Continuity unless the uniting factor so worked as to produce symmetrical results, or exercised symmetrical power.

In the following brief remarks regarding the evolution of living symmetry the independent protoplast, or cell, of the Discontinuous Multicellular Individual has been taken as the unit, or " brick," with which Nature has worked to produce its balanced effects. The cell, of course, is itself a wonderful organism with a living Continuity of its own, and it may be of symmetrical measurements, or it may not ; but it is evident that the symmetry of form of cellularly-continuous organisms is in no way due to cell-symmetry. The cells of living tissues show endless variation in details of size and shape, and can only be described as being similar to each other. They are not really comparable with " bricks."

If the independent protoplast or cell is our unit, it is obvious that in the Discontinuous Multicellular Individual we recognise no symmetry of form, for our subject is the Symmetry of Continuity. At the same time this Individual type, when theoretically complete, or composed of nothing but gametes, may lay claim to Symmetry of Numbers; for the complete Individual should be equal to 2 to the Nth, a number exactly divisible by 2, or multiples of 2. This symmetry of numbers is, however, in no way concerned in the production of symmetry of form in organisms composed of many cells, for without some special factor we could not expect the continuity of 2 to the Nth to make a symmetrical organism, or a number of such organisms. And it may also be remarked that cell-division into 2, 4, 8, 16 cells, and so on, can have no real influence in producing a symmetrical organism, though in the early stages of development it doubtless assists the work of the moulding factor.

Our proposition may be summed up as follows: That symmetry of form in living organisms has appeared as the result of the action of symmetrical or evenly balanced external forces on the developing new type; that such symmetry as we can recognise in the ascending scale of Continuity has been the inevitable accompaniment of the Continuity exhibited; that Environment, in many aspects, was the moulder, her material being the plastic, similar, Many; and that *numbers*, not symmetrical numbers, was all that Environment required for her task.

It is in harmony with foregoing pages that we put forward forces acting in terms of Attraction and Repulsion as the producers of symmetry of living form. That is, the same forces which have been opposed to each other in the evolution of Continuity; and, as in that matter, it is to the dominance of Attraction that most of the credit is due.

As the producer of Symmetry, Attraction may be said to have acted in three main ways.

I. As Terrestrial Attraction.
II. As Solar Attraction.
III. As Food-attraction, and other forms of attraction acting in a similar way.

Of these three the most important is undoubtedly the first—the Force of Gravity. Through its action this globe first took shape, and to its continued action may be attributed not only the evolution of inorganic, but also of living matter. Whatever moulding Environment may do in other ways than through the force of Gravity has to be done in subservience to this force; and this must always have been so. And the result, as a contribution to the equilibrium of personality, is maintained with Gravity's assistance, or in the face of its action.

In evolving this material world, and all within it, as so many different works of Continuity, Gravity, however, inevitably brought into action innumerable force-manifestations whose action as often as not opposed its direct pull. Thus, the intensification of Continuity resulting in the formation of the various elements with their different atomic weights is fundamentally responsible for the varying density of Matter, varying degrees of terrestrial attractability, and even for induced terrestrial repulsion. So it is that the cork or the air-bubble moves away from the earth to the surface of the water, and so it is that Gravity constantly defeats itself. In fact, the movement eternally associated with Life, as well as that of the electron in its orbit, may have its basis in Gravity's constant contest with itself.

In spite of this, Gravity is dominantly an attracting force; one which directly draws and binds objects to the earth, and compresses them by the pull it exerts on their superincumbent atmosphere, aqueous or aerial. As it is certain that all the road of Continuity's evolution up to Segmental Continuity took place in aqueous environment, we are thus bound to recognise what an important compressing factor water-pressure must have been in the evolution of the successive Individual types.

The three chief ways in which Gravity could affect living development are thus: (1) As a force directly attracting towards the earth's surface; (2) as a vertically and laterally compressing force by means of the direct pull it exerted on the developing organism's overlying atmosphere—in other words, as water-pressure. This would come into play when the organism's density was greater than that of the water. (3) As a force repelling away from the earth's surface. This would happen when the organism was less dense than the water. It would be indirect repulsion, a matter of displacement by the more strongly attracted water.

Gravity acts in the same three ways when the atmosphere is aerial and not watery.

The natural effect of Gravity being to keep an organism at rest in a fixed position, we may conclude that the question of an organism's being fixed or motile in character will be determined fundamentally by the manner and degree in which it is acted on by competing attraction-forces; for all movement, except such as is towards the earth, takes place in spite of the *direct* action of Gravity.

Living organisms may be divided into the *motile* and the *non-motile*; that is, such as have the power of moving from place to place, and such as remain fixed in position. It is unnecessary to point out that the increase in bulk accompanying growth involves movement, though in no way connected with motility. It is, so to speak, a movement of extension, and may be horizontal or vertical in its direction, or at any angle from the perpendicular.

The plan on which bulk increases varies according to the Continuity the growing organism exhibits, and it is when this is serial in nature, and growth takes the form of linear extension, that the movement of growth is most detectable. This serial extension, especially if in an upward direction away from the surface of the earth, indicates a certain degree of successful competition by some force acting in an opposite direction to the *direct* force of Gravity. The competing force may be Gravity itself acting indirectly as a repellent, causing the growing organism to pull upwards more or less as a string of corks would do if fastened by one end to the bed of a pond, and as exemplified by certain sea-weeds and hydrozoal colonies. It may be that the little air-floats of the bladder-wrack originated through Gravity, gases from all parts of the growing "plant" having percolated upwards in the direction of the surface of the water to form little imprisoned collections in terminal situations.

But it is very probable that in the origination, and maintenance, of serial growth away from the earth a force directly opposing and distinct from Gravity was a factor, namely, Solar Attraction. Moreover, this force would be a factor calculated to work for immobility. As regards submarine life, it is true that its power would vary inversely with the depth of the water, but in shallow depths it would be considerable. Its full power would come into play in aerial environment, and its results are visible in the immobility and habit of existing plants and trees. For solar attraction at its strongest is at right angles to the earth's surface, and a developing organism peculiarly sensitive to its action would during its growth be subjected to attraction in opposite directions. Thus, in the case of the plant, Gravity is pulling along a line towards the earth's centre, while the sun is pulling in an exactly opposite direction. Other things apart, this would make for serial extension, and also for immobility. Assisting Gravity in producing and maintaining immobility in the case of the plant, there would, of course, be the attraction exercised by water and nourishment in the earth on the root.

Solar attraction, however, is not the only force competing with Gravity, and is probably not the fundamental one upon whose action the motility or immobility of evolved organisms has depended; for this we believe to have been Food-attraction, and minor forms of local attraction.

When an organism has a fixed habit, its food invariably surrounds it, or is brought within its reach by causes external to the organism. In such cases, Food-attraction, as a force demanding the response of motility, does not exist for the organism, and Gravity and solar attraction successfully hold the organism *in situ*. But in many cases the attracting food is not brought within reach of the organism, and may itself be immobile; it may be patchy in its distribution, and the patches may be situated at considerable distances from each other. The organism then, as the attracted entity, has to respond to the source of attraction by calling into play its locomotive powers, which themselves originally evolved through this habitual call for responsive movement. And responsive movement of this sort has invariably to be manifested in the "presence" of the force of Gravity. Clearly, Gravity might assist movement, but in many ways it would always be trying to prevent it. On the whole, we may say that the motility displayed by so many living organisms, in spite of any opposition which Gravity and Solar attraction can offer, is proof that Food-attraction can defeat both these forces. Naturally, Food-attraction, though probably the most powerful of factors calling for motility, is only one of many ; and sources of repulsive force could demand movement away from their neighbourhood.

As we shall see, there is a Symmetry associated with immobility, and a Symmetry associated with motility, and they are distinct.

It is not the purpose here to take one by one the different types of Individual Continuity in our brief survey. Certain of these can be ruled out as asymmetrical ; for as Individuals they develop as colonies, growing in serial and lateral extension, and branching irregularly. Thus we exclude the Filamentous, Cœnocytic, Continuously Zooidal, and Continuously Megazooidal *Individuals.* And such as the Discontinuously Zooidal, Megazooidal, and Segmental can have no symmetry of form, owing to their component units being free and independent. The problem, in fact, narrows itself down to the Symmetry of certain *organisms* which may, as in the distinct zooid, be part of an Individual, or as in the higher segmental organism be the whole Individual. It is the problem of the symmetry of the zooid, the megazooid, and the segmental organism. It is to the last of these, and its bilateral symmetry, that most attention shall be given.

We may credit a zooid, such as the Hydra zooid, with being built on a symmetrical plan, though the contractile powers of the organism tend to obscure it. For all purposes it has the symmetry of a cylinder. It is impossible to say definitely how this cylindrical form had to take shape, though on page 164 we have made a few speculations on the matter ; but we would attribute the tubular form of the zooid to the effects of water-pressure on the development of a zygote whose inherited potentialities were filamentous. So that an inherited power of developing as discrete branching series of cells was realised as lines of cells united in lateral continuity. It is not difficult to see how even water-pressure acting on all sides could give and maintain a cylindrical external form to the developing new type, but the hollow interior is not so easy of explanation. It may be that the factor of diminishing density mentioned on page 164 was involved.

The cylindrical tube the zooid represents is the basis of megazooidal symmetry. There are two types of megazooid, the anemonoid and the medusoid, the former practically immobile, and the latter free-swimming, and in both there is an external symmetry of form, and an internal symmetry of parts.

In the anemonoid megazooid the external symmetry is that of a short cylinder, and it reflects the internal symmetry of structure. The theory offered on page 88, and the accompanying figures, explaining the evolution of the anemone-megazooid, serve to show how the organism came to be radially symmetrical, and to avoid repetition the reader is requested to refer to them. We would only point out once more that the new form of Continuity constituted by the megazooid was the result of compression during development. The fertilised ovum had the power of becoming many tubular zooids on a colonial plan, and an evenly compressing force, which we believe to have been water-pressure, accepted the hereditary gift of the zooidal tubes, but caused them to develop in close lateral continuity round a central stem, and the megazooid was the result. The radial symmetry of the medusoid-megazooid is to be explained in a similar way (page 94), the hereditary gift being here sporosacs or sexual zooids, and not tubular vegetative zooids.

CHAPTER XXIV

SEGMENTAL BILATERAL SYMMETRY

THIS is well illustrated by the typical Fish, and by terrestrial vertebrates generally; and as the latter have undoubtedly derived their bilateral symmetry from some primitive piscine type, it is to the modern typical Fish that we shall turn our attention.

In Chapter XIX it has been suggested that the segment of the Fish has a medusoid derivation, and that the primitive Fish was equivalent to a continuous series of medusoids which, as the series tried to develop, were compressed to become indivisible segments of one organism (see Figs. 57 to 62). As the plan of a medusoid is radially symmetrical, it is not difficult to see that here we have the basis of piscine symmetry. That is, we may regard the primitive Fish as having had hereditarily transmitted to it the capacity of developing as a cylindrical tube built up of segments, each radially symmetrical. If this be admitted, the problem which then remains is how such capacity or potentiality came to be realised as the bilaterally symmetrical Fish, The explanation which we have to offer is that Environment, as modifying force, evolved the Fish's tapering form and bilateral symmetry; and that the two main ways in which Environment acted were probably as Gravity, and sources of attraction competing with this force.

The force of Gravity, acting directly and in the form of water-pressure, could never have evolved the piscine form without the interference of other forces. Gravity, uninterfered with, would have gifted the results of its compression with immobility, and while capable of moulding development on some cylindrical plan, as in the case of the zooid and anemone-megazooid, could never alone have produced bilateral symmetry. But the primitive Fish must have been actively motile from the first, and it is to this motility in the face of gravitation forces working for immobility that the shape of the typical Fish is due.

To a certain extent the Fish's locomotive powers are based on those of ancestral medusoids; but only to a certain extent. The jelly-tissue in the bell of the medusoid has been the forerunner of the Fish's muscle-tissue. But, on the other hand, locomotion in a medusoid is almost, we might say, a side-result; bell-contractions being due to the demand for a regular radial-canal circulation. The medusoid's food surrounds it on all sides, and the organism does not move along owing to direct-food-attraction, but rather as the result of bell-contractions produced by the intake of food and accumulation of impurities. In the developing primitive Fish, however, the case would be different, for its food would not be in a fine state of suspension in the water of respiration, but was, we may presume, coarsely particulate and scattered in its distribution. The young Fish had therefore to develop the power of moving in a definite line towards a localised source of food-attraction. It would develop, in fact, a voluntary muscular system. And it is to be noted that all voluntary movement would be in the face of ever-acting gravity and water-pressure.

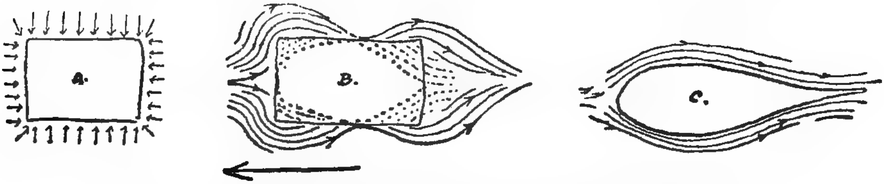


FIG. 68.—Showing how movement in the face of water-pressure would produce a torpedo-like form in the evolving Fish. A, a diagram representing the developing primitive Fish at rest, evenly pressed on all sides by surrounding water. B, roughly shows the lines of water-pressure A would experience if moving through the water in the direction of the large arrow. A being plastic, its elongating form would be made to take the shape enclosed by the dotted lines in B; that is, it would become C.

The young evolving Fish would always have the same part of its body leading the way as it moved through the water, and during movement this part would encounter strong resistance or friction. During rest the water would press evenly on all parts of the body, but during movement special compressing force would play on the developing organism with inevitable moulding results. It would cause the development of a tapering form like that of a torpedo (Fig. 68).

It is interesting to note that the form which engineers give to an object, such as a torpedo, so that as it moves through the water friction shall be reduced to a minimum, is the actual form which water-friction forces a plastic body to take when moving through the water.

But while water-friction could give the elongating primitive Fish (its hereditary symmetrical gifts being remembered) a tapering symmetrical form with a circular cross-section, it could not unaided mould it on bilaterally symmetrical lines (Fig. 69).

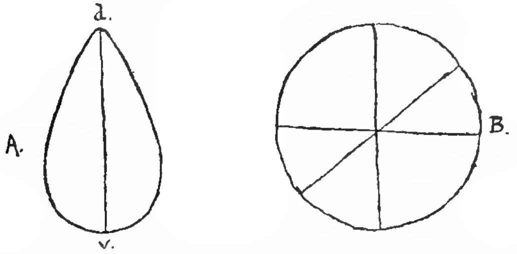
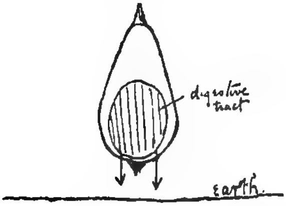


FIG. 69.—A, cross-section of Fish ; *d*, dorsal ; *v*, ventral aspect ; *d v* is the only dividing line which can give symmetrical results. B, cross-section of a torpedo, divisible into symmetrical halves by any diameter.

While terminal compression of the developing anterior segments of the primitive Fish was going on the anterior mouth was formed (see page 186), the food entering by it passing towards the primitive anus at the opposite end of the organism. This food would be more bulky or coarsely particulate than that enjoyed by the ancestral medusoid, and it would not stream through the alimentary canal, but collect in the stomach to be digested before slowly passing down the intestine. Thus the Fish would, as it were, always carry a load of food material inside it. On the presumption, then, that the digestive contents would be of greater density than the water, their attraction towards the earth would have its influence on the young Fish's physical equilibrium. We are led to this conclusion, moreover, when we examine the present-day Fish's anatomy. Apparently the digestive load was strongly attracted to the earth, and the alimentary tube, instead of being suspended in the general somatic cavity, sank down to be as near the earth as possible, where with its contents it became so much "ballast" in the body of the Fish. And as alimentary development proceeded, with the elongation of intestines and the formation of associated organs such as the liver, the digestible parts would form a bulky and heavy mass. The fact that the cross-section of the Fish is not circular, in spite of even friction forces having played during development on all parts of the circumference, but shaped as below,



can hardly be attributed to anything else than the pull of Gravity on the digestive tract. That is, the region where this tract is situated, termed the ventral region, came habitually to face the earth through the Force of Gravity, and the density of the digestive organs and contents was so relatively high as to resist the forces making for a circular cross-section and gave the Fish its ventral fulness.

It may be remarked that in all vertebrates the ventral surface is invariably that which is habitually turned towards the earth, and this inclines us to believe that the digestive viscera and their contents have always tended to be of greater specific gravity, or to be more strongly attracted towards the earth, than the nervous, muscular, and supporting tissues of animals. Exceptional cases, such as those of the sloth, or of man, only reflect the late adoption of peculiar posture.

The viscera of the developing primitive Fish would thus act as so much ballast, which, by exerting pressure downwards and outwards at the call of Gravity, would give the Fish a pear-shaped instead of a circular cross-section, and thus be a factor in the production of bilateral symmetry. The ballast would work for the maintenance of a habitual poise, and tend to prevent rolling when the organism moved through the water, and by its resistance to water-pressure forces trying to produce a torpedo form would bring about the compromise of streamline and bilateral symmetry.

Assisting in the maintenance of an even keel in the majority of known typical fishes (the exceptions being flat fish, marsipobranchs, and elasmobranchs) there is a structure known as the swimming bladder ; this lying beneath the vertebral column, and being a species of sac whose contents are nitrogen in freshwater fishes, and oxygen in those inhabiting salt water. Although in the Mudfishes (Dipnoi) it appears to have evolved respiratory functions and to act as a facultative lung, there can be little doubt that its presence in all other cases is concerned with physical equilibrium. The gas the swimming bladder contains seems to come from the fine bloodvessels ramifying in its walls, and one is inclined to suppose that the organ was originally produced as the direct result of water-pressure which caused the escape of gas from the blood. The gas would naturally tend to collect in the highest region of the fish, thus increasing the ballast effect of the abdominal organs. On this supposition, the deeper the fish would go the more gas would be in the bladder, and the nearer the surface the reverse would be the case.

The absence of a swimming bladder in flat fish, such as the flounder, is interesting in relation to the body asymmetry exhibited. For the flounder in its early days is bilaterally symmetrical, and swims on an even keel after the manner of typical fish ; but as growth proceeds, the animal generally takes to lying on one side on the sea-bottom, finally adopting this pose permanently, and living and swimming with one *side* uppermost. Thus, what appears to be the back or dorsum of the flounder was originally the side. With the adoption of the new position, one of the eyes finds itself applied to the sand and temporarily useless, but it at once begins to work its way towards the dorsal surface and comes to lie asymmetrically alongside of the unaffected eye. Similarly, the mouth becomes twisted in adapting itself to the new position. The body is also asymmetrical, the under white surface being flatter than the dark dorsal one.

It is safe to say that the developing flounder fell over because it lost its previously maintained state of physical equilibrium, and our suggestion is that this was at first preserved by the ballast of the digestive tract. It might be that the falling over was the result of relative decrease in weight of the visceral organs and contents owing to the growing fish taking to a food of low density ; but it is also interesting to note that the failure to develop a swimming bladder could help to bring about the accident. On the other hand, elasmobranchs and marsupobranchs have not this organ, and they are not flat fish.

CHAPTER XXV

SEGMENTAL BILATERAL SYMMETRY
(*continued*)

While the development of ventral ballast was proceeding in the evolving primitive Fish, other factors were working to produce bilateral symmetry of form. The bilaterally symmetrical brain was developing in response to a demand for symmetry of power in all it controlled, and this brain symmetry had its own influence in producing and maintaining that of the Fish's body and appendages.

The development of a brain was one of the results of terminal compression (page 193). For a given part of the developing Fish was constantly obliged to lead the way when the organism moved through the water, and thus became the region which received with fullest force all attracting or repelling influences acting along the line of its course. This leading or anterior part was, in fact, called on to register and distribute the influences to the rest of the body, and, as an inevitable result of the water-resistance encountered during movement, the anterior segments were massed together as they developed, and the ancestrally derived ganglia took shape as the registering and controlling brain-mass.

The young primitive Fish would be stimulated to develop its locomotive powers through Food-attraction, and also through sources of repulsion; and while the weight of the abdominal viscera would, as we have seen, assist in the maintenance of physical equilibrium, it is clear that this could be easily upset by suddenly acting external forces, and that means would require to evolve to correct this. Moreover, if the locomotive appendages formed by the Fish were not capable of exerting symmetrical power, they themselves would upset equilibrium.

But sources of Attraction and Repulsion would, in demanding the formation of the Fish's fins, also demand that these should be symmetrical in shape and situation, and for the following reasons: Lines of attraction or repulsion are for all purposes straight lines, and unhindered response along them in the form of movement towards the source of attraction or away from that of repulsion must be undeviating movement. Thus, the above forces, in inducing through evolving nerve-centres the development of motor appendages, demanded that these should in the first place develop symmetry of power calculated to prevent deviation. Such symmetry of power could be exerted by two appendages, or sets of these, asymmetrical in form and position; but in the case of the developing primitive Fish the body which was called on not to deviate was already moulding on bilaterally symmetrical lines, so that the lateral fins would naturally appear in symmetrical positions, and each pair be symmetrical in form. The asymmetrical would not be allowed to appear.

In a word, local sources of attraction and repulsion would cause the developing Fish to move, and to do this to or from them in *as straight a line as possible*; and it would be they who made the Fish produce fins, and caused these to appear in symmetrical pairs. During the responsive movements of the developing Fish external physical forces would constantly try to produce deviation from the line of attraction or repulsion, and this would call for correction; and it would be the source of attraction or repulsion itself which would correct such deviation as soon as it occurred, and do so by means of a bilaterally symmetrical brain and nervous system.

We have indicated Food-attraction as the chief of the local attractions which, in the face of, or at times with the help of Gravity must have called for locomotion. But sources of direct repulsion must also have been a powerful factor. Repulsion is, however, but reversed attraction. If the nerve-centre at the anterior end of a Fish is affected by force of repulsion acting directly on it, it moves away from the source as quickly as possible; the organism swings round, presents its tail to the source of disgust, and moves away; and it does so in as straight a line as possible. This is what the force of repulsion demands. The Fish could naturally deviate abruptly from this straight line to move in a new one at the call of some laterally situated new source of repulsion, or one of attraction; but whether this occurred or not, the point to note is that *repulsion from one source or direction is equivalent to attraction in the opposite direction.* This may seem rather obvious, but it is none the less important (Fig. 70).

Naturally the deviation to be corrected could be either upwards or downwards, or to the right or left, but we shall

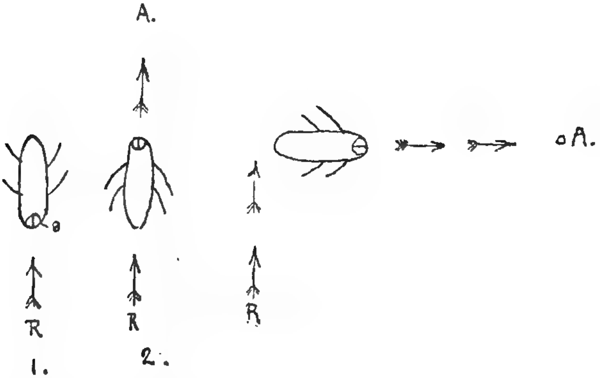


FIG. 70.—To illustrate how repulsion from one direction is equivalent to attraction in the opposite one. 1, 2, repulsion acting from R on the brain B of the organism, causes its attraction in the opposite direction along a straight line. From this line, however, there might be deviation at the call of some definite source of attraction, as in 3.

confine our remarks to the correction of lateral deviation when the Fish is moving on an even keel in a given plane. This correction would demand the formation of a bilaterally symmetrical brain.

If we draw the developing Fish as lying obliquely across a line of attraction, as in Fig. 71, it is clear that the force would be most strongly exerted on the right side of the anterior end of the organism; and similarly, in 2, it would be most strongly felt on the left side. In either case the immediate result would be asymmetrical power response.

If the Fish were a rigid inanimate object something like a torpedo in shape, and had a brain-equivalent in the form of a steel nose; and if this were to receive obliquely the attracting force of a strong magnet, then the object would swing forwards into the direct line of force and continue to move without deviation. But the Fish's movement is not passive response, and the attracting force calls for active fish movements.

If we confine our attention to the lateral fins as propelling agencies, it is clear that the Fish in the last figure, if called to swing to the right to get in the main line of attraction, would have to drive with the fins of the left side, or that furthest from the source of attraction. Conversely, if it had to swing to the left, it would have to work the fins of the right side of the body. But in either case the immediate effect would be that the Fish would swing *beyond* the straight line of attraction unless something prevented this. The next figure shows how swinging past the straight line is obviated.

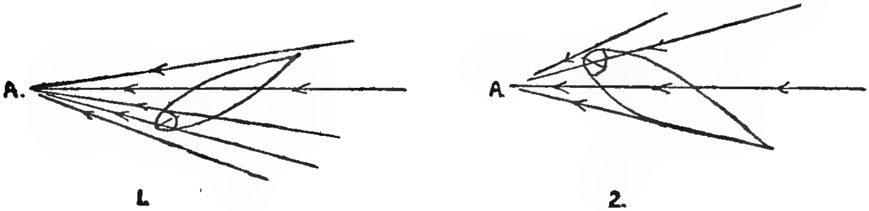


FIG. 71

Thus it will be evident that the Fish's brain would be called on to have two similar parts which would evenly balance each other and so prevent deviation; and which could also correct deviation when this occurred.

An interesting point is to be noticed here. If responsive movement to the right involves left fin movement, and vice versa, it is clear that the messages sent from the brain to the fins must cross the body; in other words, that the motor nerve-tracts would require to be crossed.

This is the logical conclusion, and the fact is that in the typical Fish, as in all true vertebrates (these having evolved through some primitive piscine type), a crossing of main motor nerve-paths always takes place. In Man, for example, the supreme motor centres are situated in the cortex of the right and left cerebral hemispheres. From these centres the right and left motor tracts pass down through the substance of the brain, converging as they do so, to the upper part of the spinal cord called the *medulla*, where, anteriorly situated, they are visible as the " pyramids." Immediately below the pyramids the majority of the conducting fibres of the right side cross over to run down the left side of the cord, while the majority of those on the left

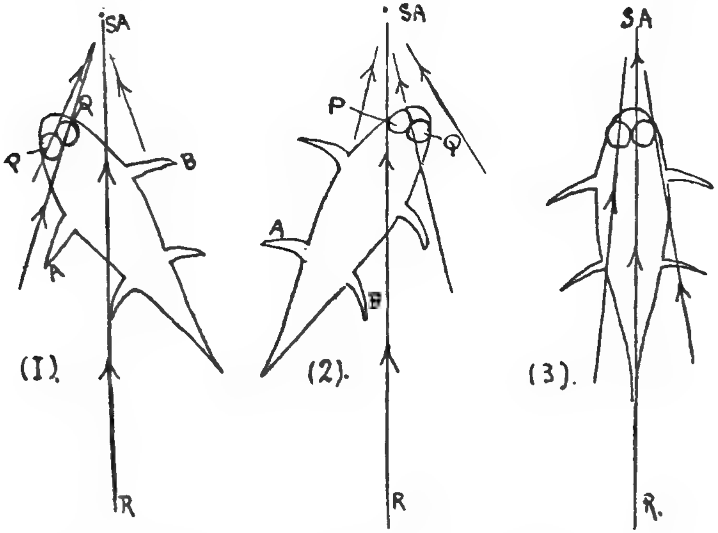


FIG. 72.—Correction of deviation in the evolving Fish. R–SA is the straight line of attraction leading to SA the source ; P, Q, are the left and right sides of the developing brain ; A, B, the left and right lateral fins. In position (1) the attracting force affects side Q of the brain more strongly than side P, and in demanding movement forwards into the line R–SA can only obtain this by obliging the left fins, A, to drive strongly. If side P is unaffected by the force at first, the swinging of the Fish into R–SA soon brings P under SA's influence, when the right fins, B, also drive. And they do so with increasing power until, when the long axis of the Fish is in the line R–SA, both sides of the brain are equally affected by SA, and the symmetrical drive of the right and left fins produces straight forward movement towards SA. A similar drawing could be made with the Fish subjected to force of repulsion from an antero-laterally situated source R. In this case the Fish would be attracted to a posteriorly laterally situated source of attraction, SA, and have a greater distance to swing round to move in the line leading from R to SA.

cross over to the right. In both cases the remainder continue down the cord anteriorly, but at intervals give off fibres to run down the opposite side, and this goes on till finally decussation or crossing is complete. Thus it is that the right side of the brain controls the movements of the left side of the body, and the severance of the right pyramid would cause left-sided paralysis; the reverse occurring if the left pyramid were severed.

In the last figures, it will be noticed that the lines of attracting force which call for deviation into the straight pass through the near side of the brain to the side of the body whose fins are called on to act strongly; and there is some reason for supposing that the habitual crossing of force-lines from before backwards was a factor in determining crossed nerve-tracts. But the brain is not an exposed organ, and force-waves have to pass to the brain along what are called sensory paths or nerve-tracts. No matter where the source of the waves is situated, these require a sensory path to conduct them to the brain cortex, from whence motor impulses pass down to the fins, and this has to be understood with respect to preceding figures.

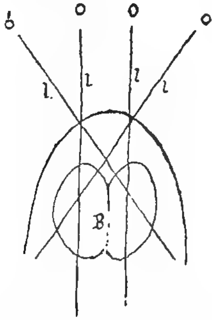


FIG. 73.—The main directions taken by light-waves passing to the brain of the developing primitive Fish. *o, o,* objects straight ahead to all purposes; *o′, o′,* objects situated well to the right or left; B, the brain; *l, l,* direction of light-waves.

While the bilaterally symmetrical brain was taking shape, sensory conducting paths leading to it would also be developing, and these may, for our purpose, be divided into three main classes: (1) those conducting waves from sources situated somewhere in front of the brain; (2) from sources somewhere behind; (3) from sources directly to the right or left.

As examples of the first we shall take the optical sensory paths.

In Fig. 73 there is represented the anterior end of a developing primitive Fish, and the main directions in which light waves would pass to the brain from objects situated anteriorly.

Now our suggestion is that the rays of light have demanded sensory paths to lead them to the brain, and also demanded that these paths should follow the direction the rays themselves habitually take; and that as a result of this a crossed sensory optic tract has inevitably been formed in the typical Fish. In the next figure the plan of the human optic chiasma is given for comparison (Fig. 74).

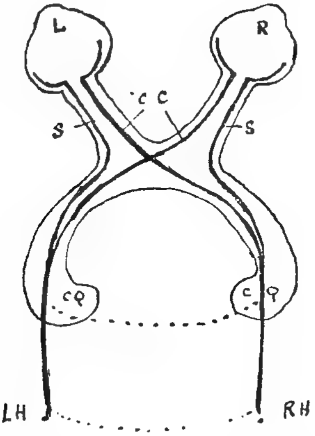


FIG. 74.—Diagram of the course of the fibres in the human optic tracts. R, right eye; L, left eye; C, C, crossed tracts; S, S, straight tracts. The crossed tract of the right eye, coming from the nasal half of the right retina, passes through the chiasma to run to the left hemisphere in company with the straight tract of the left eye, coming from the temporal half of the left retina. The dotted lines suggest fibres crossing over between the corpora quadrigemina (CQ), or further back towards the cortex. LH, RH, left and right hemispheres.

The next diagram deals with tactile impressions from sources situated behind the brain, and we can see how in every case the strongest waves the brain would receive would be those crossing to the opposite side of the brain (Fig. 75).

Naturally it is to be remembered that our evolving Fish had as an ancestral gift a nervous system somewhat as in

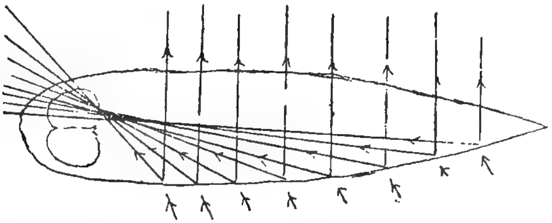


Fig. 75.—Diagram illustrating how tactile impressions behind the brain would demand crossed sensory tracts to conduct them to the brain. If we imagine the evolving primitive Fish to be constantly receiving tactile impressions on the surface of its body at different points, as in the figure, we can see that the main lines of force would be always across the body, and that of those passing in the direction of the brain the strongest would be the ones reaching the hemisphere of the opposite side.

Fig. 61 on page 192, and that this plan would, as it were, only require modification in its attempts at realisation. But our suggestion is that the method of this modification

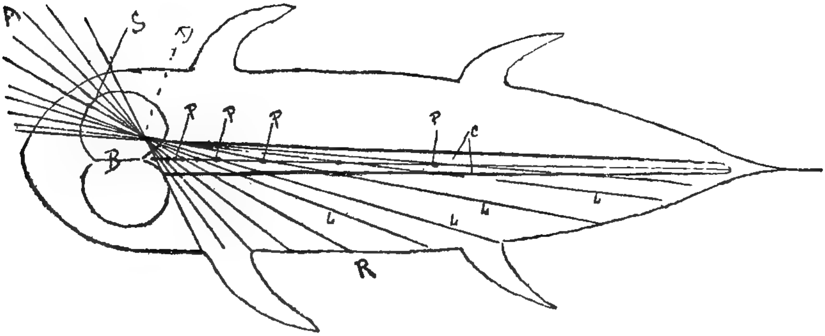


Fig. 76.—A suggested explanation of sensory decussation in the cord and medulla. C, cord; P, P, points of decussation in the cord; D, great decussation in the medulla; S, the spreading out on the cortex of the brain; L, L, lines of force whose direction may have determined the course of the nerve-tracts; B, brain.

was fundamentally due to the impressions which the evolving organism came habitually to receive. Is it not possible that the decussation of force lines as pictured in the last figure was the cause of the great decussation of the sensory tracts occurring in the Fish and higher vertebrates in the region of the medulla, and also of the spreading out of these to reach the cortex of the brain ? Might it not also explain the minor decussation at intervals all up the cord, as suggested in Fig. 76 ?

From this figure it is clear that a painful impression at, say, R would be equivalent to attraction towards A, the continuation of the line from R, and the proper motor response would be an extra strong drive of the fins on the same side as R ; the motor impulse coming down a crossed motor tract. If R were a pleasant impression, the reverse would be the case.

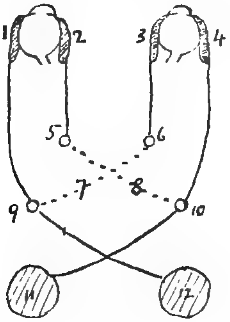


Fig. 77.—Diagram of the crossed motor tract which causes the human eyes to move towards a source of attraction on the right. 1, left external rectus ; 2, left internal rectus muscle ; 3, right internal rectus ; 4, right external rectus ; 5, 6, nuclei of left and right 3rd nerves ; 7, 8, tracts from 6th nerve to opposite 3rd nerve ; 9, 10, nuclei of left and right 6th nerves ; 11, 12, left and right cortical centres. A motor impulse from 11 would cross over to 10 and cause 2 and 4 to contract, the eyes thus moving to the right where the attracting object was situated. There is really double decussation here. (After Swanzy.)

With regard to sight sensations, in order that the eyes turn towards the source of light a crossed motor tract would also be necessary as the complement of the crossed sensory optic tract, and the next figure shows how this occurs in the human brain.

Crossed motor tracts here produce the expected result. But if we take the response of fin-movement to bring the body towards the source of light attraction, it becomes apparent that a crossed motor tract leading to a right fin would, if this drove with vigour, cause the Fish to move away from the source. The fin would have to backwater to help in the proper response. Clearly the brain is such a complicated organ, and its communicating paths so imperfectly known, and the body's responses so multiple and complex, and mutually influential, that no more than superficial suggestions have been offered above. But our main point remains to be emphasised, namely, that the avoidance, or correction, of deviation in fish locomotion would demand a bilaterally symmetrical nervous system, and that local habitually acting sources of attraction and repulsion calling for undeviating response would be the ground factors in the production of the duplicate brain.

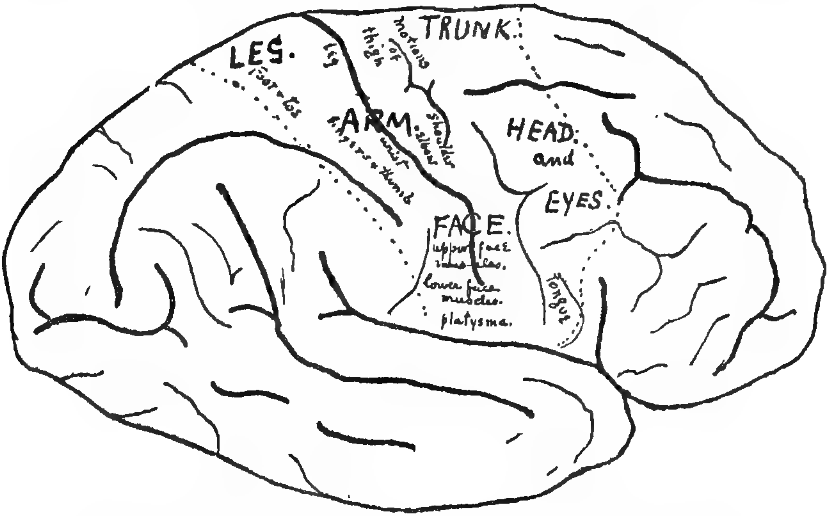


FIG. 78.—Diagram of fissures, convolutions, and functional areas of human right hemisphere. (After Jacobson and Steward.)

The bilateral symmetry of birds and quadrupeds has clearly been derived in the first place from the primitive Fish. Like the fish, the typical bird is able to leave the surface of the earth and move through its surrounding atmosphere in spite of the direct pull of Gravity; the difference being that the atmosphere of the bird is air, and wings take the place of lateral fins. On the whole, however, Gravity is victorious, and the larger part of the bird's existence is spent on the earth, or on the water. For moving on the surface of the earth the bird has two symmetrical legs, and as in the case of the wings this symmetry reflects the call for undeviating responsive movement towards any point of attraction, or away from any source of repulsion.

In the case of quadrupeds, it may be said that, with the exception of such as live in trees or live an amphibious existence, the only possible form of deviation is lateral—to the right or the left. The body-mass is, as it were, slung on four upright supports, symmetrically paired, with the abdominal contents invariably sagging downwards in the middle towards the earth's surface.

Man is after all but a quadruped who has learnt to go about constantly on his hind legs, and moving as he does on the earth's surface the deviation he has to avoid or correct is lateral. It is interesting to note that the situation of the cortical centres in man's brain tend to confirm the supposition already mentioned, that the direction of habitual force-lines impinging on the evolving primitive Fish could determine the direction of the main nerve-tracts. For if we turn to Fig. 76, and compare it with the next below, we can see that the lines from the region of the posterior limbs, or fins, pass to the mesial and anterior part of the opposite hemisphere; those from the anterior limbs to a point farther out and behind; while any from the head region would pass to a still more external or posterior part of the cortex.

CHAPTER XXVI

ALTERNATION OF GENERATIONS. PARTHENOGENESIS

Alternation of Generations is usually defined as the appearance in any Individual of two kinds of component organism, actually or virtually independent, one of which is sexless and whose chief functions are those of nutrition or support, while the other develops sexual organs with a view to the perpetuation of the species. But while such a definition is correct as far as it goes, it only describes one limited aspect of a phenomenon exhibited in all living Individuals. For our contention is that Alternation of Generations in the generally accepted sense is simply one aspect of the everywhere-obtaining Alternation of Intermediate and Terminal Cycle-stages.

In itself the term "Alternation of Generations" is not appropriate to the phenomena exhibited, for these take place within the Individual, which is one generation and no more; nor are the asexual organisms produced by any act of generation, but by gemmation or fission. This is obvious if we turn to the alternation as it is displayed by a hydrozoal colony.

The development of the normal Individual is for the restoration of the lost personalities of the originally combining elements, and it is just because this restoration is a very gradual process that cycle-stages of the Individual in which it is going on can be recognised, to contrast with the terminal or sexual stages marking restoration.

Naturally, where the Individual develops in cellular discontinuity the sexless or intermediate cycle-stages are evanescent, and the alternation is not strikingly apparent; but where Continuity unites and arrests definite numbers of cell-stages of the Individual to form zooids or higher continuous cell-multiples, which may be free or may remain attached to each other, the alternation may attract attention. For the arrest accompanying Continuity here prevents sexless or intermediate cells, or their multiples, from ever becoming sexual, and these thus remain in lasting contrast with the ultimately appearing sexual forms.

Regarding, then, Alternation of Generations as essentially Alternation of Cycle-stages, we might summarise the ways in which it is exhibited in the ascending Individual scale.

I. *The Discontinuously Multicellular Individual.*—Fig. 79 represents diagrammatically such an Individual developing as so many sexless unicellular organisms, each an evanescent intermediate stage in the cycle, and drawn as a number of "o's." When this Individual is theoretically complete it is composed of nothing but gametes (x, x).

o o o o o		x x x x x x x
o o o o o	becomes	x x x x x x x
o o o o o		x x x x x x x
o o o o o		x x x x x x x plus—

FIG. 79.

For example, an examination of the blood of a person affected with malaria will, in the early days, reveal only amœboid or "sexless" forms of the parasite; but at a later date gametes or sexual forms may be discovered. The former are stages on the road to gamete production, and become gametes in their future product. Discontinuity is here the factor which, other things being equal, allows this to occur. When the Individual is truly complete, the intermediate or "sexless" stages should all have vanished, and no alternation would be observable.

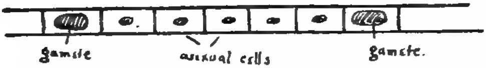


FIG. 80.—Diagram of filamentous growth (as in Spirogyra), exhibiting cellular alternation of cycle-stages.

II. *The Filamentous Individual.*—Here there is the same alternation as in I, but as there is filamentous Continuity, and as a result, temporary cell-arrest, the phenomenon is more clearly observable; a given filament displaying at the same time sexless intermediate cells and sexual cells or gametes (Fig. 80).

III. *The Cœnocytic Individual.*—In this no less than three forms of the alternation may be offered. (*a*) Protoplastic; there being protoplasts which, arrested on the road to become sexual, contrast with forms which as gametes are sexual. (*b*) Cœnocytic; whole sections of mycelium containing sexless protoplasts contrast with sections which, as *gametangia*, contain gametes. (*c*) Mycelial; as where an original mycelium produces only spores, and the mycelia arising from these produce gametes.

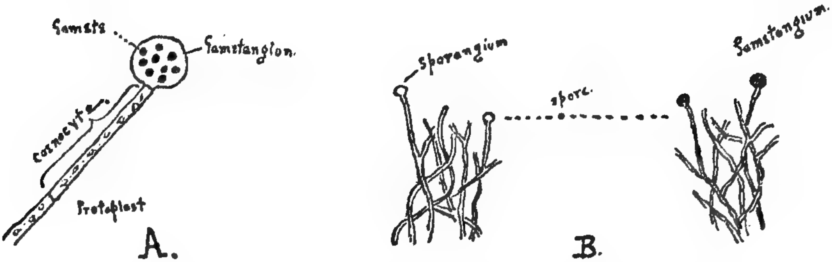
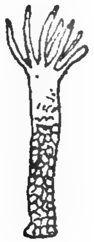


FIG. 81.—A, Protoplastic and Cœnocytic alternation of cycle-stages; the protoplasts alternating with the gametes, and the cœnocyte with the gametangium. B, Mycelial alternation, the mycelium bearing spores alternating with that producing gametes.

IV. *The Discontinuously Zooidal Individual.*—In such (e.g. Hydra), there is the alternation of the sexless body-cell with the sexual element. But in addition there is zooidal alternation. But as the zooids are discontinuous, the sexless condition is temporary. It is the alternation of the discontinuously multicellular Individual in a higher form (Fig. 82).

V. *The Continuously Zooidal Individual.*—Here also the alternation is cellular and zooidal; but as many zooids are permanently arrested owing to Continuity, and adaptation to special function, the sexless and reproductive zooids form a striking and enduring contrast, heightened by the peculiar structure of the latter. Frequently the reproductive entity is a megazooid and not a zooid (Fig. 83).



becomes

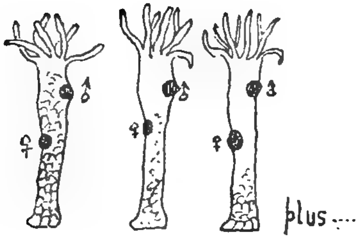


FIG. 82.—Alternation of cycle-stages in the Discontinuously Zooidal Individual.

VI. *The Discontinuously Megazooidal Individual.*—Owing to discontinuity, the sexless megazooids all ultimately become sexual (as in I and IV). The alternation is cellular and megazooidal; the example being *Aurelia* (page 103).

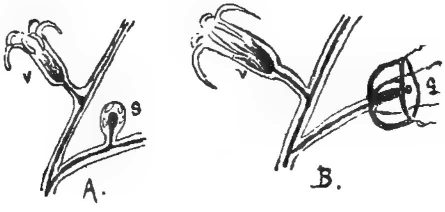


FIG. 83.—Alternation of cycle-stages in the Continuously Zooidal Individual. In A, the vegetative zooid, *v*, contrasts with the sexual zooid, or sporosac, *s*. In B, the contrast is with a sexual megazooid, or gonophore, *g*.

VII. *The Continuously Megazooidal Individual.*—The alternation here is sometimes as in VI; but in certain compound corals, such as *Alcyonaria*, some megazooids are permanently arrested for special function and never become sexual; the phenomenon being very striking.

VIII. *The Radiate Individual.*—The only alternation is cellular, the Individual being one cellularly-continuous organism.

IX. *The Discontinuous Segmental Individual.*—In what might be called a typical case, such as *Aphis*, the alternation is generally similar to that in I, IV, and VI; that is, it is cellular, and also the alternation of a sexless with a sexual cell-multiple. The discontinuity of the "neuter" aphis would lead one to suppose that were life prolonged enough, repeated "gemmation" would end in the production of sexual elements. But the presumably permanent arrest of the neuters makes these contrast strikingly with the final sexual forms. The case of the honey-bee is peculiar, for there are three classes of Bee-Individual. In one of these, the sterile worker, there is no alternation of any sort, because no sexual elements are produced. In a second, the occasionally drone-producing worker, this insect alternates with the sexual males formed from it. In the drone itself there is cellular alternation. In the third, the queen-bee Individual, the somatic cells of the queen alternate with her true ova, and the somatic cells of the drones she produces alternate with the drones' male elements.

X. *The Continuously Segmental Individual.*—Cellular alternation alone is exhibited. It is true that certain segments contain no sexual organs and alternate with those that do, but owing to close continuity the segment cannot as a rule be strictly delimited. In an organism like the earthworm we might say there was segmental alternation.

In the above sense it is therefore suggested that "alternation of generations" is a phenomenon exhibited in some form in all living Individuals; and that it is truly the alternation of intermediate cycle-stages with terminal sexual forms as affected by varying intensifications of Continuity.

PARTHENOGENESIS.

Parthenogenesis has been defined as the production of new organisms by virgin females, without the intervention of males. Owen, who originated the term, gave it, however, a wider meaning, and applied it to all processes of gemmation exhibited by sexless beings or virgin females. In our opinion Owen's definition is to be preferred, though we would modify it to "all processes of gemmation by temporarily or permanently sexless beings which are always parts of Individuals."

This is to widen the definition in one direction and to narrow it in another, making it include phenomena which are not usually held to be parthenogenetic, and ruling out the development of the unfertilised female element as not true parthenogenesis. Many, no doubt, would rule out the former and include the latter, but this apart, one thing is obvious, that the term should not be so widely applied as to embrace two such distinct phenomena as the unaided development of the unconjugated gamete or unfertilised ovum, and the production by gemmation of a Hydra zooid, a coral megazooid, or an aphis.

And for this reason: that in the first cases we are dealing with the abnormal origination of a *new Individual*, whereas in the second the matter is one of the production of a *further portion of an Individual.*

The gamete is a sexual element, but the cell from which arises a neuter aphis can surely not be classed as such. Were it to be so, then each successive neuter aphis would be a new Individual of unusual sort and represent a new generation. We would, in fact, limit the application of the term "Parthenogenesis" to the production of new organisms from cells which are not terminal or sexual cells, but sexless intermediate cells; the producer of the new organism being part of an Individual, and its product (and antecedent producers, if any) the remainder.

The development of an unconjugated gamete or an unfertilised ovum is abnormal, and where, as with certain Algæ, it occurs in Nature, one is inclined to presume that accidental special factors have interfered to upset the equilibrium of the gamete in the absence of the specific upsetter. Certainly, in the classic experiments of Loeb this was apparently the case.

Loeb found that solely by pricking with a very fine needle the unfertilised ovum of the frog he could make development start and proceed in an apparently natural manner. The unfertilised ova of the sea-urchin can also be made to develop by exposing them to the action of chemical solutions. As in both cases the development of a true sexual element occurs, in our view this is not parthenogenesis; but apart from this it is justifiable to say that in neither case was there unaided development. We might well say that the matter was one of "non-specific fertilisation."

The needle enters the ovum and withdraws; it leaves none of its substance in the ovum, but it *does* something, and the presumption is that the results which follow are due to the physical effects of the puncture. The main effect is the breach of Continuity, and it seems possible that, in accordance with the general rule, the breaking of Continuity by causing release from Arrest is responsible for the unexpected development of the ovum.

The reactions of the growth-cycle have terminated in the ovum which is in a state of arrest in that it is in equilibrium. Repulsion, the force causing and sustaining disequilibrium, is not active in it. And on the theory that the immediate result of normal fertilisation is the loss of sexual-element "identity" or internal "plan," we believe that ensuing development is due to the shattering of this "plan" and the production of disequilibrium, through active force of Repulsion. There is, we might say, living chaos followed by creation, all subsequent growth being for the reproduction of the lost "plans" and lost specific equilibrium.

It is conceivable that the breach of Continuity effected by the needle in the frog experiment is just an abnormal way of producing the results of fertilisation, and that in the same way may be explained the action of chemicals on the egg of the sea-urchin. The resulting Individual is clearly abnormal, and it is difficult to understand how it could show any except female sex, for no true male element has been concerned in the fertilisation. Certain recent experiments, however, would appear to show that male tadpoles can result from Loeb's experiment. If fully confirmed, this will upset many preconceived ideas.

But to repeat; "non-specific fertilisation" clearly starts a new *Individual*, whereas Parthenogenesis never does, in our opinion; the parthenogenetically produced organism being always *part* of an Individual.

Parthenogenesis would appear to go hand in hand with Alternation of "generations," as previously defined. All gemmation is based on intermediate cell-division, and one division-half may be said to bud the other just as a yeast cell buds a small part of its substance. It is varying forms of living Continuity which, in Individuals developing as separate cell-multiples, confuse the recognition of the common underlying principle. Thus, it is suggested that a succession of unicellular organisms ending in gamete-formation has its multiple expression in a succession of asexual zooids or of neuter aphides ending in sexual forms. We regard cell-division as fundamental Parthenogenesis.

When the Individual is discontinuous and its cells independent, or when we are dealing with the growth of a tissue, Parthenogenesis is not obvious; but when a division-result leaves a tissue of an organism to repeat the organism's structure the phenomenon is striking. Yet all is but a matter of what form of Continuity is imposed on the products of cell-division. Thus, while the Fern spore is in many ways different from the parthenogenetic cell of an aphis, still both are similar in that they are intermediate cells on the evolutionary road leading to sex, and link together cell-multiples of the Individual.

The parthenogenetic cells of the queen bee are not, in our opinion, ova in any sense, but rather "animal spores," whose further development makes in the drone a male gonophore of sorts; just as the fern spore becomes a hermaphrodite gonophore. The cells destined to become drones could not, we believe, be fertilised by male elements even if the queen bee allowed it. Are they not certain cells evolving on roads to become male elements when others have already evolved to become female elements? Is it not that the former have to finish the road outside the queen's body, while the latter manage to do this inside her body?

CHAPTER XXVII

KARYOKINESIS

The phenomena of Karyokinesis are essentially exhibitions of Force of Attraction and Repulsion in action within the confines of the enlarged cell, and it is owing to the act of mass-repulsion finishing the process of division that continued growth, and advance towards the restoration of the sexual elements, are made possible. The restoration is a very gradual process, judging from the large number of division acts preceding it, but while this is so, there seem to be certain definite stages attained on the road which are indicated by variations in the nuclear division-phenomena exhibited. Thus, in the main road of the growth-cycle three forms of Karyokinesis can be observed :—

I. Karyokinesis with double chromosomes.
II. Karyokinesis with single chromosomes.
III. Karyokinesis as exhibited in the extrusion of Polar Bodies.

Karyokinesis with double chromosomes may be described briefly as follows :—

The nucleus of the cell about to divide loses its retiform character and takes the appearance of a thick convoluted chromatin thread, coiled compactly (Fig. 84, *c*). The nuclear membrane and nucleolus disappear. The convoluted thread disentangles itself to a certain extent, and breaks into a number of short lengths (the number being fixed for the organism in question), each of which becomes bent to form a loop. The loops arrange themselves in the equatorial plane of the cell with their free ends pointing outwards, forming thus a species of rosette. This is called the "monaster" stage (Fig. 84, *e*).

Meanwhile at the opposite poles of the cell a point defines itself as a centre from which fine lines radiate to the equator, forming the so-called "spindle" (Fig. 85). Each loop of chromatin then splits longitudinally, and the resulting halves retire to opposite poles of the cell along the lines

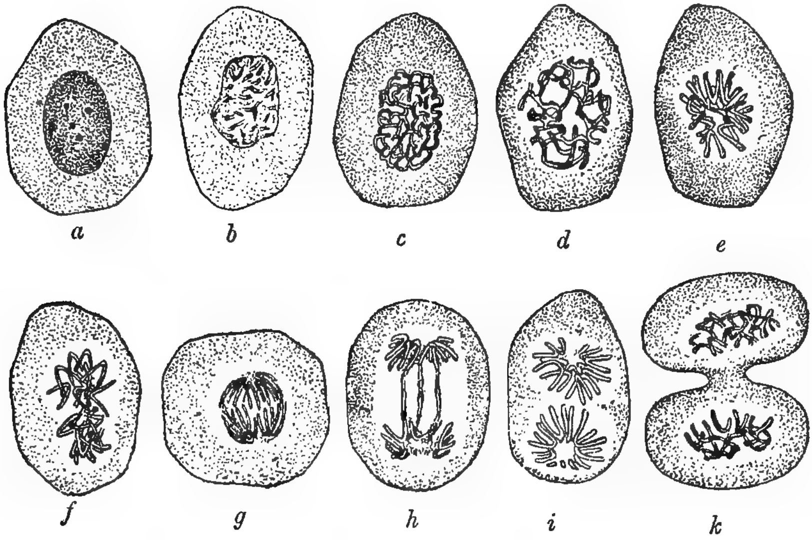


FIG. 84.

of the spindle, so that the cell now contains two rosettes, composed of loops whose free ends point outwards (Fig. 84, *i*).

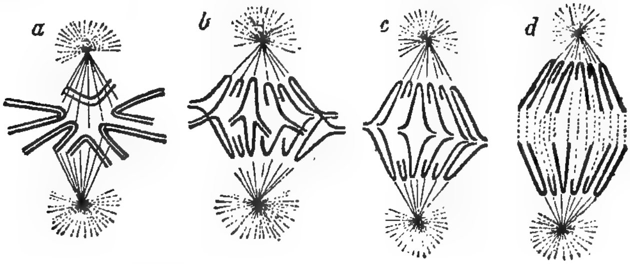


FIG. 85.

This is the "dyaster" stage. The protoplasm of the cell then divides equatorially; the rosettes of each resulting cell revert to the appearance of the original nucleus; and finally a nucleolus appears in both cases.

The above is the condensed description of karyokinesis with double chromosomes, each loop splitting longitudinally into two.

In karyokinesis with single chromosomes the process exhibited is the same, except that the loops do not split. In the first variety each dyaster has the same number of chromosomes as the monaster; in the second each dyaster has half this number. For this reason "reduction of chromosomes" is said to occur when splitting ceases to take place.

The process of cell-division has, in effect, three stages: the nucleolar, the nuclear, and the protoplasmic. In the first the nucleolus divides, and as a result each half then takes with it the nuclear substance which it controls; that is, the nucleus then also divides. Then when the nuclear halves have segregated, each draws to it the protoplasm controlled by, or in sympathy with it.

The whole process is clearly an exhibition of alternating attraction and repulsion. Cell enlargement as a whole is due to attraction; and it induces or is followed by the mass-repulsion of cell-division. The nucleolar division with which the process starts is due to repulsion, and each repelled half would seem by its attraction exerted on the nuclear chromatin to induce the repulsion causing nuclear division. In the same way it would appear that the mutual repulsion of the protoplasmic "halves" is induced by attraction towards the opposing nuclear halves. Thus, the suggestion offered is that to the attraction exerted by the mutually repellent nucleolar halves nuclear and protoplasmic division are ultimately due.

In support of this suggestion the following points may be noted:—

There is the initial disappearance of the nucleolus, and at the same time the appearance at opposite poles of the cell of two achromatic points. It is not unreasonable to conclude that these two achromatic points are the "division-halves" of the enlarged true nucleolus, whose position during the growth of the cell was indicated by a special area of chromatin concentration, capable of demonstration by staining.

Between the two points the spindle takes shape, and we can recognise in it radiating lines of attraction leading towards the opposing points. That is, the spindle is not a structure; in fact, it is not properly a "spindle" at all. Its lines are surely not anything else than the arrangement of protoplasmic granules along the force-lines leading to the poles—a purely temporary phenomenon. Further, the steady divergence of the spindle lines towards the equator

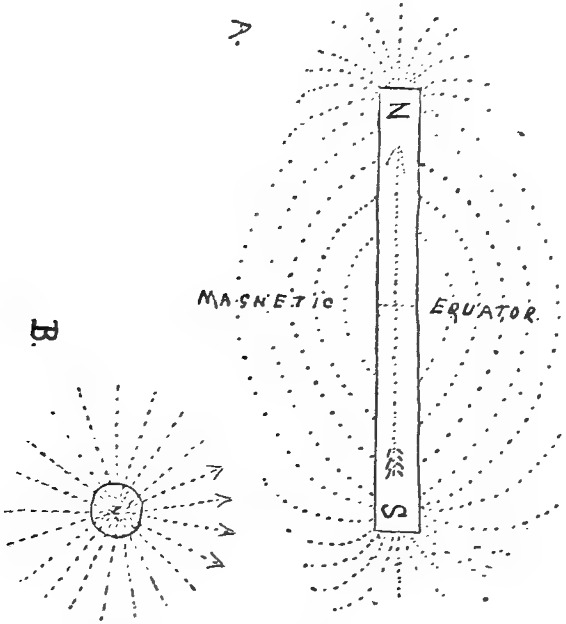


FIG. 86.—A, lines of magnetic force of a bar magnet. N, north pole; S, south pole. B, the lines issuing from the surface of the north end of a cylindrical bar magnet.

of the cell would prove, as is shown above, that they are not continuous from one pole to the other, but are indications of mutual polar repulsion.

Lying suspended between the achromatic poles is the nuclear chromatin, stationary because attracted towards *both* by reason of its containing blended closely together "elements" peculiarly attractable to the opposing poles. Thus the lines of mutual polar repulsion are also the lines of attraction acting on the nuclear chromatin. In other words, it is suggested that we have in the spindle what might be termed a "magnetic field," and in the achromatic poles two magnetic points of "similar polarity."

This can be made clearer by reference to the well-known experiment of iron filings in a magnetic field (Figs. 86, 87, 88). Here the lines of magnetic force of a bar magnet have been made evident by means of iron filings.

If two bar magnets like the above be brought near each other, so that the south pole of the one faces the north pole of the other, the two will experience strong mutual attraction, and the force lines will pass directly from the north pole of the one to the south pole of the other. By means of iron filings this can be made evident, as in Fig. 87, which shows the magnetic field between dissimilar poles.

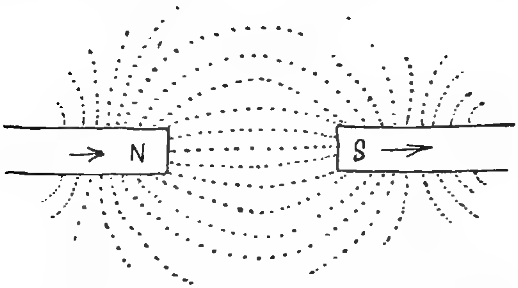


FIG. 87.—Diagram of the lines of force between dissimilar magnetic poles.

But if the north pole of one magnet be brought to face the north pole of the other, there is no attraction, but repulsion, and the magnetic field as made visible by iron filings takes quite a different appearance (Fig. 88).

Here the lines of magnetic force issuing from the poles antagonise and repel each other. There is no passing across, but where they meet a sharp angle is formed. The lines do not lie in one plane as the figure suggests, but radiate in all directions from the poles. Thus, the diamond-shaped space is really of cubic dimensions, being enclosed by a false "spindle."

In karyokinesis the achromatic nucleoli appear to act like two little magnets with *similar* poles facing; the resultant lines of opposing force being made evident by protoplasmic granules, in much the same way as occurs with iron filings in the field between the opposing similar poles of two steel bar magnets.

And now if we imagine an object, composed of two classes of elements closely blended together, one of which is peculiarly attractable to one pole and the other to its opponent, to be placed in the equator of the magnetic field; and if we take it that the "elements" are evenly represented and that the poles attract with equal force; then it is clear that the object would remain suspended, as it were, at the equator.

But if in addition we suppose that though closely blended the two varieties of "elements" were free to move within the confines of the object, then the result would be a determination of one variety to the aspect of the object facing one pole, and of the other variety to the opposite side. This is represented very diagrammatically in Fig. 89.

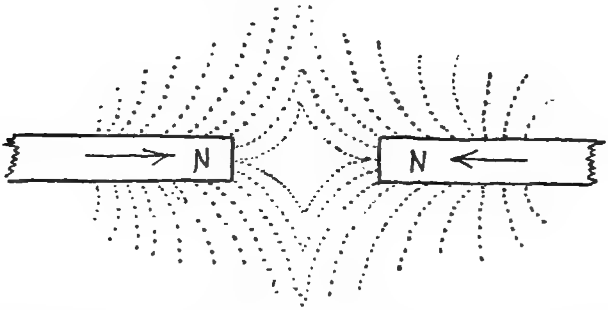


FIG. 88.—Diagram of the magnetic field between similar poles.

It is suggested that this imaginary experiment supplies us with an explanation of the phenomena of karyokinesis, and that although the exact nature of the nuclear separation process must remain a mystery, it is according to the principle illustrated that chromosome splitting occurs.

It is also possible to explain roughly on the same lines the nuclear phenomena preceding chromosome splitting. The nucleus is not a flat object, but a more or less spherical one; and it is not unlikely that the first effects of achromatic polar attraction would be that the chromatin would seek to arrange itself in the lines of attracting force. That is, that owing to the steady attraction along these lines the chromatin would gradually take the form of a convoluted thread.

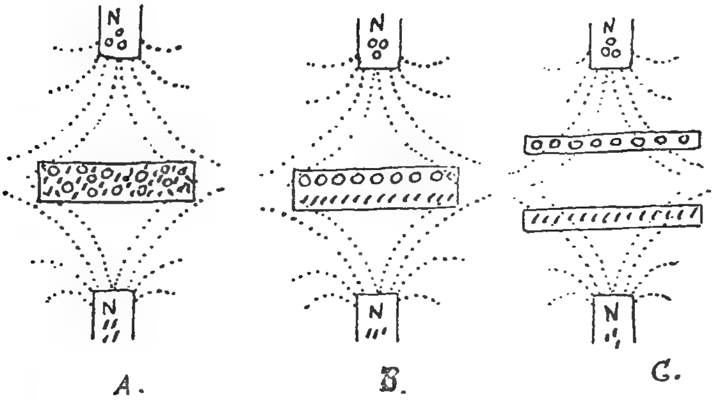


Fig. 89.—Illustrating a theory of chromosome splitting. In A the object remains suspended between the opposing poles, each of which attracts its peculiar subject "elements." As a result of this attraction the condition in B would presumably occur, and ultimately a separation, as in C, with withdrawal in opposite directions.

The achromatic poles being equal and similar, one half of the chromatin would lie on one side of the equatorial plane and the other half on the other side; so that a situation diagrammatically illustrated as above would result (Fig. 90).

Fig. 90.—Diagram illustrating how the nuclear chromatin could become a convoluted thread, by attraction along the lines leading to the opposing poles.

The "pull" exercised in opposite directions would in time produce a continuous looping as in the above figure, and the equatorial plane would be the situation where division would be expected to result from the continued pull (Fig. 91).

Without being able to explain why, we must presume that the loops when formed are still attractable to both poles, for they remain at the equator. (We are speaking of double chromosome karyokinesis.) And we would suggest that the "monaster" is due to the loops adjusting themselves to the radiating planes of force-lines which meet at the equator, somewhat as represented in Fig. 92. This is the position preceding splitting.

Fig. 91.—A further stage of Fig. 90. The convoluted thread broken at the equatorial plane, looped chromosomes being the result.

In single chromosome karyokinesis the chromosomes do not split, but as soon as they are formed one half retires to one pole, and the other half to the other.

After the dyaster stage has been reached the cell divides; the chromosomes retire to their special poles, and do so along the lines of attracting force. As the achromatic poles induced equatorial nuclear division, so probably do the chromosomes induce equatorial protoplasmic division.

The cell has now divided, and is controlled by a single nucleolar centre. This gathers all around it in its efforts to restore equilibrium. Thus, the chromosomes fuse to form a new nucleus, and the nucleolus indicates its governing position by a special concentration of chromatin around it.

We do not know why at a certain stage of growth-cycle advance the chromosomes cease to split, though it is clearly an indication that the cycle is about to terminate in sexual elements. But one might perhaps venture the suggestion that as the growth-cycle starts with a fusing of two distinct elements, and as their identities, though lost, are potentially present in the fertilised ovum, a point in cell multiplication must be reached sooner or later when there is "divergence." That is, when, through the institution of what might be called "predominance," a given cell on the road leading to sex is destined to give rise in its product to one class alone of sexual element. We do not say that this point coincides with chromosome reduction, but it is a faint possibility.

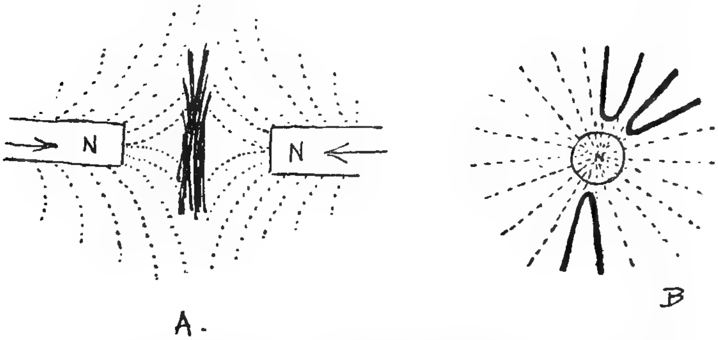


Fig. 92.—A, diagram of chromosomes lying in the equatorial plane; B, showing the limbs of the loops adjusting themselves to the force-planes leading to the pole.

In some plants the reduction occurs with the first division processes of the spore, the chromosomes of the gametophyte never splitting. In other forms of plant life where no separation into sporophyte and gametophyte obtains, reduction does not take place until the sexual elements are about to be formed. In a general way reduction suggests a simplification in the mysterious processes leading to the restoration of the lost identity of the sexual element.

The Extrusion of Polar Bodies.

Extrusion of Polar Bodies may be described as follows:—

Immediately before actual fertilisation—though the spermatozoon may have entered the ovum—the germinal vesicle, or nucleus of the ovum, begins to lose its definite form and to move towards the periphery of the ovum. Gradually the germinal spot and vesicle disappear, and two "star-like" arrangements united to form the poles of a spindle make their appearance in connection with the germinal vesicle, and one pole turns round till it comes in contact with the surface of the yelk and is gradually separated by constriction from the other half, constituting what is called the "first polar body."

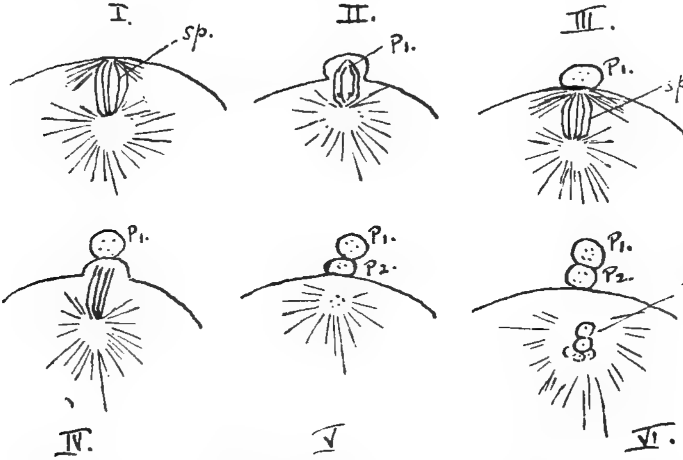


Fig. 93.—Formation of Polar Bodies in *Asterias glacialis*. I. The nuclear spindle approaches the surface. II. One half of the spindle is projected in an elevation. III. The elevation is separated as the first polar body, P1, and the inner half of the original spindle becomes again a complete spindle. IV. This spindle is protruded to half its extent. V. The protrusion becomes the second polar body, P2. VI. The deep part of the spindle becomes the nucleus, *n*, of the ovum. (After Hertwig.)

"The remaining half of the spindle is again converted into a complete spindle, and a second time one half is projected from the surface of the yelk and separated to produce the second polar body. From the half of the spindle which remains within the yelk after the extrusion of the second polar body, a small nucleus is formed which retires towards the centre of the yelk and remains as the nucleus of the unimpregnated ovum, the female pronucleus of *V. Beneden*, a structure comparable in size rather to the germinal spot than to the germinal vesicle." (Cleland and Mackay.)

After polar extrusion the final nucleus of the ovum is ready to unite with the male pronucleus; this latter being what remains (it is reasonable to suppose) after the spermatozoal head has itself performed what seems to be a form of polar extrusion. For on entering the ovum the spermatozoon first of all loses its tail, and then a small globule, "the seminal granule," is discarded by what remains. The result is the male pronucleus. The protoplasm surrounding this then assumes a markedly radiating appearance, and the male and female pronuclei approach each other, fusion takes place, and fertilisation is complete.

Polar extrusion apparently represents the second modification of karyokinesis occurring in the growth-cycle, the first being reduction of chromosomes. For the phenomena seem clearly to be karyokinetic. Achromatic poles oppose each other and draw to themselves their subject chromosomes, though this is done in a simpler manner than in ordinary karyokinesis. There is no monaster formation, and apparently no loops are formed, but straight rods which lie between the poles in the lines of attraction revealed by the spindle, and which divide transversely at the equatorial plane.

When the two pronuclei approach each other a new kind of spindle formation occurs along the lines of mutual attraction. It is exactly the opposite of that exhibited in karyokinesis, for the pronuclei represent, so to speak, *dissimilar poles*, and the lines of force pass directly without break from the male pronucleus to the female, exactly as represented in Fig. 87 of two *dissimilar* magnetic poles facing each other.

The true significance of polar extrusion is not known, but it is reasonable to regard the phenomena as those of two final acts of cell-division. It is not equal division in as far as the ovum's protoplasm is concerned, and suggests the discarding of an "impurity," necessary before complete restoration of the female sexual element. Perhaps this "impurity" may represent remaining traces of the attempted restoration of the original male element which helped to start the Individual cycle.

CHAPTER XXVIII

ABNORMAL GROWTH. TUMOURS

Up to the present time tumour formation has not been satisfactorily explained, in spite of the enormous amount of work which has been done on the subject. It is quite probable, however, that a proper understanding of abnormal growth will not be arrived at until the fundamental processes of normal growth are fully understood. No doubt there are many who believe that at any moment in these days a definite specific agency responsible for the formation of tumours may be discovered, but while this may possibly happen, it does not seem probable.

The question has really two aspects, one being the nature of tumour formation, and the other the factor or factors inducing it, and the object of the following remarks is to suggest that all neoplasms are exhibitions of one morbid process which can be excited by several different hostile agencies.

Tumours are divided into two main classes—Simple or Innocent tumours, and Malignant tumours : this is a clinical classification based on the effects produced by them in living organisms. Tumours are also classified as Typical or Atypical, according as their structure conforms to that of normal tissue or not. If the tumour tissue is similar in character to that in which it arises, it is said to be homologous ; if of a different type, it is described as heterologous. Thus a lipoma, or fat tumour, growing subcutaneously, is typical, innocent, and homologous, while a cartilaginous tumour arising in bone is innocent, typical, and heterologous. A cancer or sarcoma, on the other hand, no matter where it arises, is malignant, atypical, and heterologous.

A tumour shows its innocence in that, apart from secondary trouble the result of increasing size, pressure effects, inflammation, etc., it is not dangerous to life but remains a local abnormality. It does not give rise to tumours in other parts of the body. Its innocence is frequently emphasised in the formation of a distinct capsule which shuts it off from the surrounding tissue, though at other times such a capsule is absent, and any demarcation between normal and tumour tissue difficult to recognise. Examples of innocent tumours are: Lipoma (composed of fat tissue); Fibroma (of fibrous tissue); Chondroma (of cartilage); Osteoma (of bone); Myoma (of muscle tissue); Neuroma (of nerve tissue); Adenoma (of glandular tissue).

The Malignant tumour does not remain localised, but infiltrates the surrounding tissues, displacing and destroying their cells; this is termed "local malignancy." But in addition the growth almost always exhibits "general malignancy" in that it gives rise to other tumours, similarly malignant, in other parts of the body. The two main classes of malignant tumours are the Sarcomas and Carcinomas; the former originating in connective tissue and to some extent resembling it in structure at times, while the latter develop in one of the many situations where epithelium is present in the body.

It is to be noted that innocent tumours may, though rarely, develop malignant characters, and also that a tumour with all the microscopic appearances of malignant nature may behave like an innocent one.

The two chief factors commonly held to predispose to tumour formation are Age, and Injury in some form or another.

In the evolution of the living growth-cycle two sexual elements unite and lose their identities, and all subsequent cell-multiplication composing the Individual is the wonderful "reaction" which must end inevitably in the multiple restoration of the lost sexual-element identities.

Where the cells of the Individual are produced in *discontinuity*, the theoretically complete Individual ought to be an enormous number of gametes; but where the Individual's cells are produced in close *continuity* this is far from being so. For as part of the Individual develops on a main evolutionary road, there is an accompanying side-evolution of cell-species for the performance of special function. And these species when fixed, or fully differentiated, represent so many arrested evolutionary lines of the Individual, repeated cell-multiplication never in their case ending in the restoration of sexual elements.

It is through this fundamental interpretation of the living growth-cycle that a theory of tumour formation can be offered capable of embracing tumours innocent and malignant. This is to the effect that the problem centres in ARREST, and RELEASE FROM ARREST.

Fundamentally, Arrest may be UNNATURAL, or NATURAL.

Unnatural Arrest is the premature arrest of cells of the developing Individual, and it may occur in two forms. (1) At a very early stage of development, long before tissue differentiation has occurred, or the fixed cell-species of the body have evolved. (2) At a later stage, when full differentiation is about to be accomplished. It represents the absolute arrest of cell multiplication, and also of given lines of cell-species evolution.

Natural Arrest, on the other hand, is the normal arrest of cell multiplication which occurs when maturity is reached. In one sense it is not absolute, for all through life cell-multiplication goes on in most tissues to make good damage or loss, and for the needs of the organism. But in the sense that, in the normal body, this multiplication is rigidly controlled and limited for the preservation of the Individual's size and personality, we may say that cell-multiplication in contrast with that during development is arrested. At the same time, naturally arrested tissues are composed of fixed cell-species which as species are absolutely arrested, and under normal control cannot change their characters. Thus a fat cell can only become two fat cells when it divides.

Given, then, these forms of Arrest, it is obvious that were the controlling or arresting influences removed different results would follow—different types of growth abnormal and unprovided for in the body; all, however, would be similar in the selfish "individuality" they manifested.

TUMOURS WHICH ARE THE RESULT OF ESCAPE FROM UNNATURAL ARREST.

1. Where the Arrest was comparatively late in application.

Let us suppose that in a certain region of a developing embryo cell-differentiation from mucous tissue into fat tissue was about to commence, and that several of the cells were unnaturally arrested and remained isolated amidst the multiplying evolving fat cells. On the attainment of maturity the normal fat tissue in the region mentioned would consist of cells naturally arrested, while in their midst would be those unnaturally arrested, both as regards multiplication and species-evolution.

If now these latter cells started to multiply, their product would be unexpected, for the lack of their product earlier in the life of the Individual would have been made good by the extra proliferation of the unarrested cells.

The new growth would now try to fulfil the destiny originally potential in the unnaturally arrested cells, but would find no place for itself in the fully developed body-plan ; and as a result an innocent tumour would develop myxomatous or fatty in nature, or it might be exhibiting both characters, according to whether the unnatural arrest preceded or coincided with fat-tissue differentiation.

If the latter was the case, the tumour would be a lipoma with fat cells apparently identical to those of the surrounding fatty tissue. In reality, however, the tumour cells would be less highly evolved than the cells of the normal fat-tissue, and presumably only after much cell-multiplication would they become "equivalent" to these. At the same time this multiplication would take place in a mature body environment, and not in that of the developing body, as ought to have occurred.

That the tumour cells are fat cells suggests that their development is controlled as regards character, and it may be that the surrounding environment of normal fat tissue exerts the influence. At the same time it is to be remembered that when the unnatural arrest occurred the destiny of the cells affected was already largely fulfilled. On the whole we may regard such a lipoma as representing the late development of unnaturally arrested young somatic tissue at a time when it is not wanted, and long after its absence has been made good. It is young tissue which arrives late when there is no place for it in the well-balanced cell-republic of the body.

But as regards the *size* the tumour may grow to, two possibilities offer themselves. (1) That the tumour may grow to an indefinite size, being, with respect to multiplication of its cells, completely independent of the balancing restraint imposed on normal tissue. (2) That this complete independence does not obtain, but that the product of the unnaturally arrested cells is only free to multiply till it fulfils its thwarted destiny, or to become the cells it would have become had there been no unnatural arrest. Experience does not lead us to expect that a lipoma after reaching a certain size will stop growing.

The lipoma mentioned is an example of a homologous tumour. One simple and heterologous may be exemplified by a myxoma arising in fat tissue, or a chondroma in bone.

Here—and so far our theory is more or less that of Conheim—we presume the same unnatural or premature arrest to have occurred, but at a slightly earlier stage of development, before fat or bone differentiation had taken place; the release from arrest occurring after maturity. In such cases there may at times be additional evidence of character-control, for sometimes the mucous cells of the myxoma give rise later on to fat cells, or the chondroma may begin to form bone; mucous tissue being the normal precursor of fat, as cartilage is of bone.

In contrast with this, fat tumours have been known to degenerate and produce mucous cells. If this be true degeneration, it must then indicate diminishing control, and conceivably if degeneration went far enough embryonic cell-character would appear and malignancy be exhibited. But the possibility of some mucous cells having been unnaturally arrested along with fat cells must be borne in mind.

It is reasonable to suppose that no single factor is constantly at work in causing the *release* from unnatural arrest. An increase in local blood-supply might perhaps sometimes account for it. Local injury or breach of continuity from various causes, physical or bacterial, could conceivably set free the cells from their unnatural arrest.

Another factor appears to be Age. The majority of tumours generally, and a great number of innocent tumours, appear when the sexual life of the Individual is drawing to a close; and it might well be that at such a time there is a call for the development of any arrested potentialities, or perhaps a weakening of certain inhibiting influences which the normal tissues exercised over the unnaturally arrested cells in previous years. Internal secretion might be involved in the matter in various ways.

2. Where the Unnatural Arrest is applied early in development.

The unnatural arrest here occurs long before tissue differentiation has taken place, and release from arrest produces different results. There is tumour growth, but it is atypical. The supposition is (like Conheim's) that some of the undifferentiated cells of the early embryo, by being shut off or separated from their companions during the infolding of cell strata, or in some other way, find themselves in unnatural or uncongenial surroundings, and become arrested. They are not wanted in their locality, and they miss the growth-regulating and exciting impulses which they would receive if normally situated. Environment is hostile, and they assume, as it were, the characters of resting spores, awaiting better conditions for their further development.

The embryo so affected develops, and in time the organism reaches maturity with its various somatic tissues apparently normal in every respect; yet in a certain one there lies unnaturally arrested or quiescent a little group of early embryonic cells. The body has developed without their assistance, they perform no function, and are not really part of the body except in that they are continuous with it. If these cells escape from arrest when the body is mature or begins to decline, they proceed to multiply actively.

But the product of their division is not typical of any of the body tissues; it has the characters of embryonic tissue; and as cell multiplication goes on there will be no signs of approaching differentiation, for the growth is uncontrolled, and the influences which guided the normal evolution of the unnaturally arrested cells' original companions do not now exist. The body does not expect this new development, and its system of growth-control is in all aspects adapted for mature differentiated tissues. Further, while there is nothing to influence cell-character there is also nothing to restrain the amount of cell-multiplication—in the absence of special accidental factors. The tumour cells are young, and youth will be served; they invade, push aside, crush and destroy the normal tissues which, to all purposes permanently arrested, can offer no competition. The growing mass spreads and infiltrates in all directions; in fact, a malignant tumour develops—in the case pictured, a sarcoma.

Such a tumour represents an organism unlike any occurring in the normal living scale; an organism, *part* of the Individual, and living parasitically on the remainder of the Individual. In it every cell lives for itself, and performs no special function for the good of the tumour, behaving just as if produced in discontinuity.

Viewed as an organism—and it is clearly not a part of the real Individual—the tumour is unique in Nature as an example of cell-growth-in-*Continuity* with not the slightest signs of cell-differentiation. The malignant tumour's Continuity is not therefore true, and normal cell-arrest is not exhibited. This being so, one is justified in supposing that our sarcoma's cells may go on multiplying until some form of gamete is produced. This is only logical, for the original tumour cells are part of the product of the original fertilised ovum, and in the absence of arrest and differentiation they are free to carry on their cycles to the end.

And to carry our suggestion a stage further: the conjugation of the hypothetical "tumour gametes" should give rise to a new tumour similar in characters to the parent growth. Such a new tumour might start to grow alongside of the original one, or "gametes" might be set free into a lymph channel, or into the blood stream and thus be carried to some distance where their conjugation would give rise to a secondary tumour. This would be a potential Individual, whereas the primary tumour would only be a small part of an Individual—the Individual attacked.

These presumptions involve us in a strange state of affairs. The body is attacked by an unnaturally arrested part of itself which has escaped arrest; and this part, owing to the complete absence of control and guidance, develops as an amorphous parasite, capable of forming sexual elements and originating a new tumour as a tumour-Individual. In this connection it seems just possible that the so-called "cancer-bodies" discovered some years ago, and considered by some observers to be parasitic in nature and possibly causal agents of the disease, may be "tumour-gametes."

At the same time, there is no reason to doubt that a primary malignant tumour may give rise to a secondary one by vegetative production, and that tumour cells which are not "gametes" may be separated from the original mass and carried to new situations; a species of transplantation by cuttings.

We may believe that early unnatural arrest does occur in the developing embryo, for congenital moles and warts can be explained in no other way. Moreover, these little masses of unnaturally arrested cells not infrequently escape from arrest and give rise to malignant growths, usually sarcomatous, but at times epitheliomatous.

It will be observed that this theory that benign and certain malignant tumours are exhibitions of Escape from Unnatural Arrest is practically Conheim's theory, and that, like his, it does not explain the origin of all tumours. But Unnatural Arrest is only one form of arrest, and it is with the help of its opposite, Natural Arrest, that our theory is made all-including.

TUMOURS WHOSE ORIGIN IS DUE TO ESCAPE FROM NATURAL ARREST.

Such tumours are the product of cells composing normal differentiated tissues which exhibit the final arrest characteristic of adaptation to special function. They do not seem to arise so spontaneously as the tumours which have just been considered ; that is, there is a more gradual assumption of tumour characters. And our suggestion is that a temporary release from Natural Arrest gradually becomes a permanent and uncontrolled release.

It is common knowledge that a large number of tumours arise in situations where chronic irritation, inflammation, or ulceration has obtained for some time, and where there are no reasons for supposing that any unnaturally arrested cells have been lying dormant. These tumours are invariably malignant in nature, and chiefly arise in epithelial tissue ; this, no doubt, being largely due to the fact that surfaces exposed to chronic irritation are always covered by one or more layers of epithelium. And in this connection it is necessary to recall what happens in the healing of wounds and the regeneration of tissue.

With the destruction of a localised area of mature tissue, or on its wounding or severance, the exposed cells are released from arrest and multiply until the tissue loss is made good and local tissue-balance regained. If the wound be clean, and the edges can be brought in close apposition, release from arrest is shown at a minimum and the wound heals by "first intention." But where damage or loss of substance is great, rapid healing is impossible, and tissue restoration requires a considerable and sustained exhibition of release from arrest. In such a case it is chiefly the cells of the connective tissue which by multiplying heal the wound, and this is said to heal by "granulation." The so-called granulation tissue is composed of newly formed cells, at first embryonic in character, but later assuming a spindle shape and largely conforming to the ordinary connective tissue cell-type. It is also rich in newly formed bloodvessels, but contains no nerves.

When healing by granulation proceeds normally, as soon as the granulation tissue has restored the loss or filled the gap the surface epithelium grows across, continuity is complete, and arrest again obtains. But when the wound is unhealthy or septic, or when healing is prevented by the continued action of an irritating agency, two things may happen : (*a*) unhealthy granulations are produced in excess, so that the marginal epithelium is prevented from growing across, or is destroyed in its attempts to do so ; or (*b*) hardly any granulations are formed at all, or if formed are immediately destroyed, and the wound assumes the appearance of an ulcer, which remains stationary in size or gradually grows larger. In the latter case there is no bed formed for epithelial new growth.

Under proper treatment, and in healthy subjects, such wounds heal sooner or later, but as long as healing is delayed we may recognise a *theoretical* risk of uncontrolled escape from arrest. Theoretically, all that prevents a granulating wound from originating tumour tissue is Control.

The " proud flesh " of an unhealthy wound is in certain respects abnormal growth ; it is a hyper-production of cells, a release from arrest far greater than is necessary for the healing of the wound ; it is, so to speak, temporary tumour tissue. As a matter of fact, however, we know that the danger is not that granulation tissue, whether excessive or deficient, will become tumour tissue ; it is in the marginal epithelium that this danger arises, and particularly in chronic sores which fail to granulate. It is the epithelium which is specially liable to grow atypically, probably through being deprived of normal connective tissue influences which should locally control its typical development.

In every living organism there is Equilibrium of Personality ; there is balance of function for the preservation of identity and personality, and this balance reflects itself in the proportionate development of the different somatic tissues and organs. Thus the size of the stomach, the liver, the kidneys, the amount of fat, connective tissue, muscle, or skin in an organism, primarily reflects in each case the degree of development necessary for the preservation of the organism's identity and its equilibrium of personality. In a sense, therefore, one organ, or one tissue, may be said to control the development of another, and we may accept this influence to be exercised indirectly through the central nervous system, and also more directly by means of secretions passed into the blood stream.

The case of epithelial or endothelial tissue is peculiar among the body-tissues in that it always covers surfaces. This is so, whether we are dealing with skin, pleura, peritoneum, or secreting cells. It is thus always especially subject to damage or wear and tear on what may be called its external aspect. The other outstanding point is that the unexposed surface is always in contact with connective tissue. The free epithelial surface is very liable—and specially so in the case of skin or mucous membrane—to be wounded, severed, or have its continuity broken by many hostile agencies, and its normal functions may involve a continual cell loss. On the other hand, on the connective tissue side the blood and lymph may bring to the cells toxic substances which can wound or destroy as thoroughly as externally acting physical agencies. When the lesion heals, it does so through the release of cells from arrest, which, their purpose accomplished, become re-arrested; but it may happen that the arrest, once broken, is never re-imposed and that tumour growth results.

The theory of Waldeyer and Thiersch presumes that the underlying connective tissue exercises normally a restraint on its covering epithelium, and that malignant epithelial tumours might arise through the removal of this restraint with advancing age. Advancing age may well be only one factor, but this apart, the influence of connective tissue on its epithelium would seem to be proved by experiments which have been performed *in vitro.*

Those of Champy are very suggestive.

He found that on growing in culture a piece of embryo rabbit's kidney, tubules were soon produced of a primitive type, and finally these merged into an unformed mass of undifferentiated embryonic cells. Smooth muscle cultivated outside the body also gave rise to embryonic cells, this being specially noteworthy because smooth muscle cells do not divide when in the body. Champy's most interesting discovery was, however, that when a portion of attached connective tissue was included in the culture the epithelial cells multiplied typically.

It would thus seem clear that if tissues are removed from the body and grown in culture the *amount* of growth is uncontrolled; and this because the tissues in question are no longer a part of the body's personality. And it is clear, in addition, that in the case of epithelium if no attached connective tissue be included, the *character* of the epithelial growth is also uncontrolled. One cannot but conclude that the connective tissue exerts the influence which keeps the growth of its epithelium typical. Naturally, one would not expect the connective tissue to exert its power for very long *in vitro*, as it itself is removed from the normal growth influences of the body. Prolonged growth *in vitro* could never be accompanied by re-differentiation, but only to atypical cells with characters harmonious with the artificial environment; but in time some form of debased gamete would presumably be produced.

What we may then conclude is that epithelium in the living body cannot grow typically in amount and character unless it is in touch with the supporting connective tissue which is its normal immediate "internal" environment, and from which it receives certain normal growth influences. And this conclusion is one we could arrive at from what we see in the healing of a granulating wound, for the epithelium will not grow across bare muscle, bone, or cartilage, or bridge a space; it requires to advance in touch with new connective tissue in the form of healthy granulations. The skin graft exhibits the same phenomenon, for it will only "take" if placed on or in its proper immediate environment, healthy granulation tissue.

Let us take the case of an epithelioma of the lip or the tongue, developing at the site of some chronic irritation. Regarding the onset of malignancy several possibilities suggest themselves. (1) That the marginal epithelium comes to grow out of touch with its restraining connective tissue, so that the growing edge gradually escapes from control. (2) The connective tissue granulations may become so unhealthy owing to the continued action of the irritant that as an immediate environment they cease to have a proper restraining influence. (3) In the absence of granulations of any kind the epithelium may insist in growing without any restraining influence. (4) Through advancing age, or other general cause, affecting the body as a whole, the controlling power of the connective tissue is weakened and breaks down.

The absence of granulations in ulcers which become malignant is a common phenomenon, and the long processes of malignant cells which burrow down into the base of an epithelioma, and the curling cell-nests as observed in such a tumour in the lip, strongly suggest that in the absence of granulations the marginal epithelium has dipped down in an attempt to cover the wound; that as the epithelial processes grew longer, not only did their advancing ends fail to find normal restraining granulations, but such influences as originally passed from the healthy connective tissue near the ulcer would become weaker and weaker till they were not felt. For normally the connective tissue restrains a few layers of epithelium, and could not be expected to control a process equivalent to a hundred layers in depth.

In the light of Champy's experiments one other possibility suggests itself, namely, that epithelial cells might break away from the margin and multiply, as it were, in culture in the serum of the ulcer.

All carcinomata do not develop in elderly people, though these are specially liable to be attacked, and there is not always an ulcer preceding the tumour; but where the tumour arises in normally arrested tissues it is probable that it always follows on a breach of Continuity of some sort, due to physical injury or inflammation.

There is this peculiarity about all epithelium, and especially such as is glandular: while we may say that as a tissue it is permanently arrested in the sense that it never gives rise to sexual elements, its cells, under normal conditions, are constantly being released from the arrest of multiplication, owing to friction, wear and tear, etc. Moreover, the very function of glandular epithelium entails constant cell loss and fresh cell-division. Thus, epithelial tissue as a whole is not so rigidly arrested as the other tissues of the body, and we might suppose that on this account it was specially apt to break away from control, and that with advancing years its confirmed "habit" of cell-multiplication became a danger to the body.

We have taken epithelial tumours as examples of complete escape from the control of Natural Arrest, but it may well be that at times connective-tissue cells may also break away from all control and originate sarcomatous tumours.

An interesting question is that of the stroma of certain cancerous tumours. This could sometimes be interpreted as no more than cirrhotic connective-tissue due to the breaches of connective-tissue continuity caused by the multiplying epithelial cells; an attempt at repair, or to form internal scar-tissue. But, on the other hand, not infrequently the stroma acts as widely spreading malignant tissue, and even to the extent of almost crushing out the malignant epithelial cells.

The foregoing suggestions are admittedly superficial, and deal with the significance of tumour-formation rather than with the actual exciting agency, or agencies at work. Our own belief may, however, be repeated, that tumour-formation is abnormal growth, a morbid process which may be excited by several diverse agencies; and that these probably all act by causing an initial breach of cellular continuity whereby cell-arrest is broken. There can be no normal growth without Arrest and Control in cellularly-continuous organisms; no cell species or animal species could be maintained but for these factors, and they are the handmaidens of Continuity.

INDEX

A

Acquired variations, 121, 139; transmission of, 142
Adamsia, 86
Ædogonium, 55
Agaricus campestris, 64
Alga cell, 38
Alternation of Discontinuity with Continuity, 78
Alternation of Generations, elementary, 48; in filament, 58; mycelial, 62; zooidal, 74; general summary, 240
Alternation of Serial with Lateral Continuity, 70, 75, 77, 81, 83
Amœba, 36; amœba-stages, 44
Amphioxus, 131, 144, 195
Angiosperms, 171, 174; the flower, 175
Antithetic characters, 27
Aphis, 38, 113, 244
Archæan rocks, 160, 168
Archicarp, 64
Arrest, 127; permanent, of Continuity-types, 133
Asci, ascospores, 64, 66
Asexual cycle of malarial amœba, 42, 44
Atom, 28, 29; atomic cycle, 32, 33; atomic conjugation, 34; atomic species, 35
Attraction, the basic Force of, 25, 27; its dominance, 26, 52
Atypical Fish, 196
Aurelia, 102, 116, 180, 197

B

Bacteria, 67
Bar-magnet experiments, 252
Basidium, 66
Basoplasm, 35
Biogen molecule, 35
Blastophores, 44
Bryophytes, 169

C

Calamite, 173
Cause and Effect, 23
Cell, continuity of, 51; cells and protoplasts, 61; cell-arrest and Continuity, 49, 52; cell-arrest, release from, 74, 131; cell-caps, 56; cell-colony, 57
Cephalopods, 159, 196; evolution of, 198, 200; anatomy of, 201
Champy's experiments, 270
Chlamydomonas alga cell, 69
Chromosomes, 250
Circular canal, of medusoid, 95; of echinoderm, 107
Cœlenteron, 71
Cœlomata, 98
Cœlom, 91; cœlom "open," 98, 110, 195; cœlom of echinoderm, 107, 109; of earthworm, 114, 120
Cœnocyte, 61
Cœnocytic Individual, 59
Cœnosarc, 79
Colorado beetle, 145
Conidiophore, 65
Continuity of Matter, 21; Continuity's intensification within the Individual, 69, 95; Continuity, breach of, 129; evolution of, 20, 147
Continuously Zooidal Individual, 77
Control, 122
Coral, 105, 159
Cortical centres, 239
Crossed motor and sensory tracts, 233–7
Cycle, true, 30; of acts, 32; cyclic reaction, molecular, 29

D

Decomposition of water, 29
Deviation, avoidance of, 231
De Vries' theory, 211, 216

Discontinuity, 19; after death, 36; independence due to, 39; cellular, and gamete-formation, 44; price of, 151
Discontinuously Multicellular Individual, 39; definition, 42
Discontinuously Zooidal Individual, 70
Drone, 38
Dyaster, 249

E

Earth, its crust and strata, 158; its evolution, 207
Earthworm, 114
Echinodermata, 107; larvæ of, 110
Ectoderm, 71, 85, 95, 98
Electrons, 28, 29, 32, 206
Endoderm, 71, 85, 98
Energy, 26
Environment, general, 49; basic varieties, 50, 51; as physical force in relation to Continuity, 51, 52, 87; Environment and Variation, 140; as segregator, 167; as originator of species, 154, 214
Equilibrium, and Nature, 26; of inorganic matter, 28; of dead matter, 31; physical, of Fish, 229; of personality, 269
Eurotium, 63
Evolution, of living Individual, 37; of somatic tissue, 37; main road of, 59, 76, 150, 202; evolution of sexual structure in zooidal colonies, 92; gaps in chain of evolution, 151, 203

F

False tissue, 63; in Eurotium, 64
Ferns, 171
Fertilisation, non-specific, 246
Filamentous Individual, 49
Fish, evolution of, 181; circulation of, 183; nervous system of, 185; alimentary tract of, 186; mouth and gill formation, 187; respiratory system, 188; symmetry of, 227; fins, 230
Fishes, 159
Flounder, 228
Flowering plants, and arrest, 78
Food-attraction, 218, 221, 229
Frog, puncture of unfertilised ovum, 48, 246
Fungi, 59

G

Gametes, of malarial amœba, 44; of lower bacteria, 69
Gametangium, 58
Gametophyte, 57, 58
Ganglia, 115; ganglionic nerve cells, 85
Gaskell's theory, 191, 194
Gemmation, zooidal, 71, 78, 80
Geometrical progression and growth-cycle, 40; in hæmamœba, 46
Gonoblastidium, 93
Gonophores, 91; medusiform, 94, 166
Gravity, its evolutionary action, 161; as factor in Symmetry, 219
Growth, 25, 35
Gymnosperms, 169; the cone, 173

H

Hæmamœba of malaria, 42, 43; size of Individual, 45
Healing of wounds, 269
Heredity, 133
Honey-bee, 113
Hydra, 39, 71
Hydra-tuba, 103
Hydrozoa, 74, 80, 104, 159, 163, 172
Hyphæ, 60

I

Incomplete septa, 86
Individual, the, 38; size of living, 45
Intercalation in Spirogyra, 55
Intermesenteric chambers, 85, 89, 101
Involution forms, 68

J

Jelly-fish, 81, 91, 95
Jelly tissue, 98, 108

K

Karyokinesis, 248

L

Lateral Continuity, of protoplasts, 59; of hyphæ, 63; of zooids, 70
Law of "2 to the Nth," 46, 218; of Octaves, 207
Laws of Growth, 52
Life, general definition of, 30. First Life, 148
Lucernarida, 102

M

Malarial amœba, 38, 42
Man, as an Individual, 39
Manubrium, 95, 101
Matter, inorganic and living, 28; ultimate unit of, 32, 205. Evolution of Matter, 204
Medusa, 81, 98
Megazooidal Individuals, 82. Megazooid, 83; medusiform, 91; Discontinuously, 102; and Continuously Megazooidal Individuals 105
Memory, 138
Mesenteries, 85
Mesoderm, 85
Mesoglœa, 71
Micrococci, 67
Molecule, the, 29. Molecular dissociation and decomposition, 29; molecular species, 35
Mollusca, 196
Monaster, 248
Mucor, 59, 60; *Mucor mucedo,* 60, 62
Mudfish, 228
Multicellular Individual cycle, metaphor of, 40
Mutation Theory, 211, 216
Mycelium, 60

N

Natural Selection, 211
Nervous system, of Hydra, 72; of medusoid, 119, 192; of star-fish, 108; of earthworm, 115, 119; of phanærogam, 124; of Fish, 185. Nervous system and Control, 125–7
Nuclear fusion, 66

O

Origin of Species, 211

P

Parthenogenesis, elementary, 58; summary of, 245
Periodic Law, 207
Phanærogams, evolution of, 169
Plasmolecules, 30; Plasmolecular cycle, 36
Polar Bodies, 257
Pollinodium, 64
Polypite, 71
Progressive diminution in Discontinuously Multicellular Individual, 47; in Discontinuously Zooidal Individual, 74
Propositions, basic, regarding Growth, 40, 41
Protoplasm, 35
Protoplasts, 61, 62
Proximal cell-arrest, 56, 57
Pteridophytes, 169
Purpose, 23
Pyloric sac, and cæca, 107

Q

Queen Bee, 38, 136, 247

R

Radial canals, medusoid, 95, 97, 101; in starfish, 108
Radiate Individual, 107
Ray-fungus, 67
Reproduction, 24
Repulsion, basic Force of, 25, 27; in cell-division, 51; in karyokinesis, 251
Rosebush, 39

S

Scyphistoma, 103
Sea-anemone, 84; primitive, 155
Sea-urchin, chemical fertilisation of eggs, 48, 246
Segmental Individuals, 112; Continuously Segmental, 113
Segregation, 166, 214
Serial Continuity, of cells, 59; of zooids, 70
Sexual cycle of malarial amœba, 42, 44
Sexual element "plans," 37, 40; in Variation, 137
Side-roads of Evolution, 38, 59, 76, 134
Sieve-tubes, 124
Silurian Period, 159, 168
Solar Attraction, 218, 221
Sphærella, 48
Spirilla, 67
Spirogyra, 53, 163; theory of filament's development, 54
Sporangia, 60
Spores, of malarial amœba, 43; bacterial, 69
Sporocytes, 43
Sporophyte, 57, 58
Sporosac, 92, 173
Sporosac-gonoblastidium, 93, 96, 100, 104, 173
Sporozooites, 44
Starfish, 107
Strobila, 116
Swimming-bladder, 218

T

Tentacles, of Hydra, 71; medusoid, 96; of cephalopod, 198
Terminal compression, in Fungi, 66, 81; in Continuously Zooidal Individuals, 81; in evolving Fish, 185, 226, 229
Testis of Hydra, 73
Thallophytes, 169
Thread cells, 71
Tissue-continuity, 70
Tortoiseshell butterfly, 142
Torula condition, 62, 69
Trachymedusæ, 99
Transmission of characters, 134
Tumours, 260; due to escape from unnatural arrest, 263; to escape from natural arrest, 268
Types of Continuity, 41; evolution within, 76

U

Unicellular Individual, 39, 67; Unicellular organisms, 39
Unit cycle, 25; Unit Growth-cycle, 32, 33
Unit "somatic tissue," 34

V

Variation, 134; Natural variations, 135; Life the Great Variation, 149
Velum, 96
Vertebrate, evolution of, 180

W

Waldeyer and Thiersch, theory of, 270
Water-friction, 226
Water-pressure, 161, 185, 225
Water-vascular system, 107
Worker-bee, 38

Z

Zooid, definition of, 71, 82. Zooids, sexual, 79; vegetative, 80
Zooidal arrest, 55, 75, 78
Zooidal colony, 77, 79
Zooidal filament, 78, 83
Zooidal evolution, 164
Zoogonidium, 48
Zygospores, 60
Zygote, 44, 133

Printed in Great Britain by
UNWIN BROTHERS, LIMITED, THE GRESHAM PRESS, LONDON AND WOKING

The Mneme

BY PROFESSOR RICHARD SEMON

Demy 8vo. TRANSLATED BY LOUIS SIMON 18*s. net*

"A very interesting set of facts and theories marshalled into a seductive harmony."—*Times.*

Pure Thought and the Riddle of the Universe

BY FRANCIS SEDLÁK

Demy 8vo. 18*s. net.*

"What Mr. Sedlák is aiming at in this large and ably reasoned treatise is an original elaboration of the whole subject matter of Hegel's Science of Logic. . . . Its remarkably well sustained continuity of abstract reflection offers a salutary and encouraging discipline to students who will consider its problem from its severely detached point of view."—*Scotman.*

The Individual and the Community

BY R. E. ROPER, M.A., M.ED.

Demy 8vo. 8*s.* 6*d. net.*

A simple statement of the principles which underlie human activities and condition the combined efforts of two or more individuals: with a comparison of human and animal communities, a distinction between Community and State, and a forecast of communal evolution. A handbook of human co-existence.

Elements of Social Justice

By L. T. HOBHOUSE, D.Litt., LL.D.

Demy 8vo. 10*s.* 6*d. net.*

"He combines profound penetration with wide range and catholic sympathies. Unlike so many philosophical books, this one is written in English that is good to read."—*Manchester Guardian.*

The Rational Good: A Study in the Logic of Practice

By L. T. HOBHOUSE, D.Litt., LL.D.

Martin White Professor of Sociology in the University of London

Demy 8vo. 8*s.* 6*d. net.*

"Professor Hobhouse has rare powers of analysis and insight. . . . No living writer has applied more successfully the evolutionary method to ethics."—*Manchester Guardian.*

Human Nature and Conduct

By Professor JOHN DEWEY

Demy 8vo. 10*s.* 6*d. net.*

In this most interesting book the author deals directly and concretely with the actions and motives of men. He sets forth the belief that habit combines in itself biological factors and social conditions, and that an understanding of habit and of different types of habit is the key to social psychology.

Our Knowledge of the External World

As a Field for Scientific Method in Philosophy

By BERTRAND RUSSELL, F.R.S.

Demy 8vo. 8*s.* 6*d. net.*

The Origin and Evolution of the Human Race

By A. CHURCHWARD

Royal 8vo. *Profusely Illustrated* 45*s. net.*

The object of this book is to bring before the public such further facts and values regarding the Evolution of Man as have been discovered subsequent to the publication of the "Signs and Symbols of Primordial Man."

"Clearly the result of long study . . . interesting and ingenious always."—*Pall Mall and Globe.*

"Of supreme interest to anthropologists."—*Aberdeen Free Press.*

The Origin and Evolution of Freemasonry

By A. CHURCHWARD

Demy 8vo. *Illustrated* *Second Impression* 12*s.* 6*d. net.*

"A valuable addition to the literature on this enthralling subject."—*Freemason.*

"Contains a vast amount of information which will interest those who care for the traditions of their fathers."—*Lancet.*

Elements of Vital Statistics

By Sir ARTHUR NEWSHOLME, K.C.B., M.D.

Late Principal Medical Officer of the Local Government Board (England) and Lecturer in Public Health in Johns Hopkins University, U.S.A.

Demy 8vo. *About* 21*s. net.*

This work was first published in 1889 and re-written in 1899, since when, owing to the official engagements of the author, no new edition has been prepared, and the book has been allowed to go out of print. The new edition will be substantially a new work.

The subject divides itself naturally into consideration of the data of vital statistics, their compilation, and their interpretation; and under each of these headings the needs of physicians, public health officers and social workers will be carefully met, and numerous illustrations given of statistical errors and the methods for avoiding them.

A wide interpretation is given to the scope of Vital Statistics, which are regarded as including not only the measurement of population, of natality and mortality and of sickness, but also some of the chief problems of epidemiology, of poverty, of crime and of genetics.

Suggestion & Autosuggestion

A Study of the Work of M. Emile Coué based upon Investigations made by the New Nancy School

BY PROFESSOR CHARLES BAUDOUIN

TRANSLATED BY EDEN AND CEDAR PAUL

Demy 8vo. *Seventh Impression* 10*s*. 6*d*. *net*.

"The most exciting book published since 'The Origin of Species.'"—*Nation*.

"It is full of thought in itself. It is bound to be a cause of thought.... We very strongly advise our readers to read and study M. Baudouin's book."—*Spectator*.

The Practice of Autosuggestion

By the Method of Emile Coué

BY C. HARRY BROOKS

WITH A FOREWORD BY EMILE COUÉ

Cr. 8vo. 3*s*. 6*d*. *net*.

This little book presents to the layman the information he needs to enable him to practise autosuggestion for himself. It contains a descriptive account of M. Coué's Nancy clinic, a brief non-technical statement of the ideas underlying autosuggestion, and clear instructions in all points essential to its successful practice.

Hypnotism and Suggestion

BY LOUIS SATOW

TRANSLATED BY BERNARD MIALL

Demy 8vo. *About* 10*s*. 6*d*. *net*.

This volume, which contains a glossary of technical terms, should fill a long-felt want, as supplying a foundation of accurate knowledge which will enable the reader to follow and understand the recent developments of psycho-analysis. An exact knowledge of the various phases of hypnosis is equally essential for a true understanding of the phenomena of religion, politics, education, herd-psychology, minority rule and war.

The New Psychology: and its Relation to Life

BY A. G. TANSLEY

Demy 8vo. *Sixth Impression* 10*s*. 6*d*. *net*.

The issue of the Fifth Impression of this book—originally published in June 1920—has given the opportunity of a fairly thorough revision. Advantage has been taken of criticisms to make various statements more explicit, and a few fresh topics have been dealt with; for instance, Dr. Varendonck's recent work on Day-dreaming and Adler's views on the importance of the feeling of inferiority in moulding the character. A new preface and a glossary have been added.

Studies in Psychoanalysis

An Account of Twenty-Seven Concrete Cases preceded by a Theoretical Exposition

By CHARLES BAUDOUIN

Professor at the Jean Jacques Rousseau Institute and Occasional Professor at the University of Geneva. Author of "Suggestion and Autosuggestion," etc., etc.

TRANSLATED FROM THE FRENCH BY EDEN AND CEDAR PAUL

Demy 8vo. *About* 16*s. net.*

This is a book both for the expert and for the general reader. As far as the general reader is concerned, there does not yet exist a volume which gives a straightforward and thoroughly comprehensible explanation of the leading methods and theories of psychoanalysis, in conjunction with an exposition of the philosophical, educational, and general psychological bearings of the doctrine. Such a book is now forthcoming. But the author's main object is a practical one. "The method to which experience has led me, and whose results are here recorded," writes Baudouin in the first chapter, "is founded upon *unceasing collaboration between autosuggestion and psychoanalysis*. Many, I know, regard this as a heresy. Whether it be heretical or not, I am confident that immense advantage can be derived from such collaboration." Professor Baudouin's "Suggestion and Autosuggestion," an account of the clinical methods of Dr. Emile Coué and the teachings of the New Nancy School, has had a phenomenal success. The translators and the publishers are convinced that "Studies in Psychoanalysis" deserves, and will achieve, a success no less phenomenal.

Introductory Lectures on Psycho-Analysis

By PROFESSOR SIGMUND FREUD, LL.D.

Demy 8vo. 18*s. net.*

An authoritative introduction to psycho-analysis has long been badly needed, and this want could not be better filled than by Professor Freud himself, the pioneer of the science. These lectures, which were delivered at the University of Vienna, assume no previous knowledge of the subject and are couched with the utmost lucidity, although they embody much of Freud's latest work. They cover three fields: failures of everyday life, dream life, and psychopathology of the neuroses.

Fundamental Conceptions of Psycho-Analysis

Demy 8vo. By A. A. BRILL, M.D. *About* 12*s.* 6*d. net.*

An authoritative statement of the Freudian doctrine of psycho-analysis, written by Freud's chief American disciple and translator, done in a lively and coherent fashion, and with unusual delicacy in the choice of illustrative material.

Some Applications of Psycho-Analysis

By Dr. O. PFISTER

Demy 8vo. *About* 18*s. net.*

This is a collection of essays dealing with the nature and application of psycho-analysis in various mental and spiritual domains. The author treats of psychology, philosophy, the psychology of the sources of artistic inspiration, of war and peace, of religion, of science and pedagogics, particularly of psychic inhibitions and abnormalities in children.

The Evolution of the Conscious Faculties

By Dr. J. VARENDONCK

Demy 8vo. 15*s. net.*

This book, which is the sequel of the author's "Psychology of Day-dreams," is mainly devoted to the study of the two different aspects of the faculty of retention: duplicative and synthetical memory.

The Psychology of Day Dreams By DR. J. VARENDONCK

Introduction by PROFESSOR FREUD

Demy 8vo. 18*s. net.*

"A genuine, well documented first-hand study of an important psychological phenomenon."—*Times.*

Psycho-Analysis

By BARBARA LOW, B.A., Ex-Training College Lecturer

Cr. 8vo. *Third Edition* 6*s. net.*

"An admirable little outline of the theory and application of psycho-analysis . . . as a primer in the first elements of the subject, it could hardly be improved upon."—*Westminster Gazette.*

LIBRARY OF PHILOSOPHY

Discourses on Metaphysics

BY NICOLAS MALEBRANCHE

TRANSLATED BY MORRIS GINSBERG, M.A.

Lecturer in Philosophy, University College, London

WITH A PREFACE BY PROFESSOR G. DAWES HICKS

Demy 8vo. *About* 18*s. net.*

A translation of the *Entretiens sur la Métaphysique*—a work generally recognized as giving the most comprehensive account of Malebranche's metaphysical system. The translation is preceded by an introduction dealing in particular with Malebranche's theory of knowledge and his polemic with Arnauld, and indicating his relations to Descartes, Spinoza and Leibniz, on the one hand, and to St. Augustine and the Neo-Platonists, on the other.

Modern Philosophy

BY GUIDO DE RUGGIERO

TRANSLATED BY A. HOWARD HANNAY, B.A., AND
R. G. COLLINGWOOD, M.A., F.S.A.

Demy 8vo. 16*s. net.*

"Should act like a tonic on the spirits of drooping philosophers, for it is a sign of the reaction of philosophy to the all-encroaching claims of science and psychology."—*Nation.*

The Analysis of Mind

BY BERTRAND RUSSELL, F.R.S.

Demy 8vo. 16*s. net.*

"Brilliant. . . . One of the most interesting and important books that Mr. Russell has yet given us."—*Nation and Athenæum.*

"A perfect model of what such books should be . . . the reading of the book is an intellectual pleasure rather than a mental effort."—*Church Times.*

History of Psychology

VOLUMES I, II & III

BY G. S. BRETT, M.A.

Demy 8vo. 16*s. each net.*

"The value of a work at once impartial and scholarly, scientific and comprehensive, which, of matter all compact, surveys more than six hundred of the greatest thinkers, needs no emphasis."—*Holborn Review.*

Introduction to Mathematical Philosophy

BY BERTRAND RUSSELL, F.R.S.

Demy 8vo. *Second Edition* 12*s.* 6*d. net.*

"Mr. Russell has endeavoured to give, in non-technical language, an account of his criticism as it affects arithmetic and logic. He has been remarkably successful."—*Athenæum.*

Up Against It in Nigeria

By LANGA-LANGA

Demy 8*vo.* 24 *Pages of Illustrations* 18*s. net.*

In "Up Against It in Nigeria" the author, avoiding religiously the well-worn themes of tribal marks, pagan music, geographical features, and other platitudinous matter, throws open his store of thirteen years' experience as a Political Officer, and introduces the reader personally *by name* to the toilers, official and commercial, who have faced the despondencies, the dangers, and the changing fortunes of an Administration which only attained its twenty-first birthday on January 1st of this year. (The simple obituary footnotes are in themselves a gruesome commentary on the terrible human toll levied by the climate.)

With cynical, but entirely friendly pen, Langa-Langa sketches scenes on trek, on "safari," on patrol, in Court, and—not least exciting—on s.s. *Falaba* when, at five minutes' notice, she was incontinently dispatched to the bottom of St. George's Channel.

Adventures in Swaziland

By OWEN ROWE O'NEIL

Medium 8*vo.* *Profusely Illustrated* 16*s. net.*

The author of this thrilling and picturesque narrative was, with his companion, the only white man ever initiated into the Swazi tribe, a savage people who, under the leadership of old King Buno, were a constant menace to the surrounding Boer villages. How the old queen refused to give up her throne, how a civil war was precipitated, and how Sebuza, the crown prince, won a great victory and assumed his rightful kingship over Swaziland, completes a story that for imaginative quality and vivid power rivals anything out of the Arabian Nights.

The Long White Cloud

Ao-Tea-Roa

By the Hon. WILLIAM PEMBER REEVES

Demy 8*vo.* *New and Revised Edition.* *Illustrated* 12*s.* 6*d. net.*

"Out and away the best book on New Zealand."—*Daily Chronicle.*

Around the Shores of Asia

By MARY A. POYNTER

Demy 8*vo.* *Illustrated* 16*s. net.*

"A book to be read with fancy alert . . . agreeably written . . . cordial, sympathetic, entertaining."—*Daily Chronicle.*

"A charming book of travel."—*Church Family Newspaper.*

My Term Off

By Captain N. G. BRETT JAMES

Cr. 8*vo.* 10*s.* 6*d. net.*

"A very pleasing book. . . . I heartily recommend it."—Sir W. Robertson Nicoll, in *British Weekly.*

The Memoirs of an Ambassador

BY FREIHERR VON SCHOEN

TRANSLATED BY CONSTANCE VESEY

Demy 8vo. *10s. 6d. net.*

In this valuable contribution to the political history of modern times, Freiherr von Schoen, the German Ambassador in Paris in 1914 and former Minister for Foreign Affairs, relates his experiences as a diplomat during the period between Bismarck's retirement and the outbreak of war. Incidentally he refers to the German ignorance of diplomacy and distrust of the Foreign Office, and shows us how thoroughly those mainly responsible for Germany's foreign policy during the last twenty years justified this distrust.

My Memoirs

BY PRINCE LUDWIG WINDISCHGRAETZ

Demy 8vo. TRANSLATED BY CONSTANCE VESEY *16s. net.*

"We have seen no more vivid and dramatic account of the last stage of Hapsburg rule than that which Prince Ludwig Windischgraetz has written."—*Spectator.*

The Master Spinner

A BIOGRAPHY OF SIR SWIRE SMITH

BY KEIGHLEY SNOWDEN

Demy 8vo. *With Frontispiece* *16s. net.*

"A biography, which for intimacy of treatment, combined with unusual restraint and good taste, can scarce have had its equal of recent years."—*Westminster Gazette.*

"One of the most delightful biographies I have ever read."—SIR W. ROBERTSON NICOL, in *British Weekly.*

Seventy Years among Savages

By One of Them

Demy 8vo. HENRY S. SALT *12s. 6d. net.*

"Most entertaining . . . If Mr. Salt rides his fads hard, at least he shows a sense of humour and a wide acquaintance with people worth knowing."—*Westminster Gazette.*

"Whatever he is . . . he is not a bore; the personal anecdotes are many and diverting. His book ought to be read for its serious purpose as well as for its lighter parts."—*Times Literary Supplement.*

Modern Men and Mummers

BY HESKETH PEARSON

Demy 8vo. *10s. 6d. net.*

"Exceedingly lively . . . he is at his best when he is being amusing—and rather daring—at somebody else's expense. . . . He writes freshly and well, and he has mixed with his ink a touch of vitriol . . . there will be few people, except the victims, who will not enjoy reading it."—*Daily Telegraph.*

The History of Social Development

By Dr. F. MÜLLER-LYER

Translated by

ELIZABETH COOTE LAKE & H. A. LAKE, B.Sc. (Econ.)

Introductions by Profs. L. T. HOBHOUSE & E. J. URWICK

Demy 8*vo.* 18*s. net.*

"The vast learning, the broad sweep of thought, combined with the wealth of interesting detail, make it one of the most fascinating of modern works on human history."—*Economic Review.*

Our Social Heritage

By PROFESSOR GRAHAM WALLAS

Demy 8*vo.* 12*s.* 6*d. net.*

"For concentrated and penetrative sagacity he has, in his own school of thinkers, no rival . . all his work is infinitely suggestive. He talks with information and with acumen. He sweeps broadly, he probes deep, and he is never for a moment dull."—*Manchester Guardian.*

"A book rich in thought and most catholic in its receptivity"—*Observer.*

In Days to Come

By WALTHER RATHENAU

Translated from the German by EDEN and CEDAR PAUL

Demy 8*vo.* 12*s.* 6*d. net.*

"Clearly a book of the moment, not to be ignored by thinking men. . . . He is a man of high intellectual attainments, a scholar and thinker, and an accomplished amateur of art."—*Times.*

Human Behaviour

In Relation to the Study of Educational, Social and Ethical Subjects

By STEWART PATON, M.D.

Demy 8*vo.* *About* 21*s net*

LONDON: GEORGE ALLEN & UNWIN LIMITED
RUSKIN HOUSE, 40 MUSEUM STREET W.C.1