Hudson Tuttle

ARCANA OF NATURE;

OR,

THE HISTORY AND LAWS OF CREATION.

OUR BARK IS REASON, NATURE IS OUR GUIDE.

By HUDSON TUTTLE.

Vol. 1.

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DEDICATION.

For years I have been led through the paths of science by invisible guides, who have manifested the earnest zeal of a father for a feeble and truant child. They have upheld my faltering footsteps; they have supported my weary frame, and in darkest hours thrown their sacred influence around me. Like the reader of these pages I am a student in their portico, receiving my mental food from their hands. From these invisible authors I draw the concealing veil, and to them dedicate this volume.

H. T.

Walnut Grove Farm,
Oct. 25, 1859.

PREFACE.

LONG and patiently have we labored on this volume, which is now consigned to the public, although we are deeply conscious of its many imperfections.

Our purpose has been honest. We have endeavored to trace *received* facts to their legitimate sources, and found by their light as perfect a system as possible.

We do not present our work as a finished volume, but one as perfect as the present plane of science will admit; and every new discovery, which bears on any subject it investigates, will find a niche for its reception in future editions.

We shall profit by the criticism which it will provoke, and endeavor, at some future period, to bring it up to the high ideal we framed when we first sat down to compose it.

If the facts we have gleaned, and the theories drawn from them, afford interest or pleasure to the reader, — if thought is awakened on the mighty problem, How and Why Nature exists, — we shall feel that our task has not been wholly in vain.

THE AUTHORS.

PLAN.

I. To show how the universe was evolved from chaos, by established laws inherent in the constitution of matter.

II. To show how life originated on the globe, and to detail its history from its earliest dawn to the beginning of written history.

III. To show how the kingdoms, divisions, classes, and species of the living world, originated by the influence of conditions operating on the primordial elements.

IV. To show how man originated from the animal world, and to detail the history of his primitive state.

V. To show how mind originates, and is governed, by fixed laws.

VI. To prove man an immortal being, and that his immortal state is controlled by as immutable laws as his physical state.

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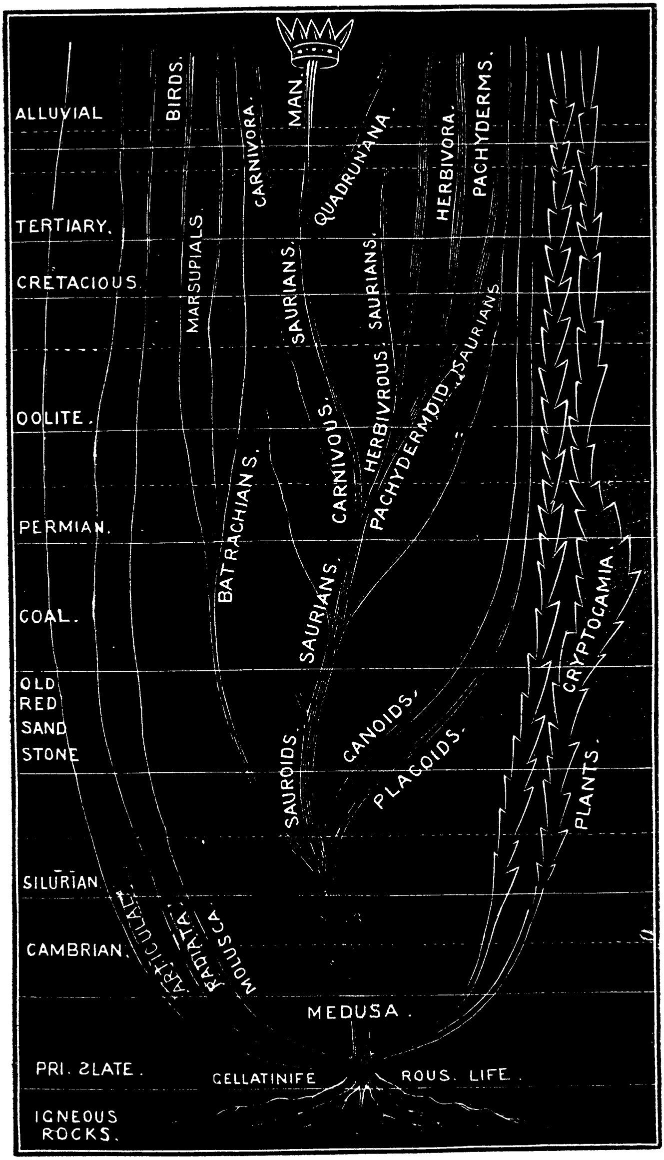

ALLUVIAL
TERTIARY.
CRETACIOUS.
OOLITE.
PERMIAN.
COAL.
OLD RED SAND STONE
SILURIAN.
CAMBRIAN.
PRI. SLATE.
IGNEOUS ROCKS.
BIRDS.
CARNIVORA.
MAN.
QUADRUNANA.
HERBIVORA.
PACHYDERMS.
MARSUPIALS.
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SAURIANS.
SAURIANS
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PACHYDERMOID.
BATRACHIANS.
SAURIANS.
CRYPTOGAMIA.
CANOIDS.
PLACOIDS.
SAUROIDS.
PLANTS.
ARTICULATA.
RADIATA.
MOLLUSCA.
MEDUSA.
CELLATINIFE
ROUS. LIFE.

THE

ARCANA OF NATURE.

PART I.

CHAPTER I.

A GENERAL SURVEY OF MATTER.

1. WE are placed in the midst of a blooming creation, surrounded by constantly changing scenes and phenomena, exciting our admiration by loveliness, or awe by their sublimity. Within and without, wherever the mind turns, it meets the stern play of mysterious forces. We know creation exists, and that we are its components; that is all the child or the savage, who stands on the plane of observation, can comprehend. The why and the wherefore are veiled from our ken, and we know not how, or by whom, the mighty fabric, creation, was set in motion. The scaffolding has been removed, and the manner in which the edifice was constructed obscured. The creation of to-day covers up that of yesterday, from which it was born.

2. It is not strange that man in his savage state should gaze with mingling adoration and awe on the mutations around him. He *was*, and *is*, the representative of the childhood of the race. His mind has the child's

understanding; his reflection is shallow, his observation superficial. Not able to deduce laws, and trace effect to its cause, he believes that invisible beings control the elements; that their being good and evil exposes him to the whirlwind and tornado, as well as gives him the sunshine and the harvest. He supposes that he can change their purposes by prayer; and hence arise his theological and religious ideas. As these dogmas advance, the multitudinous array of spirits become concentrated in a good and an evil Deity, to whom the act of creation and its maintenance are referred.

3. Such is the theological age of mankind. It views God as the Author of nature, standing outside of, and independent of, his works, and acting on matter as a mechanic, moulding and fashioning as pleases his despotic fancy. It is a sad belief which places us in the hands of an unaccountable master — mere toys to dance to this tyrannic will. Yet the greater portion of mankind prefer the stagnation of thought it engenders, to the restless research produced by its denial. It is far more quieting to settle all questions as to the origin of nature by reference to a personal God, than to enter the unsettled realm of philosophical speculation; yet the transition has been made, and intelligent minds have been thrown into the middle of the vexed ocean of observation and hypothesis. The world is casting off its chrysalis shell, and with it its theological state, and breathes a more philosophical atmosphere. Between the two conditions war continually prevails. To those who still remain in the atmosphere of theology, no amount of evidence nor force of logic can prevail. Their armor is metallic self-complacency, impervious to light. For ages the

battle has been waged on the metaphysical plane with uncertain success; for where words are substituted for ideas, as in that of metaphysics, which is the outgrowth of theology, complete, exterminating victory is impossible.

4. The champion* of theology against scientific views, at the present time, boasts of the successful issue of the battles wherein metaphysics have been the arena, and boastfully invites his opponents to the arena of what he calls science! True, science has been so little understood, and nature so wrongly interpreted, that its facts could not previously be successfully arrayed against the prejudices of the biassed mind. But every day has brought new light, and forced the conviction that the last battle was soon to be fought on strictly scientific grounds. Theology has been constantly frightened by the revelations of nature. When Galileo contradicted its assertion that the world was flat and the centre of the system, its throne seemed ready to crumble, and each new development of mind has battered it with unparried blows.

5. Slowly the light has dawned, and men of unfettered minds now feel that the true philosopher must not be guided in his interpretations of nature by any theory or bias of others. But as a little child, free from prejudice, he must walk out into the fields of causation, and observe and theorize for himself. What has been said, what written, before his day, should appeal to his judgment; if true, it should be received;

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* Hugh Miller, who wages the battle through three volumes — Footprints of the Creator, Old Red Sandstone, and Testimony of the Rocks, through all of which he has been much more ready with ridicule and polemics than facts, much more ready to misconstrue and misunderstand, and to compel a verdict in his favor than to arrive at the truth.

if not, be cast away as worthless trash, no matter if it bears the signet of a God. We well know that in nature there are no interpolations or misinterpretations. It comes to us fresh and new, unsoiled by the hands of selfishness or deception. If we read aright from its pages, and it clearly contradicts any pretended revelation, we are assured that such revelation is an imposture, no matter if descended from immemorial time, and half the world bow to its dictation.

Nature interpreted by Reason is the ultimate test of all truth; correct observation the avenue to the mysteries of causation. Such is the philosophical code.

6. Now the philosopher has stepped upon this planet, every thing, nursed and petted in the past as truth, is severely scrutinized. He has the mental crucible which digests solar systems, and extracts the pure metal from the dross. He calls unprejudiced observation to his aid, and by it unlocks the gates of mystery. First he observes the regularity of phenomena, which tells him there is no chance; that like causes produce like effects, yesterday, to-day, and forever. All idea of chance is utterly excluded. There is an observed order never disturbed; organic and inorganic matter is ruled by an undeviating method. That method he terms law, because it is similar in its tendency to artificial enactments. Still no force or power is expressed; the *modus operandi* is concealed; he is baffled in this direction by the portentous sentence, "Thus far, and no farther." Turning, he inquires, What is matter? Was it ever created, or is it eternal? What is its constitution? After surveying the entire field, he reasons thus: Matter is eternal, as far as a finite mind can conceive. This is an axiom lying at the very foundation of nature. It is to

him self-evident. In opposition to this view, the theologian brings the creative fiat of God. But what does he assume? The self-existence of God! How can he answer the pertinent question, Whence came the Omnipotent Being who could create the universe from nothing? The mystery said to involve the Godhead has little weight against the demonstrations of science. To the calm mind, it is vastly more rational and probable that the universe, with all its suns and worlds teeming with living beings, is the result of blind, fortuitous chance, than the creation of a Being capable of creating it by an effort of his will; for it is axiomatic that it is easier to create the lesser than the greater.

7. Beneath all the ceaseless changes, and the state of unrest, there is that which never changes. The fundamental constitution of matter remains eternal. Subjected to the intensest heat, the most powerful reagents, the most corrosive compounds, its form changes; it may become gaseous, liquid, or solid; it may unite in new combinations, and acquire properties it did not previously possess; yet it is never destroyed; it has only changed states, and can be brought back by reagents to nearly its original form. On this principle is founded the splendid compensations which chain together the kingdoms of nature. In the great laboratory of nature the process of renovation, of birth, death, and resurrection, is constantly going on, but there is no annihilation. The assumption of the latter is uncalled for, and whenever entertained becomes a shadowy dogmatism. Science is brought to light by observation. Generalizations are based on facts. There are facts to warrant the conclusion previously stated. When we admit that a single

atom has been, or can be, created or destroyed, at any past or future time, by any means whatever, at that moment the basis on which reason rests is destroyed, and we wander in a boundless ocean of theological speculation, involved in Egyptian night, without protection against the wildest and most fanatical system of world-building. By what evidence can it be proved that matter ever has been created, or can be destroyed? Here, on the threshold of our investigations, all the countless systems of cosmology, bearing presumptuous titles to their embodied ignorance, all metaphysical subtilty and theological cant, must alike be discarded. We must have calm, clear data, fresh from the realm of nature.

8. The defined order observed is termed *law*. If laws are traced upwards, we find they unite in principles. Farther on still, principles become attributes, which are the primoidal elements of force, beyond which it is impossible at present to reach. In this series we arise by gradations: several facts define a truth; several truths become a law; several laws a principle; several principles determine an attribute.

9. The eternity of matter depends on the eternity of its attributes. There is no reason why these attributes should be separated from their object, and termed spirit, as has always been done. On the contrary, there are emphatic reasons why they should be studied in combination, as only by so doing are mental and physical sciences harmoniously united. How can we imagine a tangible existence without impenetrability and extension? It at once becomes evident that these are necessary conditions, as a thing occupying no space, having neither breadth nor thickness, is nothing. What idea could be formed of it, if it had not weight,

and was unsusceptible of motion? When we say matter, we mean also its properties; for common sense, in opposition to theories, intuitively knows that there can be no separation between them.

10. Unlike the old philosophers who considered matter dead, and only moving when acted on by external forces, we infer from observation that motion is its inseparable constituent or companion. Throughout the labyrinth of creation there is no rest; all matter is in motion. It is superficial observation which teaches that matter never moves unless acted on. The ship is propelled by the winds, the engine by steam, and so on through the endless manifestations of force. Hence philosophers have concluded that matter possesses an inherent resistance to motion, which they have called *inertia.* Superficially considered, bodies do offer resistance to forces tending to move them; but what is the character of that resistance? Friction is always strongly opposed to motion; always present to chain objects to their present locality. The rock, which rears its gray head on the mountain, has remained without perceptible change for ages, gravity and the opposition of the soil around it preventing it from perceptibly moving; and until these are overcome, it is chained there. It is not an inherent resistance of the rock itself, but of the forces which are exerted on it. Although apparently motionless, it has been in perpetual circulation. Time after time it has rolled around with the world, oscillated around the sun; and ceaseless change and motion have gone on in the internal arrangement of its particles through all time. When we see the great world flying through space, rotating on its axis, and revolving around the sun, impelled, as by an omnipotent breath, wafting onward

whole fleets of stars, as eddying waters, we see matter has inherent motion. Here no resistance from other forces is offered, and matter is free to obey its strongest impulse. But the moss-grown rock, does it perform a function in these gyrations, or is it a passive object, acted on by a mysterious power? Motion belongs to the atom. The world is but an aggregation of atoms, and as its motions are just what those of a single atom placed in its orbit would be, each atom must be its own motor, and the combined influence of all is the influence of the earth. The power which wafts suns and worlds on their orbits must reside in themselves. Mathematical and inductive reasoning demonstrates this supposition. The agency of an Almighty Being constantly propelling them, does not meet the demands of science. A force imparted to the planetary systems at the beginning, without being constantly replenished, would at length become expended in overcoming the resisting medium existing in space. That motion innate in matter possesses the simplicity which nature demands, and we can trace its operation down from the great suns wafted on its wings, to the crystallization of a solid from solution, and the infinite movements of the living organization. Motion is ever the same, directed in different channels and fulfilling different missions, nevertheless the same, whether aggregating the particles of salt in a cubic crystal, or binding with iron bands world to world, and sun to sun, in the grand network of solar and stellar systems.

11. Life is born of motion. It is first traceable in the mutual attraction between atoms in solution arranging them in definite forms; in affinity, the attraction and repulsion of particles. It, perhaps, may

appear startling that the forces which create the crystal are living forces; but the data are many which support such a conclusion. In the lower order of animals, where life nearest approaches the mineral, the form and skeleton of the animal conform to the laws of crystalline growth, as the plates of the sea urchin, the rays of the asteria, and the calcareous framework of the coral; and even in the higher mammalia the bones always are crystalline, being formed of elongated crystals which grow in their cartilaginous beds precisely as they would in a solution. The petrifaction of wood differs not materially from the growth of bone.

12. The mysterious process of absorption in the plant or animal does not differ in the least from absorption in the mineral. The same force which takes up a fluid through walls of animal membrane, causes chalk and other porous minerals to absorb a fluid, or a capillary tube to lift it higher than its level.

13. The process of secretion, though intricate in character, can be imitated with mineral walls instead of living tissue. These facts may be regarded as faint proofs, but it cannot be denied that they furnish the clew — the footprints to the law binding the organic to the inorganic. Life of necessity depends on the mineral. It is breathed forth and sustained by it.

14. Admit that God, by a special act of creation, formed man out of the dust; then it must be received as a correct deduction that matter has the *capability* of becoming a living being. Then it must possess an inherent principle of life, the development of which is seen in every living organism. Creation is constantly going on around us, and we see comparatively inert matter awake from sleep to whirl in the restless activity of sentient organisms. But there is no neces-

sity of calling to our aid an external force. We see that it possesses the living forces. When placed in the proper circumstances, its before dormant powers awake under the new order, and the so-called inert matter becomes what is termed living matter. Life is not necessarily sentient. The lowest animal cannot be distinguished from the lowest plant, and the lowest plant grows, as a crystal enlarges in solution, by the elongation of a central axis. But this plant lives, and its life is the same as that of the ox, the deer, or of man. The plant is simply an animal without a nervous system, and consequently devoid of feeling. All the functions of the animal, except that of the nervous system, are strictly vegetative; secretion and excretion, absorption and assimilation, are identical. Some philosophers claim, that an impassable chasm exists between the organic and inorganic worlds; but where is it to be found? If life in its general aspect is but the mutual interchange of relations,* then matter itself must be admitted as living. Has it not motion in the terrific winds, which lash the heaving billows of the ocean, and in wild magnificence stalk onward amid ruin and desolation? Has it not its sympathies and antipathies in the relations existing between the elements of the chemist? Has it not its attractions in the world atoms it sends on their mighty orbits? With what anxiety we watch the agitated needle as it trembles beneath the concussions of the northern lights! And how astonished are we at the play of contending electric and magnetic forces between bodies differently charged! Assuredly if this is not life, it has all the appearance of being. Life is indi-

* Earth and Man. Guyot, p. 23.

vidualization, and when the crystal forms from solution after a definite model, is it not an attempt at individualization? Is it not the first step towards an organized being?

15. If there is not life in matter, from whence is it derived? How is the inorganic material rendered capable of supporting the living being? These are questions which must be met, if the popular idea is sustained. But they cannot be satisfactorily answered. There is the universal life of creation visible in the heaving bosom of the ebbing sea, the flow of the majestic river, the activity of the silent forces which support on their Atlas shoulders this globe of ours; that scintillates in the stars as it rolls them on their vast revolutions; that pulsates in the waves of light and heat, and sends the vibrating magnetic current on its swift pathway. An all-pervading life is seen in the wild storm, with its brow begirt with the red lightnings, and its hoarse voice of thunder; in all the ceaseless changes of the inorganic world. If this universal life is concentrated and unitized, a living organism is the result. If we rightly study the origin of life in its vegetable or animal forms, we must begin at its dawn in the lowest living beings, and observe its affinities. The lowest form of life is a simple mass of jelly floating in the waves of the sea, devoid of all organs whatever, devoid almost of structure, being little more than a mass of crystalline cells. It is closely, *very* closely, allied to the mineral, and is so simple in its structure, as seemingly to be propagated without parentage, simply by spontaneous development.

16. Such is the first specialization of universal life above the crystal. There is no impassable chasm to be passed by one leap, but the smoothest transition,

and without scarcely any change in the governing laws. The principles of crystallization still remain, and the cellular mass is but a higher order of crystallization.

17. We would now view this subject from another standpoint. All specialized life begins with the CELL. The CELL is the basis of the plant and of the animal. All tissues are cellular, and tissue is the material of which the animal is constructed. The leaf is the basis of the plant, and the cell of the leaf. The microscope has proved this splendid generalization. The necessary inference from this is, that the simplest, or primoidal form of life should be a simple cell, or mass of cells; and on an examination of the secret chambers of the great deep, this proves true. There we find the first specialization of life as a simple cell, a nitrogenous bag, filled with an aqueous fluid, so feeble the forces which hold it together that it dissolves at a touch, and it can only be distinguished from the water in which it floats by the strongest light. Is it not closely allied to the mineral? Is it not an important step in this investigation to prove that special life can be supported by a simple nitrogenous sack, wholly mineral, filled with fluid?

18. But it may be claimed that life is more closely related to the imponderable agents, light, heat, and electricity, than the mineral. True, but are not these agents material? Have they not their laws? And though we admit that they are pulsations in an ethereal medium, their basis is material. But for a moment admitting that they are not, of what avail is it to the argument? Do not the same forces prevail throughout the whole extent of nature? All the observable difference is their greater intensity in their specialized form. If in this great pyramid the apex of

individualized life pierces the higher realm of greater laws, does that cut it off from its foundation, or separate it by an impassable chasm? Not in the least; but it beautifully illustrates the perfect unity which pervades the works of nature.

19. We have seen life around us in the organic world, and we know, that should all living forms be taken from our earth, it would not wheel along its orbit dead and inert matter, but would be all alive, as at present, with the unrest of the stern elements. It was the same in the primal ages, when the bald earth turned towards the sun its bleak and rugged islands, floating in an almost universal ocean, over which the black clouds of storm and whirlwind constantly lowered, and not a living form sported in the waves; even then, life manifested its power, and like a great intelligence, labored in perfecting the rude and imperfect world.

Life, then, is the specialization of the living principles of matter.

20. Thus far we have considered life in its general aspect, common alike to all forms of matter: now we will trace it upwards, and observe the gradations by which it arises to its specialized forms. Its specialization was produced by the mutual attraction of affinitizing particles. As each crystal in a solution of several salts draws to itself only those particles which will unite with itself, so each tree and animal only uses such portions of its food as are adapted to the demands of its nature, and casts the remainder aside. A moment's investigation will convince the reflecting mind that this conclusion is true. What one being rejects as poisonous to its constitution, another assimilates as most nourishing food. The deadly nightshade twines

its roots among those of the farinaceous corn, drinks its food from the same soil, is moistened by the same drops of rain; yet one is poisonous in every vein, while the other is nutrient in the same degree. Why is this, unless the mutual attraction of affinitizing particles be admitted?

21. If a solution of sulphate of soda and common salt be made, crystals will be deposited, but they will observe a defined order. On one projecting point of the enclosing vessel an atom of salt will be thrown down, on another an atom of the sulphate. Each of these will attract such particles only as will unite with itself, while it rejects the others. Thus two widely distinct substances will grow out of the mixed solution, each as pure as if formed from a pure solution of its own.

The nightshade and corn grow in a similar manner, each assimilating those particles adapted to its own constitution, and rejecting those which would be injurious. We shall, in a subsequent volume, find the same holding good in the domain of mind, each mind assimilating food which corresponds with its development.

22. The plant is destitute of a nervous system, and consequently cannot feel. The same is true, or nearly so, of the lowest animals, or rather beings in which animal and vegetable unite. The animal, as it arises from the primoidal cell, where animal and vegetable are confounded, acquires a nervous system, and by its agency the new faculty of sensation. In a future section the relations of sensation to nervous development will be fully discussed: here we will assume positions to be proved hereafter.

23. The development of the nervous system, and its concentration in the brain, produces specialized intel-

ligence. Here we must not confound universal and special intelligence. One is adapted to the wants of the individual, the other to the universe; and although a parallel may be observed between them, the same term should not be used to express so widely remote objects. In nature we observe an order of action — law — a precision and appropriateness, which forces on the superficial observer the conviction of the existence of an omnipotent, independent Being, working on inert matter by the force of his despotic will. We have seen how the savage personifies the cause of such phenomena, and worships the creature of his fancy, which is a principle, or at most an attribute.

24. It is supposed that the presence of such a being is seen in the beautiful order of the planets, as they move harmoniously in their orbits — in their rounded form, and the order of their arrangement. The presence of principles is seen. Is there any thing more? Why does the dew-drop, trembling on the petals of the flower, always become a globe? Is it because its atoms strive to approach the centre, and produce an equilibrium, which state can only be found in a perfect sphere? or does it require a special act of Deity to round every drop? The same principles which round the dew-drop round the great world. One effect requires as much interference as the other. If such principles be granted to matter, then the rounding of globes from matter left to itself does not show independent intelligence. The same force which causes the stone to fall to the ground, chains the moon in its orbit; and if the agency of an independent being is required for the latter, it must be employed wherever a particle falls.

25. What is this intelligence? It is the perfect

adaptation of cause to effect. It is seen in every flower that blushes by the wayside stream; in waving harvests and forest trees; in suns and planets, and the activity of life. The same force which unites an acid and an alkali separates the materials of the world in the gaseous ocean of the beginning; binds its strata, its oceans, rivers, lakes, and mountains together; fixes with certainty the size, distance, and period of revolution of the planets, and the complicated order of the universe. We call it an intelligent force, because such relations of cause and effect present an analogy to the operations of an intelligent being; but this is only superficial and apparent. The phenomena of nature which we refer to intelligence are not to be compared to the operations of the human mind. The two are decidedly different, and only resemble each other in the harmony each induces between causes and effects. The use of the term *intelligence*, as applied to nature, leads to confused and erroneous views, and, could another word be substituted, less ambiguity would prevail in this disputed realm.

26. A survey of the grand history of creation deeply impresses the progression of nature on the mind of the student. Nature has progressed from age to age; each great epoch bears witness to this fact. Why is it so? Why did not the creation of to-day follow the turbulent strife of the igneous ages? Was it not because the crude form of the elements forbade? They were only capable of supporting the lowest forms, and only the lowest were produced. In the analogy to-day presented by the soil of granitic mountains, lichens and moss first appear; and not till they have grown for a time, unless organic matter be introduced, can higher organized plants grow. Pot-

ash obtained from wood ashes adds greatly to the fertility of such soils, after they become capable of supporting vegetation, although it is saturated with potash from granite. Chemists say that potash from granite rock and from wood ashes is identical; the plant says emphatically it is not. It become dwarfed and refuses one, it luxuriates when supplied with the other. Phosphate of lime obtained from bones is among the most stimulating fertilizers known; but phosphate of lime obtained from the lower rocks is worthless. Chemistry declares the element the same, whether obtained from bones or from stone; the plant makes a closer analysis.

27. Here we see an actual refinement in elementary matter, inappreciable to the rough tests of chemistry, it is true, but detected by the sensitive rootlets of the plant. Here are facts which unlock the great mystery of progression from age to age. It reaches beyond effects, down to the constitution of matter. Each era was as perfect as the then existing plane of refinement of matter would allow.

Chemistry says there are sixty-four primary elements; this chemistry teaches the infinite gradation of elements; or, accepting the popular method of speaking, the number of elements is infinite. There is infinite variety. The potash that has passed through the organization of the plant is not the same potash that existed in the mineral. It has a higher form. It can now nourish animal life, which it could not do before. The phosphate of lime in the bones of the animal is not that of the mineral. Both potash and lime are now capable of intensifying vegetation; i. e., supporting higher forms.

28. The same elements nourish the animal as the

plant; but the plant drinks up mineral elements, the animal cannot. Hence the plant is the laboratory where the crude elements are refined for the production and support of higher forms of life. The same element, or what is so considered, changes its form by each assimilation; and hence the infinite variety in the form and properties of matter, elements being but stages of progress, between which there is a continuous series of steps.

29. As change is limitless, progression is infinite. Infinite progress and the infinite divisibility of matter presuppose each other. If there are limits to the divisibility of matter, their progress, whenever it attains the ultimate, bounded by this organic limit, must cease, and nature fall into eternal stagnation. If, as we have attempted to prove, infinite progress is a law of nature, we must, according to the present system of philosophy, seek the cause of this progress in the infinite diversity and divisibility of matter.

30. The unlimited diffusion of musk, the minuteness and perfectness of nutrient fluids in the microscopic infusoria, the impalpability of odors of all kinds, have been catalogued as proving the infinite divisibility of matter; but these sink into insignificance when compared with the so-called imponderable elements, which by their ethereality refuse the test of the scales, and only indicate their presence by their effects. The subtile elements, heat, light, electricity, and magnetism, incomprehensible as they appear, are exceeded by the still more sublimated elements of spirit and of thought. But of this in another place.

31. The eternal mutation of the elementary constituents of matter produces infinite variety, so that not an atom in nature is like another. All are different.

This is beautifully illustrated by the prism. A ray of light passing through it, is divided into a rainbow of colors. If the particles composing each color were identical they would all concentrate in a distinct band; on the contrary, although concentrated in a band by itself, scattered particles are spread over the whole spectrum. Each color is differently constituted from the others, and each component particle is different from all the others. If it were not so, no scattered rays would be found. Thus infinite variety, eternal permutation, is the order of creation.

32. This outline will be filled when we extend the subjects of which it treats, and apply to facts the principles here discussed.

33. Nothing more strongly impresses us than the necessity which drives cause to its effect. Effects are produced by absolute necessity, and cannot be otherwise under given conditions. There is an iron necessity, unyielding, inflexible, and unheeding prayer or intercession. It sinks the ship though freighted with saints. It turns not aside for an archangel. Fire will burn a saint as well as a demon. Who can see the storm march on with resistless fury, unheeding the prayers of those it crushes, the mad ocean dash over the foundering bark, or the oscillations of the stellar heavens, without becoming deeply impressed with the imperative necessity which governs nature? We cannot stay our breath, assuage the storm, calm the ocean, control our birth or death, or violate the least established order. It is the same to fire whether it burns living or dead matter — the wood in our grates, or our dwellings. It is the same to gravity whether it brings the apple to the ground, chains the planet in its orbit, or drags us from the brink of the precipice to destruc-

tion. Well was it spoken long ago, that nature could be governed only by obeying her laws. Think of it as we will, we are hedged in on every side by imperative necessity. The worm which crawls along the pathway, the world rolling in its orbit, man grasping at the solution of mysteries, every thing, organic and inorganic, is driven on by destiny. There is no revocation or suspension of the defined order. It is the property of steam to explode, of fire to burn; and these never vary. We seek to understand these conditions and properties, and are happy only as far as we conform to them.

34. We would not array this course of reasoning against the existence of a God. We have not, nor shall not, enter the domain of theology. That whole province is left to the theologian, who may prove the existence of such a God as he chooses, and show how these attributes are but efforts of his will. We are in the field of philosophy, and are justified only in going so far as our observations lead us. We have laid aside educational prejudice as far as possible, and sought to trace facts to their causes. In the strict observance of this principle we cannot go farther than the attributes of matter, until new light is shed on the pages of nature. But if the theologian, pursuing another path of inquiry, meet us at this point, then the system of creation is complete, and we cordially grasp hands as brothers in the study of divinity.

35. We have arisen by successive steps from the first manifestation of life, in the attraction of atoms through the cell, to sensation and intelligence. We do not bring assumptions of the metaphysicians to our aid; we rest on the observation of nature alone, far above cant and the idle play of words.

36. It is admitted that the physical world is governed by fixed and immutable law. We shall endeavor to prove the same true, not only of the world of life, but of mind. The operations of law in the two last provinces are obscure, and hence their phenomena have been referred to the direct action of Deity; for men had rather refer an effect they do not understand to miracle than to confess their ignorance. But slowly the domain of chance and mystery has been narrowed, until small indeed is its area; and there is hopeful promise that it will become absorbed in the sunny land of science, and not a corner of creation left for the goblins, Chance and Miracle, to hide their wretched forms.

37. We assume what we shall henceforth endeavor to prove: that every cause pursues an established path to its effect; i. e., every phenomenon is produced by established law. We may be ignorant of the *modus operandi* it pursues; it may appear mysterious; yet we are assured law is in operation, however veiled. In the philosophical study of nature we must adhere strictly to facts and their deductions, nor be drawn aside by educational prejudice, or received religious ideas, nor be frightened from conclusions by consequences. We must reason from the data before us with boldness and decision. In so doing we make a sure advance in knowledge, for every step taken in the right direction gives us a more comprehensive view of nature, and draws us nearer to the Infinite Mind.

CHAPTER II.

THE ORIGIN OF WORLDS.

Nebular Theory of the Creation of the Universe. — Geological Testimony. — Increase of Temperature. — The central Ocean of Fire. — Volcanoes sympathetically related. — Earthquakes. — Torridity of Climate of the ancient Eras. — Figure of the Earth and Planets. — Geography of the Moon. — Lunar Volcanoes. — Physical Constitution of the Sun. — Rings of Saturn. — The Asteroids. — Intimate Relation between the Members of the Planetary System. — Size. — Distance. — Density. — Direction of Revolution and Rotation. — Eccentricity and Obliquity of Orbit. — Planetary Laws. — Comte's Calculations. — Nebulæ. — Herschel's Conclusions. — Refutation of the prevailing Theory. — Nebulæ of Andromeda, Argo, and Orion, Change of Form in; Distance of; Constitution of. — Magellanic Clouds, Constitution of. — A Review of the Heavens, and Conclusions.

38. If we commence an excavation on a level plain, we shall, as we descend, cut through various layers of clay, sand, and gravel reposing horizontally one above the other. If it is a plain bordering a river, for the first hundred feet or more, we shall find these strata of alluvial formation referable to floods which have occurred during long centuries, each having thrown down a deposit of clay, mud, or sand, borne from the distant sources of its tributaries.

39. After descending through these recent deposits, containing remains of existing plants and animals, such as flourish on the river borders, we meet with older strata, containing forms with which we are totally unacquainted. As we continue to descend, we meet with more unique forms, and these in rapidly diminishing numbers, until we come down to the primitive slates, gneiss, and quartz, when all vestiges of life fade out.

Lastly, after penetrating through these, all of which present unmistakable evidence of having been deposited from water, we meet with the granite, showing absolute proofs of having resulted from igneous causes. Though the various superincumbent strata differ widely in character in different localities, the granite invariably underlies them. It is the foundation on which all the other formations repose; it is the framework of the globe; it is not only the universal subjacent rock, but, on careful inspection, it is found to be the common parent of all others, however widely they differ from it in their various characteristics.

40. The primitive fires have written its history in its composition and crystallization too clearly to be mistaken — spread all around the world; torn and distorted, overlapping the more recent strata; thrown into lofty mountain ridges; cresting the Andes and Himalayas, by the terrific grandeur of the scenes it produces, it ever speaks of its fiery birth.

What lies beneath the granite? In this investigation we have found the same conditions as are observed in a partially cooled lava-tide. As we descend, the temperature constantly and rapidly increases. This remarkable fact has been long observed, and has been a perplexing problem in science. The increase varies with locality, as the underlying rock is a better or worse conductor, from thirty to over one hundred feet for a degree. The mean of all observations is about fifty-four and one half feet for a degree.

41. If this increase is constant, as stated by some authors, it is a problem reduced to numerical certainty that at a depth of less than fifty miles the most refractory substances must become fluid. Even

if Reiche's determination of one degree for every seventy-six and three tenths feet be accepted, or, more liberal still, one hundred feet for a degree, the thickness of the crust above the melting point of rock is but slightly increased.

42. This increase of heat cannot be constant. Wherever rocks or earth are of like character for transmitting heat, it is certain that the greatest escape of heat must be at the surface of the earth, especially if the surface is covered with water. If forty feet at the surface of the earth increases the heat one degree, it will require more than forty feet to produce another degree. The ratio will increase until the central lava is reached: experiment on a small scale will prove this position. If a quantity of iron rods are bound together, and one end of these rods is placed in a furnace, and the other end in water, it will be seen that the heat will escape much the fastest from the ends that connect with water than at the ends connected with the furnace, and that the increase of heat will be less, in proportion to the distance, as it approaches the furnace. If iron is thus affected, all other substances must be in a similar manner. This proves the earth's crust to be much thicker than has been generally calculated. The thickness of the earth's crust is unquestionably very uneven. In some places it may be two hundred miles, in others, especially along the range of volcanic action, it may not be ten miles. The average thickness may be nearly one hundred and fifty miles. The very different results obtained of the increase of heat, as a given depth is reached, is owing to the different substances having different powers of transmitting heat, or the internal lava being at a greater or less distance from the surface.

43. Is this crust the result of a cooling process continued through decades of millions of years, and was the earth originally a globe of lava? What evidences have we in answer to the assertion that such is the truth? The records of geology tell a plain tale. They could relate vastly more were the earth quarried. The form of the globe is that which it *must* be of necessity were it originally a fluid mass rotating in space with its present velocity. Its spheroidicity holds a direct ratio to the rapidity of its rotation — a relation which is inexplicable, unless its rotation determined the polar contraction, which it could not do unless the earth was fluid.

44. If the centre of the globe yet remains fluid, as the increase of heat as we descend proves, and this ocean of fire is enclosed by a thin crust, some indication of this internal state must be exhibited on the surface, as the crust contracts by cooling. Volcanoes are such manifestations. They are passageways to this deep-seated fiery sea. That they do not arise from local causes is certain from the fact that the volume of lava thrown out often exceeds several times the mass of the entire mountain. It has long been known that the power of volcanoes, wherever it may be located, is deeply seated, for a sympathy exists between widely-separated vents. Theories worldwide have been framed on stupid and ignorant assertions made by hobby-riding philosophers, and received as truth by learned societies because supported by such men. The theories of subterranean rivers and lakes of fire of small extent, the action of the alkaline bases, and the energy of electric currents, stand on a par with the thousand other erratic wanderings of befogged reason guided by diseased fancy.

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Universal effects cannot be accounted for by local causes.

45. The situation of volcanic vents along great fissural lines, as on the crusts of mountain chains where great distortions of the strata have occurred, is a strong indication of their deep-seated origin.

46. The chain of the Andes, stretching from the Polar Sea along the western shore of the Americas, in a series of magnificent crests, and ending in the terrific fires that illume the frozen shores of the antarctic continent, is the external manifestation of a great fissure which extends down to the realms of internal fire. If the theory of internal heat were true, along such a fissure volcanoes should be situated; but if not, then we should not oftener find them there than isolated on the plain, for all these mountain chains running in the same direction are of the same age, although situated in different hemispheres — a fact illy conforming to the idea of local causes.

47. Active volcanoes are generally situated near the sea — a fact which strongly supports the theory of internal fire; for there, where the land is constantly removed from the coast line, and carried away by the ocean, the established equilibrium of the pressure of the crust on the subjacent lava is disturbed, and along the line of such disturbance volcanoes and earthquakes would be expected. Thus this inexplicable phenomenon becomes a link in the chain of evidence here brought together.

48. The same great waves which produced the fissural lines determined the form of continents, thus again showing the sympathetic relations existing between remote effects.

49. The conclusions derived from induction are

confirmed by observation. Along the entire range of the Rocky Mountains the remains of extinct volcanoes are plainly visible. They are now silent, like those of Auvergne in France; but they are, perhaps, reposing for renewed efforts. In the Cordilleras and Sierras active vents are met with. Popocatapetl, Casiguino, and others, together with the entire length of the Andes chain, are but a series of volcanic activity. The four great Mexican volcanoes, Colima, Jorullo, Popocatapetl, and Orizaba are on the same fissural line. Jorullo, when it broke forth in 1759, sprang directly over the linear line which connects the other three. On the same night that Orizaba was in action, four hundred and eighty miles to the northward, Aconcagua was belching forth its fires, and two thousand seven hundred miles still farther north, Casiguino, which had remained at rest for twenty-six years, burst forth anew, accompanied by an earthquake felt over an area of more than one thousand miles.

50. Such phenomena prove the cause of volcanic activity to be deep seated and wide spread. The earthquake felt at Lisbon traversed the Atlantic, and was plainly perceptible at Quebec and on the great lakes of America, and from Sweden on the north, to Africa and Martinique on the south, an area many times the size of Europe. To understand phenomena of such magnitude we must recognize adequate causes. Are we not forced to admit that we stand on a thin crust, beneath which the primitive fires yet burn slowly and dimly in their expiring hours? A thin and yielding crust, which bends in lightning waves to the earthquake, sinks and rises, forming extensive fissures; bends and contorts

under the energy of the interior forces which here and there burst forth in volcanic fury. Lo, all beneath is fire, the fire of the new-born world, still unsubdued!

51. Though admitted to be extremely probable, it may be objected that the theory of the earth's former fluidity cannot be demonstrated. It of course cannot, from its nature, be demonstrated like a problem in mathematics, but there are other methods of arriving at correct results. We are endeavoring to unite the detached links of evidence in a perfect chain of argument. The decrease of temperature, caused by the slow decrease of the eccentricity of the earth's orbit, has been produced as sufficient cause for the high temperature of ancient times. Admitting that such variations cause changes of temperature, they cannot exceed a few degrees without endangering the safety of the system; and the immense forests of tropical plants which flourished at the present poles during the ancient coal period, together with the entire flora and fauna of the early epochs, indicate a high temperature in those localities. This warmth of climate has been referred to the form of the ancient land and water. If the land was all at the equator, and the water at the poles, it is evident that a much warmer climate would result. The elevation of arctic lands, or mountains, greatly depresses the warmth of climate, and the character of the strata reposing on the summits of these, shows that they are of comparatively recent origin. But allowing the most favorable distribution of land and water possible, it would fall far short of producing the requisite elevation of temperature which is well known to have existed, especially during the coal era, at the present location of the poles. Hence we must admit that a more than torrid tem-

perature prevailed at the poles, or that the poles are not fixed, as has been supposed, but have removed from their former position. If we take the first position, we meet with unanswerable objections. If the temperature at the poles exceeded the heat of the tropics, the then existing torrid zone must have been a desert, the furnace heat of which no living being could endure; and what is still more fatal to the position is, that by no tenable theory can this astonishing temperature be accounted for. For at the dawn of the coal period the crust of the earth had attained at least three fourths its present thickness; and if at present the escape of internal heat is not sufficient to melt a stratum of ice one millionth of an inch in thickness, how can such an astonishing temperature be accounted for by this argument? If, on the other hand, we presuppose the movement of the poles, no great elevation of temperature need be entertained; for if we remove the poles, we also move the equator towards their former position. Present facts point towards this theory. It is readily seen that the ice phenomena of the poles must leave deep traces on the rocks. Hence, if the poles have been removed, the point they formerly occupied, as well as their line of advance, must be plainly traceable. Investigations to determine this point have not yet been made, both from the character of the region in which these phenomena probably occurred, and also from the vagueness in the few observations which have been made. It is probable that the site of the north pole in the tertiary period, was near the Caspian Sea, and that it advanced to its present locality in a parabolic line. When this region, together with Thibet and Northern India, is carefully explored, it is highly probable that facts having a strong bearing on this question will be developed. Of the probable cause of the changing of the poles, mathematics would suppose that it was a poising or balancing of the earth, to induce an equilibrium which at first was not established. Conjecture might call to its aid the less probable causes of cometary collisions or planetary attractions.

52. The strata of the terrestrial spheroid are not only concentric and elliptical, but the lunar inequalities show that they increase in density from the surface to the centre. This certainly would have occurred if the earth was originally fluid, for the denser parts would subside towards the centre, and the lighter remain at the surface. The pressure of the superincumbent mass contributes to this result, but not in the degree philosophers have supposed. It has been computed that if gravity alone exerted its influence, steel would be compressed into one fourth, and stone into one eighth, of its volume, if placed at the centre of the earth. This would make the earth much too dense to agree with its ascertained influence on the moon; and hence it may be inferred that another force exists. What can it be but the antagonistic expansion caused by the earth's central heat? This conclusion must be received, or the idea of the earth's cavernous structure be adopted—a conclusion worthy only of the dreams of ignorance.

53. Every contortion of the earth's strata, every mountain peak and gorge, every uplifting or depression of continents and islands, is direct testimony of the fiery state at present prevailing in the central regions of the globe. The composition of its rocky framework speaks in an unmistakable voice, seconded as it is by the structure of all the planets and stars revealed

by the telescope. Planets are not round, in the form of a liquid mass freely suspended in space, but spheroidal, a form necessarily generated by the revolution of a spherical liquid mass on its axis; but to the telescope their surfaces reveal the jagged, mountainous surface produced by volcanic action on their crusts.

54. The moon, by its nearness, affords the best opportunity for examination. The surface shows mountainous masses, towering to a great height from the centre of vast and rugged plains, and in other places several long chains extend in a remarkable manner from a common centre. Dip valleys occur abundantly. They are known to be such by the manner in which the light of the sun falls into them. The height of the mountains have been estimated by Schorœter, a German astronomer, to be five miles, while the valleys are four miles deep. The same astronomer affirms that in proportion to its size the surface of the moon is much more broken than the earth's. Herschel supposed that he had obtained decisive evidence of the existence of volcanoes in the moon. Not only did he discover, as he thought, the light of their fires, but accumulations from their action, after the fires were extinct. When it is considered that an object at the distance of the moon must be a mile in diameter to become visible to the highest magnifying power, we can scarcely realize the extent of convulsions which make themselves recognizable to earth. They, at least, must greatly transcend the most terrific the earth witnesses at present.

55. The surface is torn and distorted in every conceivable manner, and presents a very rough and jagged aspect. Such is the condition of the moon, almost devoid of an atmosphere, and with but little

water to level down by its disintegrating energy the broken surface, it remains a witness of its own fiery birth.

56. The planets are too far removed to be closely examined. Venus and Mars, the only ones which can present any proof, speak in the same language as the moon. Their surface presents mountainous elevations with intervening plains, and it is evident that they were produced by similar conditions.

57. The sun, by its constitution, bears according testimony. If it is the residual mass remaining after the detachment of the zones, or matter which formed its planetary system, and if its condition originally was gaseous from intensity of heat, then it remains as a self-evident deduction that a mass four hundred times larger than the combined volume of all the planets and other bodies of our system must remain incandescent for a much longer period after the bodies thrown from it have cooled. This must occur from two causes: first, the superior size of the sun, which, according to Galle,* is seven hundred and thirty-eight times greater than the combined volume of all its planets; and second, the enormous condensation of its superior mass. Now, the time elapsing between the birth of Neptune and Mercury, to finite comprehension is inconceivably great, and probably the first planet was inhabited while the latter was yet involved in the central body. The superior attraction, and hence the greater condensation, of the atoms of so large a body would produce a much higher heat than would be emitted from the smaller planetary bodies. The temperature, at the sun's surface, at present, must

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* Cosmos, vol. iv.

exceed by a thousand times that of molten iron. If the nebular theory be true, such a high temperature would necessarily exist, for reasons previously stated. I am well aware of the conflicting hypothesis, which is intended to sweep away this proof of the nebular origin of our system, and am prepared briefly to state the objections which array themselves against it. At most it is merely assertionary; and in the absence of antagonistic explanations, it has been adopted out of deference to its able supporter, Herschel. This hypothesis supposes the sun an opaque body, like the planets, but surrounded, several hundred miles from its surface, by a light and heat-generating atmosphere, or protosphere. The solar spots are breaks in this protosphere, through which the dark body of the sun is revealed. This hypothesis does not account for the existence of the penumbra around the dark nuclei of the spots, for the depressions or shallows so frequently observed, nor for the mottled, shagreen aspect of its surface. If it were true, the nuclei should be totally dark; whereas the light they emit, according to Herschel, is two thousand times that of the full moon. When we consider that Drummond's dazzling light produces a black spot when projected on the sun's disk, we can realize how brilliant these spots may be, and yet appear totally black. This hypothesis not only fails to account for the observed phenomena, but its foundation is mere conjecture. A light-producing atmosphere is wholly a fancy, and utterly without support. It simply serves for the classification of facts in the absence of any opposite theory. It was supposed that the nebular theory failed to account for the facts observed, for the polariscope showed that the sun's light emanated from a gaseous body, and not from a fluid or solid; but we will endeavor to explain all the heretofore unexplained phenomena in the simplest manner by its application.

58. First, let us inquire what conditions must prevail on the sun's surface if it is a molten mass. We can arrive at an approximate conclusion by studying the operation of like causes on earth. Increase the heat two thousand times above the melting point of iron, and it were easy to infer the conditions that would prevail. The most stable elements would become fluid, and incandescent with a light equal to the rays of the sun. The more unstable elements would be vaporized, and form a dense atmosphere around the fluid nucleus, while the gaseous elements would be driven off to an immense distance. These materials would, according to their degree of attenuation, form various concentric atmospheres, all luminous from intensity of heat. Apply these inferences to the sun. We shall then see the intensely incandescent fluid nucleus surrounded by a series of concentric luminous atmospheres.

59. The theory of a protosphere, as advanced by Herschel, derived its chief support from the evidence of the polariscope. This instrument made the light of the sun tell its own history. It proved that its light was derived not from a solid, but from a gaseous body. So far as this fact is concerned, it is equally applicable to one as the other theory. The protosphere and nebulous atmosphere would affect light identically the same. So far both theories explain the fact. Now, we ask, which gives the most rational explanation of solar spots? One theory presents no cause for the existence of the protospheres; the other goes far back, to the beginning of things. It is evident that the dense stratum lying next the solar nucleus,

formed of vaporized metals and metaloids, would not mingle with the permanent gases, which, greatly expanded by the intense heat, would tend to fly to an immense distance. If otherwise, from well-known laws, a homogeneous mass would result, as permanent gases are vacuums to each other. The lower stratum, formed of molten gases only at excessively high temperatures, would constantly arise, until it reached an elevation where it could rise no farther. Then condensing, it would be precipitated, to arise again. The still more attenuated external envelope, constantly saturated with the internal heat, would refuse to mingle with it, and thus distinct atmospheres would be formed. Unsubstantiated as this theory may appear, it has greater support than the gratuitous assumptions popularly received.

60. Sir John Herschel, in his explanation of the solar spots, adhered to his favorite hypothesis of a "protosphere," and maintains that this protosphere is broken through by hurricanes, or other vast aerial commotions, and through the openings thus made the dark body of the sun is revealed. Granting that the body of the sun is a molten mass, from which his light and warmth originate, on the supposition of solar hurricanes a far more tenable hypothesis can be framed. Disturbances in the dense substratum would generate whirlpools on its surface, which, by well-known laws, would produce deep, cup-shaped depressions, such as are seen in the solar spots. It is well known that light, passing from one medium into another, is greatly affected by the limiting surface between the two mediums. If the rays strike that surface at a large angle, some of them pass through, but most are reflected from it. If, however, the limiting surface

presents an acute angle, all the rays will be refracted. Such a surface is presented by the highly-inclined sides of the solar vertices, and hence refracted, all the light will appear black. The transition from partial reflection to partial refraction will take place suddenly, as a given angle cn the borders of the vertex is reached, and the dark nucleus be sharply defined. As the currents will be smoother around its border than farther removed, the light of the penumbra should be greatest there — an inference exactly according with observation. If, however, the spots are produced by whirlwinds, they should be of regular form, whereas they are very irregular. Granted ; but the objection is equally applicable to both theories, and while one totally fails to account for this discrepancy, the other offers an easy solution. The spots are seen by us through the rarer upper medium, which, agitated by currents, must greatly distort objects seen through it, and though the spots be perfectly circular, they would appear jagged and distorted when viewed through this outer envelope. Complicated as the phenomena are, presented by the solar disk, this theory offers a rational explanation of them all. The luminous mountains observed in eclipses of the sun, the mottled aspect of its surface, pores, streaks of light, &c., are all explicable by varying reflections and refractions of light produced by currents and agitations in the sun's aerial envelope. The assumption of hurricanes may be considered gratuitous; yet when it is considered that the solar spots occur almost always within a zone extending thirty degrees each side of the equator, a region corresponding to our torrid zone, in which whirlwinds prevail, it must be admitted that the supposition at least is plausible.

61. Turning now to the individual consideration

of the planets, we find the facts presented pointing in the same direction. The rings of Saturn were seized by the vigorous intellect of Laplace, and brought to the support of his theory. If the idea of special creation or final cause be supported, well may it be asked, Why did the Creator give rings to Saturn, which, surrounded by its six moons, can have little need of them, while Mars is left in total darkness? If there was any special *design* in the plan of the solar system, the rings should be given to a moonless planet; that they were not, teaches the reverse. What is remarkable, Saturn's rings are in precisely that position they should be, according to the principles of mathematics. If the nebular theory is true, we should not expect rings around the small planets with slow diurnal motion, but around a large planet of rapid diurnal revolution. It is evident that a ring thrown off from a dense nucleus, in which the centripetal and centrifugal forces are balanced, must ultimately become resolved into a planetary body, from its inability to maintain its equilibrium. For like reasons we should not expect such zones on the outskirts of the system, for those planets were formed from gaseous matter. It would be still more improbable to find them at a great distance from any of the planets. The rings of Saturn occur just where they would be expected according to the nebular view. Surrounding a large planet, and one in which the centripetal force is extremely great, mark the coincidence that, at that distance from the planet, theory would indicate that zones would be most likely to occur; when the rapidly condensing nucleus, still half gas eous, half fluid, was sufficiently consolidated to give stability to the detached zone, while it gave it mobility of form. Only where the centrifugal force is very great, as it is in Saturn, can such rings be preserved. This relation is more than an occurrence of chance; it is a result of law, in accordance with which the solar system was created and is sustained, as is fully shown by the result of Laplace's calculations, which make Saturn's rotations to that of his rings as 427 to 438 — an amount of difference that was to be expected. Look farther, and another remarkable coincidence occurs. Between Saturn and his rings an attenuated zone of vapor is suspended, which sometimes covers, as with a gauzy veil, the face of that planet. Such a phenomenon is not presented by any other planet; and a moment's reflection will serve to convince any one that the preservation of a vapory zone is impossible, unless suspended, like this one, between two oppositely attracting forces.

62. In further support of the theory of nebular condensation, the asteroids speak in unmistakable language. If creation be referred to a final special cause, the existence of a swarm of very small bodies, moving in a very irregular manner, must remain involved in mystery. If, however, the theory here presented be accepted, their existence beautifully harmonizes with its inferences.

63. The zodiacal light, that twilight zone surrounding the sun, may be considered as a residual product of nebulous condensation, and when considered in this light is a strong evidence in its support.

64. From the individual consideration of the bodies of our system, we pass to their general consideration. If they were evolved by one cause, then a general similitude must pervade the entire system. Such is a legitimate deduction; but if they were created by a

final cause, the utmost diversity should be manifested. What are the facts? The first relation we will discuss is that of distance. If we take the distance of the earth from the sun as 1.0000,* Mercury will be represented by 0.38709, Venus by 0.72333, Mars by 1.52369, the Asteroids by 2.4500, Jupiter by 5.20277, Saturn by 9.53885, Uranus by 19.18239, Neptune by 30.03628. We perceive here, as a general expression, that each exterior planet is twice the distance of the next interior one. This is not perfectly true, nor according to theory should it be, but it approximates closely to the general expression.

65. As an illustration of this relation, it is interesting to learn that astronomers predicted the existence of a planet in the gap between Mars and Jupiter long before the Asteroids were discovered, and also the distance of Neptune from the sun before that body was observed.

As respects size, the planets nearest the sun are the smallest, and there is a gradual increase as the distance from the central orb increases. The zone from which Saturn originated was vastly larger than that which gave birth to Mercury, and consequently that planet must be proportionately large. Thus, as a general expression, the size rapidly decreases as we approach the sun. The external zones must have been composed of rarer material than the internal, and consequently there must be a relation of densities. If the density of the Earth be represented by 1.00, the density of Mercury will be represented by 1.12, Venus by 0.92, Mars by 0.95, Jupiter by 0.24, Saturn by 0.14, Uranus by 0.24,

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* Humboldt's Cosmos, vol. iv. p. 107.

Neptune by 0.14. These numbers are presented not for their accuracy, but because they give an approximation to the truth. The collateral sources of error are so many and great, that it would be absurd to pretend that these were more than estimates; yet crude as they are, they represent a general order. Velocity of rotation, degree of condensation, and difference of elementary constitution, fully account for the irregularities observed.

66. If the solar system originated from an extremely flattened spheroid of revolution, all the zones thrown off must of necessity rotate in the same, or nearly the same, plane, and the planets evolved from these zones must pursue pathways corresponding to the orbits of their parent zones. Apply this inference, deduced from purely theoretical grounds, to nature. We find that the planets revolve in orbits which almost perfectly coincide. The Asteroids depart widely, it is true; but other causes have operated on them than on the others, and they cannot be introduced as an objection. Mercury departs widest, and its inclination is scarcely more than seven degrees.

67. Kepler's great planetary laws must not be forgotten, which combine the elements of planetary motion in a relative proportion, so that when one is given the others can be deduced. They show in the most beautiful manner the intricate network which binds the solar system together, and prove, of themselves alone, creation by law, and not by special design.

68. Thus in our system we perceive a general order pointing to one great source. The planets all move around the sun in the same direction, and almost on the same plane. The satellites move around their

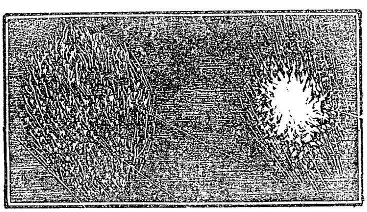
primaries in the same direction as the planets; with the exception of those of Uranus, their diurnal rotation corresponds with their motion around the sun, and with the sun's rotation, and their orbits have small eccentricity. Such are the elements of planetary relations. They point, not to a creation by an arbitrary power, but to a grand law of evolution. Those who argue the theological side of this question may advance in its support that the revolution of the planets around the sun in the same direction is necessary for the stability of the present order; but they must acknowledge that so far as stability is concerned, it would be as well if the rotation on their axes were in opposite directions, or if the sun did not revolve in the same direction as the planets.

69. Taking for granted that the system was evolved from a vaporous ocean, and that the volume of the sun filled the entire orbits of each of the successive planets when they were eliminated, M. Comte made a mathematical calculation what the rotation of such a mass should be, and the results he thus obtained very nearly coincide with observation. Thus the sun, when it filled the earth's orbit, previously to the evolution of the earth, should rotate on its axis in 365 days. Comte's calculation made its period 357 days—a close approximation in so intricate a problem. The moon's rotation differed from the results of his calculations by only two and a half hours. The same agreement was found with all the planets, in no case differing more than one forty-fifth of the period. If Comte's calculations are received, then the nebular theory becomes a demonstration of mathematics. If they are erroneous, it is difficult to detect the source of error.

70. Having glanced at the mechanism of our sys-

tem, and the constitution and inter-relation between its members, we will suspend our investigations here, and arise to the contemplation of systems outside of our own, and attempt to discover the relation they hold to the theory we are discussing.

71. When Sir John Herschel directed his great reflector to the scattered nebulæ, before irresolvable, and found them separated into countless stars, he came to the conclusion that if telescopic power were sufficiently increased, all nebulæ could be resolved into stars. After years of patient and conscientious investigation, however, he reversed his previous conclusions, and maintained that "there are nebulosities not of a starry nature." When the mammoth telescope of Rosse resolved nebulæ which Herschel deemed irresolvable, many astronomers returned to the latter's first conclusions, and maintained that the resolvability is solely a question of distance; that all nebulæ are galaxies of stars, some of them far surpassing in splendor our Milky Way, and that distance alone veils their beauty from our eyes. Such is the prevailing supposition, and by assuming it as demonstrated, its supporters consider the nebular theory demolished. We do not attack this position because it conflicts with our theory, for so far as it militates, if all the nebulæ were blotted from the heavens, the theory would stand unharmed; for although nebulæ first suggested the idea of



cosmical world vapor yet uncondensed, its support is derived from various and widely separated sources. It were scarcely to be expected that cosmical vapor could be observed, as the same causes which condensed one mass into worlds would operate with equal force on all others. Its discovery is a remarkable illustration; its denial and disproof does not affect the theory.

72. Contrary to the idea that nebulæ are vastly remote star clusters, independent of our stellar system, we hold that they are intimately connected members of it. In support of this heterodox theory, we present the stellar mechanism. Their distribution in space, and relation to surrounding stars fully maintain our position. "The spaces which precede or which follow simple nebulæ," says Arago, "and *a fortiori*, groups of nebulæ, contain generally few stars." Herschel found this rule invariable. Thus every time that, during a short interval, no stars approached, in virtue of the diurnal motion, to place themselves in the field of his motionless telescope, he was accustomed to say to the secretary who assisted him, "Prepare to write; nebulæ are about to arrive."

73. If there were no physical connection between nebulæ and our stellar system, it would be a singular occurrence for a nebula to be thus situated in a starless space; that two should be thus situated would be highly improbable, and that thousands should correspond in such a remarkable manner would be infinitely improbable. This law applies still farther. In those regions where stars are sparsely distributed, nebulæ abound. In the zone where stars are very numerous, they are extremely rare; while clustered around the poles of this zone, they are abundant. Scarcely any nebulæ lie near the plane of the Galaxy, but they are crowded around the galactic poles. Such evidence is overwhelming, and cannot be regarded otherwise than

as clearly demonstrating nebulæ to be integral members of our system.

74. Distance is not the veil which renders nebulæ irresolvable. It is taken as an approximate datum that the stars are remote inversely as their magnitude. Thus a star of the eighth magnitude is vastly farther removed than one of the first. This assumption, of course, is based on the supposition that all stars are of the same magnitude; but this is sufficiently accurate for our purpose. Of course the same will apply to nebulæ, and those scarcely discerned by the telescope must be considered more remote than those discernible by the naked eye. Hence, if all nebulæ are clusters of stars, the largest should be resolved, while the difficulty of resolution should increase as the magnitude diminishes. Such are not the facts. While the individual stars of a nebula of the eighth magnitude are clearly seen, the great nebula in Andromeda, two and a half degrees long and one degree wide, appears as a diffused mass. According to the popular theory, the instrument which fails to reveal a star when near, renders it plainly perceptible when removed to eight times the distance.

75. According to astronomers, the Milky Way is a lens-shaped nebula, and our sun is one of its component stars, situated near its centre. Its major axis is estimated at seven or eight hundred, and its minor at one hundred and fifty times the distance of Sirius. Now, the best telescopes fail to resolve the remote regions of this zone, while they easily resolve nebulæ of the eighth magnitude, which are supposed to be a million times the distance of Sirius. What shall we say of an hypothesis which supposes a telescope capable of revealing individual stars, a million times the

distance of Sirius, while it totally fails to reveal stars two hundred times the distance of that star?

76. The Magellanic clouds afford another strong evidence that nebulæ are a part of our system. "The nebula major, as well as minor, consists partly of large tracts and ill-defined patches of irresolvable nebula, and of nebulosity in every stage of resolution, up to perfectly resolvable stars, like the Milky Way; as also of regular and irregular nebulæ, properly so called, of globular clusters in every stage of resolvability, and of clustering groups sufficiently insulated and condensed to come under the designation of clusters of stars." *

77. From the intimate relation which exists in these tracts of nebulæ, they must be regarded as situated at nearly the same distance from us; yet while some portions show stars, others exhibit not the least indication of resolvability.

78. After a careful review of the heavens, we cannot otherwise regard these vapor-like masses than cosmical vapor in various stages of condensation. We find that its state is constantly varying, sometimes appearing as elliptical disks, single or in pairs, occasionally fan-shaped, as an electrical flame variously branched, or like well-defined rings enclosing an unoccupied centre. Here and there are spots gradually fading away from a bright nucleus, which is usually a star; at other times forming a luminous homogeneous spot. These stars are not accidental bodies projected on a nebulous ground, but a part of the nebulous matter which surrounds them. In these masses a mutual relation of parts must exist.

* Herschel, Observations at the Cape, p. 146.

79. The nebulæ in Andromeda and Orion are among the few which are discernible to the unassisted vision. On a clear evening the one in Orion is plainly visible, resembling a luminous wisp of cloud. When highly magnified it presents a mottled or curdled surface. There is no indication of stars, and the appearance is entirely different from those nebulæ which are resolvable. Here are two large nebulæ, very much nearer to us than stars of the eighth magnitude, plainly perceptible to the unassisted eye; yet, while the telescope resolves nebulæ seen only by its aid a thousand times farther removed, it fails even to approach a resolution of these. Such are the evidences which favor the hypothesis, that all, and more than all, the largest telescope reveals, form one great world-continent. Thus the distance of sixty-one cygni from the sun is computed to be six hundred and fifty-seven thousand semidiameters of the earth's orbit, a distance which takes light two years to traverse; and Herschel estimates that a star revealed in the Milky Way by his twenty feet reflector is so remote that light would be two thousand years traversing the incomprehensible interval. Such is the vast extent of the stellar system to which our sun belongs. Yet it has bounds. It is supposed we are nearer one side of this system than the other. If so, there is a possibility, with sufficient telescopic power, of looking out into space, as, when on the border of a forest, we can look out on one side, but trees and branches shut out the view in the opposite direction. This has been accomplished,* and the patient observer has been gratified by the appearance of the illimitable space-ocean seen through the vista of stars.

* Herschel's Astronomy.

80. If the stellar system is circumscribed on one side, it must be on all others. If so, it is not infinite, but has limits. Star clusters and detached stars are but component members of one system evolved by a common cause. After we have investigated the origin of the solar system, we shall apply the same principles to the creation of this stellar system, or world-continent.

81. The magnificent condensations which must be taking place in nebulæ are occasionally observed. Direct observations show that changes of form are occurring in Andromeda and Argo, and in the interior portions of the great nebulæ in Orion. These movements are confined to a series of aggregations and condensations. Herschel, by noting the variations in the light of a star passing through the nebula in Orion, and year by year finding less and less interference with the stellar light, drew the inference that motion was occurring on that border where the star was located. Other masses are not as favorably situated, having no star near them by which we can mark the changes which are gradually progressing, and are so much farther off that the movements must be so great, to produce a visible effect, that millions of years must be allowed. When we consider the distance at which the nearest is situated, we find that a concentration of a million of miles in their diameter would not be apparent, as it would not appear, at that distance. more than the thinnest line.

82. In view of such facts we must admit the existence of self-luminous vapor scattered in detached masses through the regions of space. When we look out into the sidereal heavens, and sweep past these bodies with the telescope, the growth of worlds becomes to us as the growth of trees in a forest.

Here we see a tall, magnificent oak. Did it grow from an acorn? By its side we see a smaller oak, one still less, a sapling, a little oak just creeping out from the acorn shell, and an acorn. Are we not justified in concluding that the oak, tall as it is, sprang from the acorn? Here, time is represented by distance. Several centuries which intervene between the development of the oak from the acorn are supplied by a few feet of ground. If all the undergrowth was destroyed, and we were placed by the side of the oak, perfectly ignorant of its origin, we should reflect without making the least advance towards an accurate conclusion. The undergrowth reveals its history.

83. So it is among the stars. Here is a world-ocean; there it condenses; in another place the process is carried still farther; and, in another, a mass transformed into a stellar system is presented. Space here supplies countless ages of time, and by a few moments' observation of the heavens we can read the history of a million of ages.

CHAPTER III.

THE THEORY OF THE ORIGIN OF WORLDS.

Cometary Vapor. — Primoidal Nature of Nebulous Vapor — Origin of Comets. — Production of Planetary Zones. — Experiment. — Cause of Revolution and Rotation. — Form and Size of a Stellar System; Centre of; Motions of. — Special Design, &c.

84. Comets show the possibility of reconverting solid matter to its original vaporous form. When these wanderers rush down from the outskirts of the

system past the sun, they are subject to the intense heat of its rays — a heat in some instances two thousand times that of red hot iron. This temperature not only vaporizes the matter of which they are composed, but expands it to vast dimensions until it is so attenuated as to appear like a speck of cloud or lock of down, admitting the passage of the sunbeams through them uninterruptedly, reflecting light from their internal as well as external surface, and not intercepting the light of the smallest star.

85. Of like nature was the world-vapor from which our system was evolved. After the foregoing researches we are justified in assuming data, and proceeding to harmonize the diversity of facts which are embraced by our theory. Let us assume the existence of a mass of world-vapor, the diameter of which, at least, is as great as the distance of Sirius.

86. Of the primoidal condition of this vapor nothing can be known. To say that it was an ocean of fire involves inexplicable difficulties. The heat manifested at a later epoch undoubtedly resulted from condensation — was an effect, instead of a cause. After great condensation by gravitation, matter is first presented to our contemplation as an intensely heated vapor. Previous to this epoch nothing is known.

87. Having assumed the existence of such a mass, let us study the changes which must necessarily occur according to well-known physical laws. This ocean of vapor would contain all the elements, gaseous and solid. No compounds could exist from its intense heat; but all would be resolved to primitive elements, and

these elements mingled in a homogeneous mass Every atom of this ocean would tend towards the common centre. This would round into a spherical form, and by condensation develop heat, which would resist condensation until radiated. The process, in consequence of the vastness of the mass, must progress slowly. As the temperature diminished, chemical laws would operate. The denser material would gravitate towards the centre, while the lighter would constantly tend towards the external; hence the central portion of the mass must become more and more dense than the external. Particles of like nature would attract each other, and similar masses would result. These would take directions towards the centre in accordance with their form and density. They would rotate in various directions around the common centre; but there would be an infinite improbability that a perfect equilibrium would be preserved: a greater number, or larger flocculi, would revolve in one direction than another. These would establish an independent rotation of their gaseous envelope, which would gradually draw into itself all the other flocculi, and the entire mass would revolve in common on its axis. Thus rotation was produced. Of the existence of such flocculi we have proof in the matter which constitutes comets; for, according to Herschel, "the luminous part of a comet is something of the nature of smoke, fog, or cloud, suspended in a transparent atmosphere."

88. This process we can see, by the aid of a powerful glass, in the heavens. As before stated, and in remarkable harmony with the theory, it is not the largest nebulæ which are resolvable. The large and irresolvable nebulæ are of irregular outline, showing

that they are not condensed. Arago says, "The forms of very large diffused nebulæ do not appear to admit of definition; they have no regular outline." In such nebulæ the process of condensation has not proceeded far enough to round them into symmetry. On the other hand, the globular and spiral nebulæ are resolvable. The spiral nebulæ, which are in a transitional form between the irregular irresolvable, and the globular resolvable nebulæ, as theory would advocate, must be more condensed, and hence small, which is true. In them there must be a partial aggregation. The spiral streaks of light which their surfaces present, correspond to the paths of aggregating matter moving towards the centre, as developed in the preceding course of reasoning. At the centre, spiral nebulæ are resolvable — a fact also remarkably in accordance with the abstract theory. At the centre the smaller masses should unite into larger ones, and these into still larger, until a few bright orbs should take the place of the detached masses.

89. Globular nebulæ bear out the theory still farther. They are always resolvable, and always present a dense clustering of their constituent masses around the centre; and as the degree of this concentration must vary, so do we find all degrees of aggregation.

90. Comets, according to Laplace's theory, had no place in our system: they were chance wanderers from system to system. This theory has never satisfactorily accounted for their existence, and on this ground a great objection has been urged against the whole nebular theory. But let us see if the apparently insurmountable objection cannot be rationally explained. The flocculi, before mentioned would,

under the influence of their irregular forms, take spiral pathways towards their common centre. On their journey they would unite in larger and larger masses, until complete condensation resulted; but it would be improbable that all should be thus drawn in. Composed of lighter material, those from the most external portions would be delayed until the formation of planetary zones, when they would remain distinct, and revolve in orbits of their own. Coming from all parts of the external region, and remaining distinct and uninfluenced by the rotation in common impressed on the gaseous envelope, their motion would have no relation, in direction, to that of the planets. In accordance with this abstraction of theory, we find that out of two hundred and ten comets known in 1855, one hundred and four were direct, and one hundred and six were retrograde. Another very significant fact is, that although comets come from all parts of the heavens, they are by no means equally distributed; they are far more abundant at the poles of the ecliptic than at its plane. It is estimated that for every comet coming from the plane of the ecliptic, 11.5 come from its poles. This fact not only overthrows Laplace's theory, and that of Lagrange, who considered them fragments of exploded planets, but clearly proves that they are not accidental bodies; it shows that they were created by some law. While planets revolve in circular orbits corresponding with the plane of the ecliptic, and in one direction, comets are their opposites in having a close relation to the poles of the ecliptic, revolving in extremely eccentric orbits, and having both direct and retrograde motion. These characteristics, peculiar to them, were undoubtedly received by the physical properties of the rotating nebulous ocean.

91. When the mass had sufficiently contracted to establish a rapid rotation, its poles would contract until it became an extremely flattened spheroid, or lens-shaped. The external portions of this mass, overcoming by their centripetal force their gravity, would become detached, and form a ring around the central mass, such as Saturn's rings illustrate. If the rotation of the central mass were perfectly arranged, all the zones, and hence planets, must revolve in identically the same plane. If we consider, however, that the independent flocculi, previously to their being drawn into the central aggregation, must revolve in orbits cutting the common rotation at every conceivable angle, the slight diversity existing among the planets is readily accounted for. Those planets first formed would partake of this disturbing cause more than those formed after perfect rotation had been established; and we find that the orbit of Mercury, the latest formed of the planets, makes an angle with the sun's equator of only one third of a degree. The earth's orbit makes an angle of seven and one third degrees, and the external planets still greater.

92. A German professor instituted a very beautiful experiment in illustration of the nebular theory. He suspended a globule of oil in a fluid of precisely its own density, which of course negated the gravitation of the globule thus suspended; it at once assumed a globular form. By an ingenious contrivance it is made to rotate on its axis. It immediately becomes spheroidal, and its spheroidal form increases until a fine ring is thrown off near its margin. This ring continues to revolve, soon breaks up into detached masses, which unite, and, rotating on its axis, the

resulting globule again throws off rings imitating in miniature the solar system.

93. The various rings must be of the same density as the material of which they are formed; and as the density increases from the surface to the centre of the nebulous mass, the density of the rings, and hence of the planets, must conform to this arrangement of materials, the most external being the lightest, and the internal the heaviest; which is true to a remarkable extent.

94. The rotation of the planets on their axes in one direction points to a common law of genesis. This was determined by the form and rotation of the rings from which they originated. Laplace supposed that the breaking up of the rings, and the direction and amount of rotation of the resulting planet, were dependent on the difference of velocity in the external and internal portions of the rings; but the phenomena resulting from differently formed rings are obvious. Zones thrown from an exceedingly large and nearly spherical mass would be shaped like a hoop, having very much the greater diameter at right angles with the plane of its rotation, while a zone thrown from a smaller rapidly rotating spheroidal mass would have its greater diameter corresponding with its plane of rotation. In the former case the resulting planet would have a slow rotation; and from the small difference between its interior and exterior portions, a retrograde rotation might be established. In the latter case direct and rapid rotation must follow. Apply this course of reasoning to the solar system. As a rule, the large planets have a rapid while the small planets have a slow rotation. This is fully explained by the inference drawn from the theory, which is self-evident, that a

large planet necessitates a large zone; and the difference between the exterior and interior velocities must generate great rotatory power. Uranus, and probably Neptune, have a retrograde motion, judging from the motion of their moons, and hence have been urged as objections against the nebular theory. But when we consider the circumstances of their evolution, the difficulty, so far from being insurmountable, vanishes. Uranus is of small size compared with the two next interior planets, Jupiter and Saturn. From the vastness of its orbit, the zone from which it was produced must have been extremely slender; in consequence there would be little difference between the relative velocities of its internal and external portions. Hence the direction of rotation of the planet would be but slightly influenced by this cause, and hence a rotation nearly perpendicular to the plane of its orbit. While Saturn's orbit is only one half the diameter, its size is eight times greater. Hence its genetic zone must have had a considerable breadth, and in consequence the planet has a direct rotation differing from its plane of translation by only thirty degrees. The orbit of Jupiter is only half that of Saturn, while its size is more than three and one half times greater. Hence the plane of rotation of this planet differs from its orbit but three degrees. The zones from which Mars, Earth, Venus, and Mercury were formed, considering the small size of these planets, must have been extremely small; and hence the plane of rotation again diverges.

95. Having thus inquired into the causes of the planets' genesis, we may ask an explanation of their rotatory force. It is an axiom that in a nebulous mass the farther particles have to travel before reaching the

centre, the more rapid will be their velocity. The larger the genetic ring, the greater the velocity of the planet. We see this condition in Jupiter; and it rotates in less than ten hours, while Mars, Earth, Venus, and Mercury, whose rings must have been slender, take double that time. The smallest takes the longest.

96. These facts are without meaning unless the nebular theory be received. By its aid all this diversity of phenomena is harmonized, but without it they become meaningless, and each one casts a slur in the face of the received hypothesis of a final cause.

97. The satellites repeat in miniature the solar system. They rotate on their axes in the same direction they go around their primaries, and their orbits diverge but little from the equations of their primaries. When we pass inward across the planetary orbits, we find two bodies of nearly the same size; then they rapidly increase in volume, and then decrease as rapidly. This singular arrangement is repeated by all the secondaries. Jupiter's two outer satellites are the largest, and according to Lassell, the same is true of the four satellites of Uranus. In Saturn, from the large number of satellites, their arrangement is still more complete. The three outer satellites are large, the inner ones small. Those next to the planet can scarcely be discerned by the best telescope, while one of the external ones is nearly the size of Mars.

98. By the nebular theory we can not only determine where satellites should be found, but their number also. We know these problems depend on the rotatory velocity of the planets. In order to form a satellite the centrifugal force of the planetary mass must exceed its gravity, that the exterior atoms can be thrown off. Although great changes in velocity may

have taken place, we are justified in supposing that in those bodies where it is greatest at present it has ever been the greatest. Now, granting these data, those planets which rotate with the greatest velocity should have the most satellites. Apply this to the planets. Let us estimate what proportion the centrifugal force bears to gravity. In Mercury it is $\frac{1}{362}$; in Venus, $\frac{1}{282}$; these planets are destitute of moons. In the earth it is $\frac{1}{289}$, and the earth has one moon; in Mars, $\frac{1}{326}$; in Jupiter, $\frac{1}{14}$, and this planet has four satellites; in Saturn, $\frac{1}{6.2}$, and the planet has eight moons; in Uranus, $\frac{1}{9}$, and the planet has six satellites. There is one exception to theory here. Venus has, according to the received computation, greater centrifugal velocity than the earth, and should have a moon. According to several noted astronomers* it has one, and Lambert calculated its elements. If, however, this should prove erroneous, it remains that the diameter of Venus is variously estimated, and its centrifugal force in consequence may hold a less instead of greater ratio to that of the earth's. If so, these relations are incontestable arguments in favor of our theory.

99. Another fact still remains equally conclusive. The moon rotates but once on its axis at each revolution around the earth, and hence always presents the same surface to the earth. We may well ask why this is so; for, as a work of design, it is a failure. As a luminary, to us it would have served its purpose equally well if it revolved with greater rapidity, and for the benefit of any future inhabitants of the moon such an arrangement would be vastly better. According to Laplace, the supposition that this arrangement

* Cassini, Roedkier, Montague, &c.

resulted from chance is infinitely improbable, but that by the genetic laws of our system such an arrangement would be very likely to establish itself; and he also shows, from the same laws, that the lateral oscillation called the moon's libration would arise.

100. Equally beautiful relations exist with the satellites of the other planets. This relation has become familiar in regard to Jupiter's moons; and such is the relationship between them, that, the distance of two of them being given, that of the others can be accurately found by calculation.

101. These views have yet to be extended to our stellar world system. The same principles are displayed throughout its infinite domain as in the formation and revolutions of a satellite. A moon and its primary is a type of the universe. The solar system is lens-shaped, because it was evolved from a rotating spheroid; the stellar system, to which we belong, is lens-shaped, because it was evolved from a greater rotating spheroid. Remarkable is the correspondence between comets and nebulæ. While comets crowd around the poles of the plane of revolution of the planets, nebulæ crowd around the poles of our stellar stratum, the line of whose orbit is represented by the Milky Way. Such a correspondence and similarity of constitution point to a similar origin, and it becomes a legitimate inference that nebulæ are to the central sun of our stellar system what comets are to our solar system: they are comets to the great central sun.

102. That such a central orb must exist, is a necessity of all systems of nature. There must be a centrality to chain sun to sun, else they would rush in straight lines through space, until, meeting with a controlling attraction, they would form orbits, and a

system would grow up by the arrival of new members, as each body added its attraction to that previously excited. A centrality would be thus created, were the stars thrown into the immensity of space, like grain from the hand of the sower. It is a necessity of the law of gravitation and repulsion.

103. If this stellar system has a centre, it has a circumference, as already proved by observation, a glimpse having been obtained of the exterior space-ocean which laves it on every side. So far as observation extends, it has a plane of revolution corresponding to our zodiac, around the poles of which the nebulous comets cluster.

104. Such is the nebular theory of the creation of worlds. It is in direct opposition to the popular hypothesis of creation. While every fact yet observed corresponds and supports the one, all negate the other. The mystery said to shroud the Deity is worthless in a scientific investigation. We must have facts, and a positive philosophy based on nature and reason.

105. If the universe was created by a final cause, why were some of the planets so abundantly supplied with moons, while others were left destitute? Special pleading may say that the moonless planets are so near the sun that they do not need moons. Nay: from the brightness of their days, the nights, by contrast, must be very dark, and need moons as much, if not more, than more external planets. But why, admitting the explanation, was a moon given to the earth, and not to Mars, which is twice the distance from the sun? Why were eight moons and three rings given Saturn, while Uranus has but four, (or, according to Herschel, six,) although he is twice the distance from the sun? What freak of fancy gave Saturn

his rings, and left the other planets destitute? Still farther: if these moons were created for the purpose of giving light to their planets, why were not the largest, instead of the smallest, placed next to the planet, and not so far off as to be nearly useless, while the smallest are of little use from their diminutive size? These questions are not cavil, but pertinent, and each one has power to overthrow the hypothetical dream of a final or partial cause. Moon revolves around its primary planet, planet around its sun, which, in common with the countless host which spangle the canopy of night, revolves around one common centre, which binds this stellar continent into one system, and moves in an infinitely extended orbit, as one planetary system around an inconceivably remote centre; and this centre is not established for one such system, but for a multitude, scattered through infinite space. Grand conception of the unity of nature! Splendid vision of the completeness of the great whole!

106. Thus began the present order of nature. Matter could not have remained dormant, and at that particular time have awakened to action. Perhaps it had existed in an infinite number of universes before, passing back to its primitive condition each time, slightly more refined, until it became capable of forming a system as perfect as the present. The reader may say this is too imaginative. Not so; for does not the earth show the marks of infancy, and do we not see infant worlds in process of condensation? The WORLD must have had a beginning. Matter without a beginning must have been active, in whatever form it existed; and the play of antagonizing forces would have built up and destroyed system after

system, in the lapse of an infinitude of ages. Matter, under the stimulating influence of the great principles or laws of nature, has been urged on in its progression, from its lowest state through various channels, until it ultimated in the various elements we witness around us. The primitive ocean was a stupendous mass of unorganized matter, in which the forces of electricity acted and reacted, in drawing together like materials; in separating order from disorder, and giving to each world the elements which suited it best. The world-forming experiment succeeded to the utmost that could be desired, and to-day the bright sunshine and the blue sky disclose the wisdom of God, as seen through his attributes acting on matter.

107. The earth attracted to itself the elements which were best adapted to its condition, and from those combinations the gorgeous scenes which are spread around us have arisen. The azure arch, the grand ocean, the activity of animal life, all, all declare the harmony and adaptation of these conditions, which connect remotest suns, chain the comets in their fiery paths, and ultimate in thought, wisdom, love, and INFINITE INTELLIGENCE.

108. We will now turn our attention from the magnificent contemplation of solar systems and stellar universes, to the special phenomena presented by our earth. As it is a type of the universe, if we understand nature as there presented to us, we shall understand it as it is presented in all other worlds. Let us analyze the effects we observe around us, and seek their cause.*

* Works consulted in the astronomical portion of this work: Humboldt's Cosmos; Herschel's Outlines of Astronomy; Olmsted's Astronomy; Fourier, Theorie Analytique de la Chaleur; Poison, Theorie Mathematique

CHAPTER IV.

HISTORY OF THE EARTH, FROM THE GASEOUS OCEAN TO THE CAMBRIAN.

It becomes liquid.—Law of cooling Bodies.—Creation of Water.—Deposition of the Metals.—Scenery, &c.

109. The intensity of the heat which resulted from the pressure of the atoms composing the earth, by the power of gravitation, was very great. As the earth radiated its surplus heat into space, it contracted its area until it became fluid. Its limits, at first extending beyond the moon, were greatly reduced, still of course its density was less than that of the atmosphere. Grand and awful was the scenery presented during the infinite period in which the forces of radiation and segregation worked on to their destiny. The lurid firmament glowed with the internal fires. Through the red haze the sun and stars shone with portentous hue. The blue sky and the mild beaming of the planets enlivened not this scene of wild commotion, but the terrific forces of the conflicting elements of the new-born world labored on in convulsions and fire.

110. By radiation the temperature continually decreased, and after a long succession of ages, a slight crust began to form over the fiery surface. A crust,

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de la Chaleur; Sargey, Physique du Globe; Newton's Principia; Madler's Astronomy; Herschel's Observations at the Cape; Nichol's Thoughts of some Important Points relating to the System of the World; Philosophical Transactions, vol. lvii.; Delambre's Histoire de l'Astronomie Moderne; Laplace, Expos. du Système du Monde; Nichol's Architecture of the Heavens; Vestiges of Creation, and Sequel.

however, would not begin to form until the temperature of the whole mass was lowered almost to the solidifying point. The process was like that which would occur in a globe of water in the same position. Under the influence of a high temperature, it would first exist as a vast body of steam. When the heat diminished sufficiently, the vapor would become fluid, and as the temperature diminished, the whole mass would be affected equally, for by the well-known laws of fluids, currents from the centre would tend to reduce the temperature of all parts equally. A crust of ice would next begin to form, until the entire globe became reduced to 39½ degrees, when the currents would cease; the surface would not fall to the centre, but would remain growing colder and increasing in thickness. If we endeavored to elevate the temperature of a fluid globe, it would be of little avail to apply heat to the surface, for the cold portion, being the heavier, would remain as near the centre as possible, while the heated surface, becoming lighter, would tend to remain in its position, and being an extremely bad conductor of heat, the subjacent stratum would remain unaffected. If we commenced with a globe of ice, its central portions would remain congealed until it was brought to the surface by the superficial stratum being converted into steam. The same principle is seen in heating a quantity of water. If the heat is applied beneath — the same as heat applied at the centre of the earth — the temperature rapidly increases, but if the process is reversed, the heat being applied at the top, the lower stratum will not be affected in the least. The same law holds good for all fluids; and had this fact been given its full weight by theorists, or by those who dispute the theory of original fluidity, there would never have been such untenable objections urged against it.

111. It is not a universal law that heat expands all bodies. Within certain limits it is true, but at some given temperature the increase of heat contracts instead of expands. Thus, if water in the form of ice at zero is heated, it *contracts* until it reaches 39 degrees; then it expands in a regular ratio with every increment of heat. Nor is it true that cold always contracts; for if melted iron be cooled, although contraction holds good to the point of solidification, the law then changes, and cold expands; though, in different elements, the points where the laws of contraction and expansion supplant each other greatly vary, being in fresh water 39½ degrees, while in iron it is 2000 degrees, all substances have these points, and in consequence many of the most astonishing effects around us are produced. To suppose that a crust should form on the surface of our planet, while the internal mass was intensely heated, is unphilosophical. The external particles, becoming relatively dense, would sink towards the centre, thus establishing tremendous currents to and from the surface, which would continue until the whole mass was cooled to that point where granitic atoms are not contracted, but expanded, by cold. Near this point a crust would begin to form. It is thus rendered certain that the temperature of the interior of the earth is little above the melting point of granite, and the central portion is not materially higher than that which laves the under surface of the congealed rock.

112. This overthrows the wild speculations which supposed the centre of the earth to be intensely heated, and several times denser than at the surface. The tem-

perature which must exist—just above the melting point of granite—would in a measure annul the force of gravity; and hence the density should not increase until water at the centre would occupy only one sixteenth its present volume, but it should remain nearly the same, and the density of the earth should be that which calculations based on other data have declared it to be—a result perfectly satisfactory, as has been shown in the discussion of the nebular theory.

113. At length a crust was formed over the fluctuating, igneous ocean. This, at first, was constantly ruptured by the waves beneath. It continued to thicken, and to attract to it affinitizing particles. But the equilibrium was unstable. The contraction of the fluid and solid matter being very unequal, the crust necessarily broke in fragments, and so gave vent to the internal fires. Tossed into wave-like folds and jagged pinnacles, the surface presented the appearance of an ocean congealed during a violent tempest. There were no mountains, but numerous elevations, for the crust was not yet sufficiently thickened to be elevated to any great height without breaking and immediately giving vent to the disturbing fluid. The rocky crust was not like common granite as it now exists, but porous and friable, from the slight pressure under which it was formed and the escape of internal gases. It was not the dense, hard substance which now juts up to the sky in the wild mountain peak, but was soft, and readily acted on.

114. It may be interesting to inquire at what point the fluid globe would begin to solidify. Not at the centre, as has been supposed, but at the surface, as has been previously shown. At what part of the surface? The earth, while an almost aeriform fluid, must have been

very much more spheroidal than at present. Currents would rise from its centre to its equator, and currents set in a counter direction; but these currents would not rise in a perfectly perpendicular direction, but would take the course of the least resistance from the centre, which would be along the axis of motion: arriving at the poles, they would produce such a surplus of matter there as to disturb the mechanical equilibrium of the spheroid, and hence would set towards the equator in spiral lines. During their long passage over the surface, they would become cooled by radiation, and when the internal portions had become sufficiently cooled, solidification would occur; first, on the equator, from which line they would as gradually extend towards either pole. Fragments of solid matter, formed before reaching the equator, would meet similar fragments coming from an opposite direction. They would not be drawn into the current setting towards the centre, but would remain congealed together. Thus it is evident an equatorial zone would be first produced, and the polar hemispheres closed up by the growth of its edges.

115. During these ages of violence, all the elements which are volatilized by intense heat existed as vapor, and the immense atmosphere of all the gases, oxygen, hydrogen, nitrogen, carbonic acid, many of the metals, and other elements, enveloped the earth with its dark folds. All the oxygen that now enters into the composition of the oxides, of water and the metals; the hydrogen that now forms a part of the wide extent of ocean; the carbonic acid that is now combined in the lime-rock, and the vast beds of mineral coal, were all united in that nebulous atmosphere. In connection with this atmosphere, the granite contained every

element in the world. All the metals not volatilized were united in the granite, though in such minute quantities that they could not be detected, and it had to be subjected to the law of crystallization and the action of electricity before they were separated.

116. The next advance made by the elements was the production of that essential substance — water. Oxygen found its equivalent of hydrogen, and water was the result. It of course first existed as vapor, enveloping the earth in its magnificent folds. As soon, however, as its temperature was sufficiently reduced, it condensed and fell in showers on the heated surface; slow and mistily at first, but as time advanced it fell in floods from the black sky. Then commenced a new series of actions and reactions, which, for terrific grandeur and awful sublimity, can only be equalled and witnessed in the primal evolution of worlds. A new and potent condition was here introduced, and its results were vast and incomprehensible. The water, falling from the atmosphere, ran down into the hollows of the rocks, penetrating the crevices, and, coming in contact with the internal heat, became converted into steam, rending the new-formed rocks into fragments, and producing the awful effects witnessed in the volcano and the earthquake. The atmosphere, like a sponge, absorbed large quantities of water from the seas and ocean, and gave it back in one continual shower, furnishing an immense power to disintegrate the porous rock. The water, by collecting in larger basins, formed thermal lakes and oceans, which boiled like great caldrons, sending up steam and spray. At this period mountains were of slight elevation; but around their jagged heads the clouds gathered, and poured their torrents down their broken sides.

117. The continual falling of water gradually purified the atmosphere, by washing out its crudities and absorbing its gases and other foreign materials. This increased the density of the ocean, and caused it to act on the rocky surface with greater force. The water, having great dissolving power from its high temperature, and acting on porous rock, rapidly disintegrated it, dissolving the soluble portions, and washing the fragments into the hollows. The fragments thus washed down were spread over the floor of the boiling sea, and consolidated into gneiss rock, bearing a striking resemblance to granite, differing only in having its materials stratified. The metals, besides a vast quantity of other mineral matter, were dissolved in the ocean. Then they acted and reacted on each other, until, by well-known crystalline forces, they were deposited in mineral beds and metaliferous veins. Electricity, as it circulated through the ocean, or around the earth, created a silent but mighty influence on these depositions. This concentration of the previously diffused metals has conferred a great and very important benefit on mankind. If the metals had remained diffused in such infinitesimal quantities through the granite, they would be unattainable; but nature, seemingly aware of the wants of distant ages, set her forces at work in the great world-crucible, and extracted the elements for future usefulness, while the useless portions were again converted into rock. By this *forethought*, as it were, man receives numberless blessings; in fact, without this separating and refining process, the world would be incapable of supporting human life. The ocean dissolved all the metals, and then deposited them — gold, silver, iron, &c. — each in a concentrated form.

118. The demarkation between granite and gneiss is indeterminable. It is impossible to ascertain where granite leaves off and gneiss begins. The disintegrated granite, consolidated without stratification, differs not from the original rock. This is the origin of the gneiss, which was deposited by the action of water. Hence there are all shades of difference between granite and gneiss. The difference between the true granite and the micaceous slate consists in the mode of deposition in calm or troubled water, different degrees of temperature, and numberless other causes.

119. Although the primitive stratified rocks were mostly deposited at this period, their formation is by no means restricted to this interval, as it continued long after the advent of life.

120. The slates reposing on the gneiss were deposited in a cooler and deeper sea, and were formed from fine material. The blending together by indefinite shadings, of the primitive rocks, is incontrovertible proof of their common origin and of the theory here advocated.

121. At this period the earth presented a strange scene. Confusion of the elements universally prevailed. The land and water intermingled, the sea being an archipelago, in which the thickly interspersed islands were but masses of rugged rocks. The low, irregular peaks scarcely appeared above the waves, and their ragged sides spoke of their fiery birth. The wild landscape of confusion and disorder contrasted with the black, lowering atmosphere and the lurid glow of the internal fires, when the crust yielded to the con traction or internal pressure, and deep fissures were formed, allowing the molten tide to issue forth. Creation put on a strange garb in those her morning days,

yet order reigned supreme amid the wildest confusion. Even then the vast plan of creation, in all its minutiæ, was written within the secret chambers of the constitution of the atom, and all this commotion was only its throes and spasms, as it strove to enter higher and higher planes of perfection.

PART II.

CHAPTER V.

LIFE AND ORGANIZATION.

Relations of Life to the physical World.—Impenetrability and Extension—Elasticity.—Gravity.—Electricity.—Heat.—Light.—Affinity.—Absorption.—Capillary Attraction.—Endosmosis.—Catalysis.—Cause of the Ascension of Sap.—Of the Circulation of Blood.—Secretion.—Respiration.—Nervous Power.—Digestion.—Creation of Life by Electric Currents.—Author's Experiments.—Conclusion.

122. To superficial observation, nothing can be more dissimilar than the inanimate crystal and the active, intelligent animal. Countless distinctions can be drawn, each one of which seemingly places an impassable chasm between them. But when research is carried beyond superficiality, most of these distinctions become confounded or vanish.

The organic being represents every physical property and force found in the mineral. Impenetrability and extension are the same in both. The elasticity of the lungs, arteries, and heart is similar to that of a metallic spring.

Gravity acts on the most refined living matter identically as on the falling stone; on the currents, circulating through veins and arteries, as on the babbling waters of the brook or flowing river. It establishes the equilibrium by which endosmose is manifested in the organic body.

123. Heat holds the same relations to living as to inert matter. This is true, whether we consider its

evolution within the organism, or its external application. It warms the body, and if intense, decomposes the unstable organic combinations, evaporates their aqueous parts, coagulates the albumen, and crisps the tissue. The only opposition offered is by the strength of the affinity which holds the compounds together. As soon as this is overcome, the body is disorganized. Nowhere can the presence of a vital force be recognized independent of physical agents.

124. Electricity readily traverses organic bodies, and effects the same changes in the salts held in solution by their aqueous fluids, as in an artificial solution.

125. Light exercises a great influence over organization. The relation of the eye to light is purely physical. It is a perfect optical instrument, achromatic, and adjustable to all required focal distances.

Affinity, or the attraction of atoms to each other by invariable principles, wields a potent influence in organization. The same elements, governed by the same laws, act in the organic as in the inorganic world. The chemist, understanding the properties and relations of one, may learn and comprehend those of the other.

126. The principle demonstrated by a glass tube lifting water higher than its level, or capillary attraction, has a wide application in the realm of life. This is the universal phenomenon of absorption. When a porous body is plunged into a fluid, its pores become filled with the liquid, and the latter is elevated above its source, as the wick of the lamp lifts the oil to the flame, because the oil is attracted to, and wets the walls of its fibrous tubes, and flows upward till its attraction is overcome. A glass tube, one twenty-fifth of an inch in diameter, will lift water one and one

fifth inch. It will be readily inferred, that in organic bodies where the pores are from one two-thousandth to one six-thousandth of an inch in diameter, capillarity must produce very important effects.

127. If a piece of chalk slightly rests on water, it will become moistened throughout. Cartilage, or muscle, acts in the same manner, as can be seen in the living animal. From the hints furnished by capillarity came the discovery of endosmosis, by Dutrochet.* This may be defined, as well as explained, by saying, that when a membrane — as a piece of bladder or intestine — is interposed between two fluids of different densities, a current will be established through the membrane from the rarer to the denser fluid, whereby the quantity of the latter will be augmented and its density decreased; and also a counter current from the denser to the rarer fluid, whereby its quantity will be decreased and its density augmented. The first is called *endosmosis*, the second *exosmosis*. The rapidity with which this interchange is effected depends on the relative density of the two fluids; the greater the difference, the more powerfully and rapidly will it be performed. The currents continue until prevented by the similarity of the two fluids. The force of endosmose is sometimes equal to seventy pounds to the square inch.

128. As physiologists explain many of the most intricate animal functions by endosmosis, before proceeding farther, I will show what relation the physical facts bear to living beings. I will apply it to the

* This curious subject is illustrated by numerous experiments, in article "Endosmosis," in the Cyclopædia of Anatomy and Physiology; Dutrochet's Mémoires Anatomiques et Physiologiques, and in Matteucci's Lectures on the Physical Phenomena of Living Beings.

absorption of the chyle by the absorbents. The rarer chyle is brought on one side of a thin membrane, the dense blood on the other, and, as would occur in the purely chemical experiment, the chyle pours its soluble portion into the veins, which reject its insoluble or undigested portion. When the hand is plunged in water it absorbs it, the skin becoming a membrane between it and the blood.

129. Understanding the application to be made of our facts, we return to the physical investigation.

130. Matteucci found that the rapidity of the currents is considerably affected by the direction in which they traverse the membrane. When he employed the skin of the torpedo, placing water on the internal side, and a saturated solution of sugar on the other, the current was so rapid as to raise the interior fluid 80 degrees; but when the positions of the fluids were reversed, it only raised it 20 degrees. This fact explains the transudation of sweat from the surface of animals, as the structure of the dermal membrane, with few exceptions, is such that endosmosis is from the internal to the external surface. The same principle is involved in the secretion of mucus, by which the bodies of fishes and reptiles are protected against the water.

131. It is remarkable that any thing which destroys the functions of the membrane in the body destroys its endosmostic power when employed in experiment; as gangrene, decomposition, drying, &c.

132. Exosmose, in relative quantity, bears no relation to endosmose. It may be very slight; so that while the denser fluid is greatly diluted, the rarer does not increase its specific gravity, or the reverse. Chyle passes into the absorbents, but there is no corresponding current of blood passing out. It is only in an

abnormal state that the serum of the blood flows into the intestines, and only in disorganization does the red blood flow into them.

133. Organic membrane is the best material for experiment; but to illustrate the purely physical nature of the process, a mineral wall can be successfully substituted. A thin lamina of baked clay, lime, sandstone, or plaster of Paris will give identical results.

134. The vitalists maintain that absorption is purely vital, or dependent on a super-physical force. A more rational school of physiologists refer it to both vital and physical forces combined. Neither theory is alone admissible, as the experiments with membrane from which the vital principle has fled, and still more emphatically with mineral walls, overthrow them. If, when membrane is used, the currents are slower than in the living animal, the fact is fully accounted for by the collapsed state of its pores and the stagnation of its fluids.

135. If the leg of a frog,* be immersed in ferrocianide of potassium, every portion of its tissue will in a short time become penetrated by the salt. The same will occur if a living frog be employed, but with greater rapidity, for the salt, as soon as absorbed, is taken into the circulation, and immediately transmitted to all parts of the body. Absorption is frequently observed in man. Turpentine applied externally is soon manifested in the urine. Prussic acid spread on the skin is immediately taken into the circulation, and conveyed to the vital organs, which it destroys.

136. Bacchetti's experiments prove that endosmose

* Matteucci, Lectures, &c., p. 5, 73.

occurs with greater rapidity when the separated fluids are in motion. The fluids of the body are in constant motion; hence the rapidity of absorption.

137. The action of medicines and of poisons has engaged the attention of the profoundest physiologists, and theory after theory has been framed and exploded. The discovery of endosmose has at least developed the great principles which govern their effects. Poiseuille proved that endosmose took place from Seidlitz water, sulphate of soda, and common salt, to blood. This is precisely the result which follows their application internally. The fæces contain an abundance of albumen, the serum of the blood flowing in an endosmotic current into the saline solution introduced into the alimentary canal.* He also discovered, what is equally remarkable, that when morphia is added to a saline solution, it weakens the endosmosis of the serum, and even changes its direction. Such are its effects when administered for diarrhœa. It checks the flow of serum into the intestines, and ultimately changes the current in an opposite direction. When the solution in the stomach is denser than the blood, there is a flow of serum to dilute it, and thirst is excited.

138. It were a useless task to enter into a minute description of the countless phases of vegetable absorption. In all, certain general principles prevail. All, or nearly all, have roots through which they derive their nourishment, by absorption from the surrounding soil. The ascension of the sap through the trunk of the tree was long referred to vital force, but can now be fully explained by physical principles.

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* Matteucci, Lectures, &c., p. 7—10.

139. The lower orders of plants, as the cryptogamia, absorb their nourishment by their entire structure, as a sponge is moistened; but in the higher orders absorption is confined to the roots, except in abnormal circumstances, when other parts, as the leaves, perform that function.

140. The primary force which propels the sap upwards can be traced to its seat by an ingenious process. The stem of the tree is cut off; the sap continues to flow. It is cut still lower, to the main roots, past them to the smaller ones, to the radicals, to their very extremities; and there only does it cease. Their extremities spread a delicate membrane, on the inside of which, in the embryo plant, is a solution of the nourishment stored for its support, and afterwards the elaborated sap; on the other, the aqueous solution of its mineral food. Endosmose consequently results, and the water, with its dissolved elements, passes into the plant. Exosmose also results, carrying out what is called the *excretion* of plants.

141. Prof. Henslow remarks, "If we suppose the plant capable of removing the imbibed fluid as fast as it is absorbed by the spongioles, then we may imagine a supply being kept up by the mere hygroscopic property of the tissue; much indeed in the same way that the wick of a candle maintains a constant supply of wax to the flame which consumes it." * This explains the fact that absorption continues in a detached branch when its cut extremity is plunged in water. So long as the leaves exhale, absorption continues by the open mouths of the exposed vessels.

* Treatise on Botany, in Cabinet Cyclopædia, p. 117.

142. The force of endosmose has been stated to be as great as seventy pounds to the square inch. Hale found that of the spongiole of the vine to be fourteen pounds to the square inch. This would lift the sap thirty one feet high. If we add the power of the capillaries to this, a force will be obtained sufficient to lift the sap twenty feet higher; for if a tube one twenty-fifth of an inch in diameter lift water one and one fifth inches, the pores, or tubes, in the trunk of a tree one six-thousandth of an inch in diameter, would lift water over twenty feet. But the attraction is not exerted in a direct channel; one set of pores unite with another, and thus extend it indefinitely. As fast as the sap is transmitted to the leaves, it is evaporated or sent downwards by another set of vessels. Unite these three forces, and the ascent of sap, mysterious as it appears, is explained as clearly as the falling of water down the channel of the brook.*

143. Nor does the selecting power of the spongioles imply a vital force. This choosing power results from the size and conformation of their pores. When coloring matter is added to the liquid so as to distinguish the various atoms, the finer particles seem to be absorbed, and the coarser rejected. If a plant will take up a salt of one base, it will an isomorphous salt of another base, though its properties may be entirely different, and highly injurious. Plants readily absorb soluble substances extremely detrimental. As tannin, which in small quantities speedily kills them, common salt, also, is destructive to some plants.

144. Every condition which physiologists lay down as favorable to absorption in the living being, is in

* Treatise on Botany, in Cabinet Cyclopædia, p. 117

strict accordance with the physical laws of endosmose — solubility, penetrability, or vascularity, elevation of temperature, movement of the fluids. These are not mere coincidences; they point to an established law common alike to all forms of matter.

145. Digestion is a chemical and mechanical process, and can be readily performed by the chemist in a retort. The food before entering the stomach, or digestive sac, is masticated by the teeth, and mixed with saliva, the flow of which its presence provokes. It has been suggested that the bubbles of air entangled in the viscid saliva aids digestion. When injected into the stomach it is mixed with a secretion poured out by the latter. This secretion is pepsin diluted with acidulated water. The motion of the stomach, by shaking its contents together, has a similar effect as shaking a bottle in which substances are placed which act chemically on each other. The action is promoted. The secretion of pepsin, and the nervous influence will be treated hereafter. After being subjected to this process, the food flows from the stomach as chyme, a thick, white, creamy mass. Mysterious as the process may appear, it will take place as well out of as in the stomach. If starch be placed in a glass vessel with a few drops of pancreatic fluid, it will rapidly dissolve, every trace of it vanish, and sugar or dextrine take its place. There exists in pepsin, and Magendie asserts in the saliva, a substance similar to diastase in its action on starchy matter.

146. The chyme, as it passes from the stomach, meets the bile secreted by the liver, and is again decomposed. Chyle results — a fluid better prepared to enter into organized forms. The absorbents, distrib-

uted along the alimentary canal, by their closed extremities absorb it, as the spongioles drink up the fluids of the soil. Physiologists were long in doubt how the fatty portion of the chyle was absorbed by the chyliferous vessels, as it is not digested by the fluids of the stomach. It is not presented to these vessels in a solution; hence it must be excreted. But it is found that endosmose occurs from a fatty fluid to a free alkali. If two funnels are filled with sand, and water poured on one, and an alkaline fluid on the other, and after these have passed through oil be poured on each, it will not penetrate the sand thus united with water, but will be readily absorbed by the other. The closed extremities of the chyliferous vessels are filled with an alkaline fluid which attracts and absorbs the undigested fatty particles.*

147. The endosmose of the contents of the alimentary canal to the blood presupposes exosmose of the blood into the intestines. The character of the fæces fully confirms this inference. The blood throws out in this manner a peculiar secretion.

148. It is necessary that the blood remain slightly alkaline; but the neutral azotized substances which it so abundantly receives would soon destroy this state, if it were not replenished by the alkaline chyle, lymph, bile, and pancreatic fluids. In this process it would be difficult to determine one point of superchemical action. From first to last it can be performed in the retort with reagents.

149. The *modus operandi* of vegetable circulation has been already explained. Equally simple is it in the lower animals. It becomes more complex in the

* See Carpenter's Principles of Human Physiology.

higher orders, but its principles remain the same. The capillary veins, distributed among the capillary arteries, take up the blood by endosmose through their membranous walls. They unite in veins which draw away their contents by capillarity. At their termination, the heart, by each pulsation, produces a vacuum, and draws in the contents of the veins, as a force pump draws in the contents of its feed-pipe. The regular pulsations of the heart result from the nervous influence received from its appropriate ganglion, and although intricate and but partially understood at present, will, undoubtedly, be found to conform to physical laws.

150. Respiration, by which oxygen and other substances of the air are united with the blood, and animal heat generated, is partly mechanical, partly chemical — mechanical in the introduction of air into the lungs; chemical in the decomposition there effected. The lungs are constructed of delicate air cells, through the walls of which the mesh of capillary vessels are spread. In this manner, in a small space, an enormous surface of blood is exposed to the atmosphere; not stagnant blood, but blood in rapid circulation. It comes loaded with carbonaceous and effete matter, broken down cell walls, disorganized tissue, fatty particles from the chyliferous vessels, and spreads itself out to the oxygen. The latter, impelled by its affinity for carbon, unites with it, or is absorbed by the blood, to work changes as it courses through the arteries. The dark, venous blood is immediately converted into arterial fluid, and rushes back to the heart, to be sent again on its mission of organization. The conversion of venous into arterial blood can be effected out of, as well as in the body. If dark, clotted blood

be shaken in oxygen, it becomes arterial in its properties. Indeed, the surface of blood when exposed to the air always retains its color and fluidity.

151. Still more mysterious is secretion. Many of its phenomena cannot be accounted for with our present limited knowledge. Yet experiments indicate that even here established chemical and physical principles reign. It is found that albumen attracts the endosmotic current from almost all other fluids. It is peculiar in this respect. This explains why it is so tenaciously held in its appropriate channels. The secreting organs act by endosmose, or furnish a fluid which acts on the constituents of the blood by catalysis, either eliminating substances already formed, or forming new ones by this agency. When serum, salt and sugar, are mingled in solution, and placed on one side of a membrane, and water on the other, the salt and sugar pass through into the water, leaving the serum; in other words, are secreted, as urine is secreted by the kidneys. When water and alcohol are placed in a bladder, the water passes out, leaving the alcohol.

152. The recent discovery of the artificial formation of tissue throws great light on the phenomena of secretion. Organization of tissue can be artificially performed by acting on albumen with phosphoric acid, or by agitation. The fibrous tissue which results presents to the microscope all the appearances of organic living membrane. M. Gluze made a microscopic examination of this artificially formed substance, and asserts that it resembles serous membrane. "Fibres are plainly distinguishable in the amorphous mass, and groups of globules." Dr. Lyon found these globules of various sizes, and having an elliptical

shaped nucleus, which appeared when every chance of mistake was obviated.* This discovery lets us far into the secret of secretion. The saturated solution of albumen conforms to the conditions of the blood and the mechanical motion is like the rush of the blood through the arteries. In either case, in the living body, or the test glass of the chemist, there is a deposition, almost identical, of fibre and nucleated cells.†

153. There is no will or consciousness in the circulation, or any of the functions of which we have treated. The respiration of the zoöphyte is the absorption of oxygen from the surrounding water, and its circulation the endosmotic currents from one cell to another through their walls. In more complex — hence termed *higher* — animals, the nutrient fluid is confined to appropriate channels, and is exposed to the action of the oxygen of the air or water in appropriate organs.

154. There is a physical necessity for the oxygen of the air to unite with the carbon of the blood; they are forced in contact by the pulsations of the heart; the pulsations of the heart are produced by the nervous influence of its ganglion, which acts on the muscular fibres of that organ by electric currents generated by the decomposition and recomposition constantly taking place in the organism; such are the conclusions to which experimental research leads.

155. The discussion of nervous force and its physical relations we leave, until we treat of the origin and philosophy of mind.

After thus glancing over the phenomena developed by life, we are ready to ask, "What is organization,

* Annual of Science, 1853, p. 252.
† M. Melsen, An. of Sci.

and what is life?" Organization is formation from previously existing particles. It is the arrangement of those particles in a definite order. Hence the first movements of matter in the gaseous ocean of the beginning was towards organization. The crystal is organized from solution, as is shown by its polarization and refraction of light, in a very complex manner. The solar system was organized from the chaos of the beginning. After having proved that vital and physical forces are identical, can we regard life otherwise than the resultant of the extension of those forces which develop the crystal and the world? The living being exists as the product and personification of physical causes. Examine the organization of the lowest being—which is only a cell or mass of cells. Its walls are nitrogenous, the contained fluid, water. When these cells unite, they form a gelatinous mass of scarcely greater consistence than the fluid in which they float; each cell drawing into itself nitrogenous particles, and reproducing by division. Such is the dawn of life.

156. The present course of reasoning would be complete, if, by fulfilling the proper conditions, a cellular mass could be created from an inorganic solution. For if life came on this globe in its early ages by the concurrence of physical conditions, then by understanding and producing that concurrence, the chemist should be able to evoke it at any time in his laboratory. But, even if we understood the proper conditions, and complied strictly with them, the result becomes vitiated by an unforeseen obstacle. It becomes difficult, if not impossible, to guard against the introduction of germs of the lower order of animals, which fill the air and water, and penetrate into all

porous substances, ready to germinate whenever favorable conditions permit. To wholly exclude these is of the first consequence in experiments in this direction.

157. I performed an experiment in this province, in 1856. My battery was two large copper plates, enclosing one of zinc, buried deep in the moist earth. I took a glass jar, and placed in its mouth a glass tube bent so as to form an escape valve to any gas which might be generated in the vessel; a tube to insulate the negative pole; a tube through which to introduce the matrix fluid, and the wire of the positive pole. The mouth of the jar was now placed in a mould of sand, and filled with fusible metal. The negative wire was inserted in the tube, and the glass melted around it by a blow-pipe. The poles, I should state, were of platina, in the form of ribbons, and approached within the sixteenth of an inch for the space of one inch. The jar was now immersed in boiling water, and a solution of glauber, epsom and common salt, iron, and lime, (in the proportion they exist in sea water,) dissolved in six ounces of distilled water, was poured while boiling through the tube, which penetrated nearly to the bottom of the jar. Immediately a current of carbonic acid was directed into it, (from a vessel previously plunged in boiling water,) generated by sulphuric acid and carbonate of potash; the air escaping through the valve. When full, and the fluid had become saturated, a globule of mercury was dropped into the valve tube, and the other tube hermetically sealed. The apparatus was shaded from the light. By its side was placed a sealed jar, containing distilled water, through which an electric current passed. The apparatus was formed in April; slight decomposition took place, but no other change

until the next November, when in the first jar a thin, gelatinous mass could be seen by a strong light, stretching between the poles. The other jar remained unchanged. I do not know what would have been the result if the experiment had continued for a great length of time; but during an unusually cold night the fluid in the jar unfortunately slightly congealed, and the gelatinous creation disappeared.

158. In another experiment I used a similar solution; but to guard more faithfully against the admission of germs, I enclosed the battery in the jar. It did not seem necessary to employ such intense currents as Weekes supposed requisite, but constancy seemed the desirable quality. I united two platinum plates with a copper ribbon, bringing the poles very near together. The battery thus formed I inserted in a glass jar with a nicely-adjusted stopper, and then poured the prepared solution boiling hot into the vessel, and inserted the stopper. I placed the apparatus in a shaded position, and occasionally observed it. In about five months *acari* made their appearance in the fluid.

159. There is a wide field here open for research. Perhaps it is hasty to introduce the few and unsatisfactory experiments made in this field into philosophical discussion; yet it must be admitted, dubious as they may be, they coincide remarkably with the conclusions towards which the preceding investigations have led us. The justly discarded experiments of Dr. Cross and Mr. Weekes rather provoke contempt than yield support. If life originated on the globe by the concurrence of physical and chemical causes, and from its rude beginning progressed to its present elevation and diversity, it is a necessary inference that it began in its lowest type. Hence, if originated by

artificial means, it should also be of the lowest type; whereas, in the famous experiments of these students, a being comparatively high in the scale of existence was supposed to have been produced. This fact alone is sufficient to negate their experiments and their resulting inferences.

160. But there can be no reason why the lowest forms of life should not be originated by artificial means. If the essential conditions are understood and conformed to, it will be readily seen from foregoing principles, that life can be as readily eliminated as the crystal. Failure must be expected in the commencement, from the unknown realm which such experiments explore. But success will follow in the exact ratio to the knowledge acquired.

CHAPTER VI.

PLAN OF ORGANIC BEINGS.

Blending of all organic Beings in the Cell. — Vegetable and animal Lines of Advance. — Embryonic Growth. — Four Archetypes of Creation. — Four Types of the Vertebrata. — The Plan of living Beings.

161. Infinite as are the variations in specific organic life, one great plan or archetype prevails, to which all conform. Specific distinctions are departures, in a greater or less degree, from this Grand Archetype. A still greater variation is called *Generic;* a still greater *Class*, and the greatest of all, Kingdom. The lowest and *Universal Archetype* is the Cell. The cell is the lowest form of life, yet it combines the essence of all forms. It is the fundamental

material from which all living beings are created. Bone, sinew, muscle, brain, all are the product of the union of cells. The great subdivisions of natural history arise from the difference of aggregation the cell assumes. In their wide divergence from the primitive type, it is easy to draw the distinctions of class; but in their point of contact, difficult indeed, is it to define characters. Great are the distinctions between the oak and the bird carolling in its branches; the bee and the flower from which it sips the nectar; but when we trace the widely separated chain of beings, — vegetable and animal, — downward, they meet and inseparably blend. Naturalists have wrangled about the proper position the zoöphytes should occupy, and their lower members have been repeatedly transposed from vegetable to animal, and animal to vegetable, and it still remains unsettled. They have been confounded, because they assumed that the zoöphyte must be referred either to one kingdom or the other — a mistake, for their structure is strictly intermediate. They are the link which unites vegetable and animal, and to the inquiring mind become important as revelators of the plan of creation.

162. The lowest plant with which we are acquainted is composed of an aggregate of cells, not differing in appearance in the least from each other, and each being a distinct and perfect individual. They are condensed in a homogeneous mass, irregular and formless. One step higher they unite in a linear direction, as in the *protophyte;* and still higher, they multiply transversely, and produce a leaf-like expansion, as in the *ulvæ.* But even here the component cells appear to live, each by and for itself; each being able to multiply itself by division — which

is performed by throwing a wall around a portion of its contained fluid, and thrown off as a bud or germ. Somewhat higher, a distinct separation is made between the *germ* and the *sperm* cell, but here both are confounded.

163. Scarcely distinguishable from the *protophyte* is the *protozoa*, which occupies the same relation to the animal kingdom as the former does to the vegetable. It is a gelatinous mass of independent cells, without determinate form, each cell having a separate existence, and multiplying itself by division. It has neither organs of prehension, digestion, or sense; a simple mass of living jelly, nourished directly by absorption from the element in which it floats.

164. Reproduction in both *protophyte* and *protozoa*, is effected in precisely the same manner—by throwing off buds, or gemmæ, and by division. The smallest fragment is capable of reproducing an entire being. This method of reproduction appears in some of the higher orders of animals, especially in the mollusca and crustacea, which are capable of reproducing lost parts and limbs. Parallel instances occur in the vegetable kingdom. The *bryophyllum* can be divided into the minutest portions, and each fragment will produce a perfect plant. We render this principle practical in multiplying desirable varieties of plants by cuttings or grafting. The same principle manifests itself in the vertebrata in abnormal growths, often greatly affecting the fœtal and mature form.

165. The intricate blending of plant and animal is shown by the impossibility of fixing a clearly-defined difference of character between them. It has been supposed that all animals have stomachs, which plants have not; but this does not hold true of the zoöphytes,

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which are either destitute or nearly so of a digestive cavity. Another distinction is said to exist — that plants are nourished by mineral, while animals require organic food. But it is questionable whether any plants but the very lowest forms can flourish wholly deprived of organic nourishment. A better distinction, because based on a higher organ, is the presence of a nervous system in the animal, which the plant has not. But this is also objectionable; for the *protozoa* has not a trace of a nervous system, nor has the sponge, or hydra, and their allies. It has been conjectured that the nervous system existed in these forms in a diffused state; but the conjecture is not supported.

166. The vegetative growth is seen in all animals, as in the arms of the cephalopod and pentacrinus, in the excessive multiplication of rings in worms, the multiplication of rays in the fins of fishes, and of vertebræ in serpents.

167. The archetype of the vegetable kingdom is the LEAF. The cell builds up the leaf, the leaf the plant. Botanical science boasts of no grander generalization, than that which refers all the organs of the plant to modifications of the leaf. A leaf is coiled and sent downwards to become the absorbing organ of the plant; a leaf ascends to form the central axis, or stem; the leaf is the respiring and digesting organ; it is modified in the calyx and petals; still further in pistils and stamens, and still further in the fruit. These modifications are proved by intermediate forms.

168. The vegetable kingdom is divided into two lines of development, Cryptogamic and Phrenogamic; but as it is sufficient, in this investigation, we confine ourselves to the laws governing animals, and shall not endeavor to trace out the affinities and relations of the orders of plants.

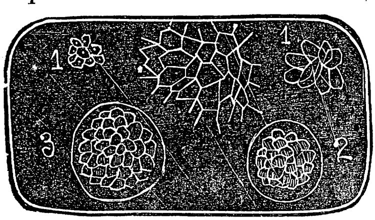
169. The specific characters of animals are departures from their common archetype, not obtained by the addition or destruction of organs, but by the greater or lesser development of organs which all possess in common. To this archetype no organs are ever added or lost. Thus the proboscis of the elephant is but an extended nose. The wing of the bat is not an additional organ, but an extended or altered hand. The neck of the giraffe does not contain any additional vertebræ, but the same number extended by extraordinary elongation. The shell of the turtle is but modified vertebral ribs and sternum, nor its horny jaws additional organs, for they are formed from the same elements which produce the teeth of reptiles.*

If, from the conditions in which the animal is placed, particular organs are not required, and hence are not developed, they are present in a rudimentary condition. In fishes we find the rudiment of lungs, even when not sufficiently developed to serve as an air bladder to regulate the specific gravity of the body. The abdominal sternum and ribs are faintly traceable in the abdominal muscles of mammals. In those mammals which are destitute of a clavicle, that bone is represented by a ligament. When these traces of undeveloped organs cannot be found in the adult animal, they can be in the embryo. The bronchial arches of fish exist in the embryos of all mammalia, and sometimes remain permanent in monstrosities. The rudiments of teeth can be detected in the embryo whale, but are never developed. The rudiments of the canine teeth, and of the incisors of the upper jaw, which are not subsequently developed, are present in the embryos of all ruminants.

* Carpenter's Comparative and General Physiology.

170. The unity which pervades the realm of life is proved by the successful restoration of the outlines of extinct plants and animals from a petrified fragment of bone or scale, and the correctness of influences drawn from such sources of the habits of their possessors. To such strict rules has comparative anatomy been reduced, that a scale or a tooth reveals the size, form, disposition, and habits of the animal. It does this with the same exactness, whether the tooth be recent, or taken from a fossiliferous rock; thus not only proving that living beings are formed after one great plan, but that that plan embraces all the extinct species of the past. From the dawn of life on this earth to the present time, fossils testify that one principle has maintained in the realm of life.

171. Embryonic development not only supports the theory of progressive development, but bears evidence of the unity of origin of all organic beings. Zoöphyte, fish, mammal, man, all commence at the same point—the germ cell. As each matures, it diverges more or less from this archetypal form. Nature moulds all her children after this first model, before they advance to any higher form. In the accompanying figure, 3 represents the mature animal of the lowest grade, 2 represents an early form of the mammalian ovum, 1 represents the cellular structure of plants. It will be readily perceived that there is no apparent difference whatever in the two cellular masses, (2 and 3,) both being alike composed of nucleated cells.



Chlamydomonus — Early State of Mammalia.

172. The embryo lobster is a miniature trilobite. The lobster began where the development of the trilobite terminated; or, in other words, the latter was a permanent *larva* of the former.

The white-fish is an osseous, while the sturgeon is a cartilaginous, fish; but the *young* white-fish begins life precisely where that of the sturgeon terminates. The thin cartilaginous line which is its vertebral column, becomes ossified, however, while the sturgeon's is not ossified except at its apophyses. The sturgeon's mouth is far back on the under side of its head, and its tail is unequally forked. In these points the embryos of all osseous fishes remarkably conform. The cartilaginous fishes are permanent *larva* of the osseous.

173. Agassiz, seizing these facts with an acumen of a master mind, moulded a classification the most perfect science has yet possessed. He starts with the well-attested proposition that the longer two classes remain alike in fœtal growth, the nearer they are allied, and they are widely separated in proportion to the rapidity with which they separate. He also decides the position of species in the scale of progression by embryology. It is difficult to ascertain by appearance which is the highest, the lobster or the trilobite; but embryology decides the question by proving the trilobite to be the larvial lobster. It were equally difficult to say which were the highest, the white-fish or sturgeon; but this science proves the latter to be permanently on the same grade as the larva of the former.

174. By assuming the unity or common origin of living beings, naturalists have been enabled to decide the position of species by the study of transitional forms. In this manner the complex limbs of mam-

malia were traced downward to the thread-like expansions from the sides of the lepidosiren. The position of the amphioxus was decided by embryonic growth. It is destitute of a head and skeleton, a thread-like line represents the spinal nerve and column. But all the mammalia are like the amphioxus in their early fœtal life. It represents the larva of all the mammalia.

175. The change of form, once supposed restricted to the transformation of a caterpillar into a butterfly, and a tadpole into a frog, are now known to be universal. Species all begin at the same point, and diverge in proportion to the degree of their development. In the lower orders there is but a slight difference between the larva and the mature form, but the higher the development, the greater this difference becomes.

176. Science has verified the aphorism of the ancients — all life originates in the egg. Mammals, as well as birds, are at first ova, or eggs, and are subject to as much greater transformations than the tadpole, as they are higher.

177. It is by connecting the metamorphoses which occur before, with these which transpire after, birth, that the key to the gradation of species is obtained, and the presence of a great unitizing law, and the common origin of all species, deduced.

178. Strange as beautiful are the changes which occur in the germinating egg. First a dark line appears, on each side of which two ridges rise, the edges of which gradually approach each other, and unite, enclosing a semi-gelatinous fluid, in which two white fibrous threads are seen lying side by side. The dark line is the vertebral column, and the threads the rudi-

mentary spinal cord, on the development of which the character of the animal depends. A series of dots next appear along the line of the fibres,—the rudiments of the vertebræ,—which soon become rings enclosing the spinal cord, and throwing out spinous processes.

Thus far the end is nutritive, and the vegetative functions predominant. The heart is but a pulsating dilatation in the main trunk of the circulating system. The respiratory system—as yet useless—is undeveloped. The heart is next divided into two chambers, one for the reception of the blood, the other for sending it through the system. Here the development of the circulating apparatus of fishes is arrested. The heart is next divided into three chambers, by which arrangement one half of the blood is aërated. Here reptiles are arrested. The embryo mammal rests not here, but acquires a fourth chamber to its heart, by which all its blood is sent to its lungs, and thus the highest degree of activity secured to its circulation.

179. Thus not only are species united by intermediate forms in an unbroken chain of being, but also by fœtal growth; the same law seems to prevail in the gestation of the individual being as of the globe. Not only is the same principle manifested in the unity of present types, but in all those of the infinite past. How are such facts to be explained? Inductive philosophy draws its conclusion—one which cannot be subverted. As all living and extinct organisms can be traced to one point, all must have diverged from that point. All types must have originated from the common archetype. They cannot exist by separate acts of creations, without supposing a constant miracle. As such an assumption is without

proof, and discarded by inductive science, which teaches that all beings are fashioned after a determinate plan, there can be no independent creations.

180. To that plan or archetype we now turn. IT IS THAT WHICH THE CONSTITUTION OF MATTER WOULD CALL INTO EXISTENCE AND SUSTAIN. Living beings pursue different courses in their divergence from this common point, by which arise species, genera, and distinctions of classes. They are divided into four great divisions, in accordance with the methods by which they seek the same ends — adapt themselves to the conditions surrounding them — by different means. These great divisions are Radiata, Mollusca, Articulata, and Vertebrata, commencing with what is usually termed the lowest, and ascending to the highest. The idea, however, which has caused them to be arranged thus is incorrect. They do not overlap each other, and there is no continuous development from the radiata to the vertebrata, as certain philosophers have taught. Cuvier presented the subject aright, when he remarks that each division is modelled after a type peculiar to itself.*

181. The RADIATA are little more than a simple digestive sac, or stomach, the orifice of which is usually surrounded by a set of arms or tentacula, for drawing in their food. In its lowest genera, the body is little else than a mass of living jelly, without form, and destitute of any stomach whatever. There is a tendency in all its groups to a radiate or crystalline growth, as in the star-fish and the ancient stone-lily. All are destitute of proper locomotive organs, though some families have movable spines, which assist their

* Règne Animal, 11.

locomotion through the water. Some species, in which the radiate structure is obscure, conduct us towards the mollusca; others lead to the articulata; while the sponges and corallines evidently approximate to the vegetable kingdom, so close, indeed, that it is difficult to assign their true position.

182. The Mollusca have a soft body, enclosed in an elastic muscular skin. This skin is, in most instances, loosely applied to the body. From this skin calcareous particles transude and solidify in the *shell*, which seemingly separates the animal from the other divisions by a vast interval, but in reality is of the same nature as the framework of the coral, and has no influence on the *grade* of the animal it protects. They have not a spinal cord, but medullary masses distributed in different parts of the body, the principal one, called the *brain*, enclosing the gullet. The organs of the senses and motion have not the regularity of mammals; and still greater are the variations in the position of the respiratory organs and heart. Their circulation is a complete circle; but they have but one fleshy ventricle, and that placed between the veins of the lungs and arteries of the body, and not, as in fishes, between the veins of the body and arteries of the lungs. When there is more than one ventricle, they are not united, but disposed in different parts of the body, so that they may be said to have several hearts. Equally great variations exist in their organs of deglutition and digestion. On one hand they approach the zoöphytes; on the other, in the cephalopods, they almost equal fishes, having a true brain, a symmetrically formed body, and acute senses.

183. The plan of the Articulata is to spread the skeleton on the outside of the body. Instead of having,

like the mollusca, an organization for digestion, they have a muscular development adapting them for activity. The crust which envelops them and forms their shell is an exudation from their skin, similar to the formation of the shell of the mollusk. Their nervous system consists of two parallel nervous cords swelling into ganglia at each segment, and terminating in a larger ganglion in the head. It includes, on the one hand, annelidæ scarcely superior to the lowest mollusks; on the other, beings endowed with instinct almost approaching intelligence.

184. The VERTEBRATA are characterized by a back bone, a spinal cord, a concentrated brain, and an internal skeleton. It extends from the amphioxus to man. These four divisions extend side by side, as diverging branches from a common source. Their higher members differ most, as in them we see the ultimate departure from the common type, while their lowest members approach nearest. If we would study them understandingly, we must not place them in successive order, but side by side, and compare corresponding genera; placing the lowest species of each together, and the higher in opposition, preserving each line of progress inviolate.

185. Thus, at the foot of the radiata we find the sponges, half vegetable, half animal, without digestive cavity, without any organs whatever, living apparently by absorption from the water, which circulates through pores in its gelatinous mass.

From these we pass to the foot of the molluscous division, the tunicata. In the ascidia and aggregata, the soft and gelatinous beings are united in masses, each individual communicating with the others organically, thus connecting the mollusks with the zoöphytes.

Such was the resemblance, that early naturalists confounded this family with them.

186. Passing to the foot of the articulata, we meet with the intestinal worms, the gordians, and leeches, the organization of which is equally simple; the alimentary canal being, in the entozoa, a channel cut through the substance of the body, and the absorbent system being simply a diffusion of the nutrient fluids through the substance of the animal. The nervous system, where its presence can be detected, is a simple filament of a nervous character.

187. Passing, lastly, to the foot of the vast vertebrate series, we find the amphioxus so lowly organized, that, until subjected to strict and scientific investigation, it was supposed to be a mollusk. Although so soft as to be transparent, it has all the necessary characteristics to be allowed a place with fishes.

188. The ammocetes is scarcely higher in structure, not having even a vestige of a bone in its glutinous body, not even a tooth. How remarkably do the divisions conform! The molluscous type prevails, and we find a general failure of all the characters by which they are generally distinguished. There is a common approach to the universal archetype.*

189. Now let us compare the highest members of the divisions, or the branches, in their most widely separated forms. In the radiata we meet with the enchinus, with their beautifully arranged calcareous shells, a complicated digestive, prehensile, locomotive, and generative system. At the head of the mollusks we find the cuttle-fish, having all the agility of the fish, with feet capable of seizing their prey, walking,

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* Lyell, Hugh Miller, &c.

and swimming. They have a large, concentrated brain, with well-developed ganglia, and acute organs of sense.

At the head of the articulata, if development of instinct be the test, stand the hymenoptera, or the common bee, which has excited the admiration of all ages by its habits, almost akin to reason.

At the head of the vertebrata is man, who, by the endowment of reason, becomes the ultimate of creative power.

190. The sub-kingdoms are branches thrown off at various points, and, each receiving a peculiar direction, endeavors by different means to attain the same end. The vertebrata attain a solid consistency for the attachment of their muscles by their osseous skeleton; the articulata obtain the same by their external, dermal crust; the mollusca, by the thicking of their mantle, or by means of their shells; the radiata, by their calcareous internal framework. In obtaining their food, the vertebrata usually pursue and capture it; so do the articulata; but the other divisions, being usually stationary, are provided by long arms surrounding the mouth, which seize their prey and force it into the digestive cavity. In their circulatory, respiratory, digestive, and secretory apparatus, — in short, in every thing but external form, — all the four divisions correspond in their uses. True, superficially there are great deviations; but when attentively considered, it will be found that these modifications are produced by the non-development of some parts, or the greater relative growth of others. Certain organs are essential to the existence of life, and these are always present. Other organs adapt the species to peculiar habits, or conditions, and these are added.

191. We will here leave the general and trace the special. The vertebrata are subdivided into widely separated families; and our argument will receive greater force by tracing out the affinities of its orders, than by discussing affinities of unknown and obscure beings, as those which stand at the foot, or commingling of the sub-kingdoms, generally are. For a few pages, we will confine ourselves to the investigation of the red-blooded vertebrate series.

192. The back bone is the symbol of this division. The vertebral column is divided into vertebræ, each one of which, viewed* by the acumen of genius, proves to be the archetype of every bone in the body. I present this theory as a conclusive proof of the unity of design in animate nature; of its common origin; of developmental growth by influence of conditions, and as the fundamental philosophy of the different and various vertebrated classes.

193. Each vertebra has a central portion, called its centrum. From this, two proceed, or branch off, one on each side; they ascend and meet above, forming a ring enclosing the spinal cord, and two descend, usually being greatly prolonged, and meet in the *sternum*, enclosing the viscera. These are the ribs. Thus two rings, joined at their circumference, form a type of a vertebra; through one of which the spinal cord passes, and the other containing the viscera. This typical form is modified so as to meet the wants of every part of the body. In the skull and limbs it undergoes its extreme transformation. The brain is formed by the consolidation of the four first ganglia of the spinal cord, and the skull is produced by the aggregation of

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* Règne Animal.

their four enveloping vertebræ. The fore limbs or legs are detached appendages of the occipital vertebra, removed to varying distances, and the hind limbs or legs are appendages of the pelvic segments.

194. It is interesting to observe the points at which embryonic growth is arrested in different tribes. All the vertebrates begin alike. In all, the spine, by which they are characterized, is a fibrous sheath filled with cells containing jelly, while the elements of the vertebræ are laid down by fibrous bands. At this stage the skeleton of the "lancelot" — amphioxus — is arrested. The fibrous bands are next converted into cartilage, and divided into definite sections. At this stage, the skeleton of the sturgeon is arrested. Ossification imperfectly commences, and the type of cartilaginous fishes is presented. The deposition of osseous material is complete, and the higher grade of osseous vertebrata obtained.

The vertebrate type of structure is displayed in four different forms. Fishes, reptiles, birds, and mammals. These form a series which can be traced from the lowest fish to the highest mammal. Fishes merge into reptiles in the extinct sauroids, and reptiles approach very closely to fishes in many of the extinct saurians.

The reptilian branch is composed of a great diversity of forms, which, however, bear a close anatomical relationship. There is a wide difference between the skeletons of frogs, serpents, lizards, and turtles; but this depends not on the acquirements of new parts, but the suppression or greater growth of existing organs. The limbs in serpents are suppressed, but their rudiments exist under the skin. The shell of the turtle is formed of modified ribs and vertebræ; and the skeleton of the lizard is but the more perfect development of all the parts.

195. Birds, although they present analogies to reptiles on one hand, and to mammals on the other, cannot be regarded as intermediate between these classes. They are fashioned after a type peculiarly their own, and which, through transitional forms, leads to the batrachians.

196. Mammals are the highest organized of the four classes — a fact seemingly dependent on the longer period or duration of the embryo with the parent. They are connected with reptiles by the marsupials and edentata, and from this extreme ascend to man. Not that all mammalia originated from a common stock. On the contrary, as previously shown by the affinities of its various classes, widely remote must have been their source. The marsupials, with birds, are branches of the batrachians; the pachyderms and herbivora are branches of the herbivorous saurians; the carnivora, of carnivorous saurians; the quadrumana, of carnivora; and man of quadrumana. So their affinities teach.*

197. In tracing what has been called the "chain of beings," naturalists have committed the great error of arranging the sub-kingdoms in an ascending series, tracing their pretended chain from one to another. So sure as there is one chain of being, there are four; for one type has as much right to the preference as another. If we would successfully follow the line of progress, from the lowest to the highest, in that series at which man stands at the head, we must confine ourselves to the vertebrata, descending to the foot of that sub-kingdom, and commencing with the most "archetypal" form. Such a form has been already named as the lowest of fishes — the amphioxus. In the fossil

* See frontispiece, with its explanation.

world we find sauroid fishes combining the character of fish and reptile. The character of the fish is separated, and pursues a line of progress of its own; the reptilian character pursues its path. The batrachians are related to the *labyrinthodon* and its allies, and the birds in the remarkable series of unknown species which have left their footprints on the sandy rock. In the tertiary, or perhaps previously, the saurian reptiles began to combine the qualities of the mammal with those of the saurian. Soon after we find the huge pachyderms of that era ushered into existence, and the saurians becoming extinct.

198. Having delineated the general plan of organized creation, and clearly indicated how widely the divisions separate, as well as how closely they approximate, I shall next endeavor to show that the conditions of the inorganic world are capable of producing the differences observed, by modifying the primordial archetype. If this can be done successfully, the argument is irresistible, as even the strongest opposers of the developmental theory admit.*

CHAPTER VII.

INFLUENCE OF CONDITIONS.

Definition of Species. — Hybridization. — In the Horse. — Ox. — Sheep. — Deer. — Dog. — In Plants. — Influence of Conditions. — Of Domestic. — of Natural. — Design in Structure.

199. NATURALISTS, ever since the dawn of science, have been engaged in combat in regard to the proper

* Lyell, Hugh Miller, &c.

definition of specific characters. This appears singular to those whose observation is limited, for it is easy to distinguish between a horse and a dog, an ox and a sheep; but if he follows the naturalist down into the walks of the lower orders, he will find all his distinctions melt away, and he will no longer feel surprised at the confusion of philosophers. Morton* terms species "a primordial organic form," a definition true, but impractical, because of the imposibility of determining what are, and what are not, "primordial forms." Cuvier, Buffon, and other eminent naturalists, indorse the maxim in natural history, that "the faculty of procreating a fertile offspring constitutes identity of species, and that all differences of structure and external appearance incompatible therewith are solely the effects resulting from variety of climate, food, or accident; consequently are forms of mere varieties, or of races, of one common species." This, however, is untrue, as will be subsequently proved. For if true, all the canidæ, as well as many other genera, can be refered to one species, as they are all prolific together.

200. No general definition can be given. When it can be *shown* that two races have a separate origin, they are termed *species;* and in absence of proof, this is inferred, when peculiarities of organization are observed transmitted from parent to offspring. When races originating from a common stock present marked differences, they are called *varieties*, and the variety is called *transient* when it manifests a disposition to disappear, or *permanent* when it continues fixed. The limits of species are every day becoming more indistinct. The report of every voyager adds to the

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* Types of Mankind. Nott and Gliddon.

catalogue of already countless beings in which the reputed limits of species are fast vanishing away. Naturalists pride themselves in the discovery of new species, more than the thorough acquaintance with those already known, and have by the multiplicity of specific names, many of which are known to be synonymous, filled their catalogues with confusion. A spot on a butterfly's wing, a greater length of limb of a quadruped, or of wing of a bird, is often sufficient proof, with them, of diversity of origin, and a true difference of species. Instead of aiming at a philosophical system of nature, to which the study of special forms is subordinate, they have ignored all idea of unitizing their observations even by hypothesis, and scorned all attempts at theorizing. They have met in associations, and occupied their time in filling ponderous volumes with dry and prolix details utterly devoid of value. By such means scientific reputation is acquired, while the cause of science remains stationary. In opposition to such a course, from the facts recorded in the volumes of science, I shall deduce a theory, and endeavor to support it by many examples and observations. I have presented the plan of creation. Now, if it can be shown that the conditions of the inorganic world can produce new species, then we have the key which will unlock the mysterious halls of nature.

201. That species unite and blend, cannot be better supported than by the difficulty, before alluded to, of forming a proper definition. To all intents, any definition will apply to variety as well as species. If the origin of a variety is *unknown*, it is called a species. That species hybridize, and that their offsprings are fertile, has been clearly established. Though far from

agreeing with those theorists who refer *all* the intermediate forms to hybridization, yet it seems certain that many species have originated from intermixture.

202. In presenting the subject of hybrids, I will first introduce the equine, (*equus caballus*, Lin.,) or horse family, composed of six species: the horse, dzigguetai, ass, zebra, onagga, and quagga. The offspring of the horse and she-ass, the hinny, is rarely met with, being small, refractory, and useless, and hence not profitable to rear. The hinny copies the horse much more than the ass. The head and ears are small, and precisely like the father's; the legs, feet, and tail slender, like the mother's. The offspring of the female horse and male ass, the common mule, is much better known, being bred on account of its hardiness. It reverses what is seen in the hinny, and is much closer related to the ass than the horse.

203. The female ass and the male quagga breed together, but the male offspring, crossed with a mare, produces an offspring more docile than either parent, combining their best physical qualities — strength and speed. Cuvier mentions his having seen the cross between the ass and zebra, as well as between the zebra and horse. It must be remembered that the ass and horse are not the nearest related of the equine genus. Bell and Gray are even disposed to found a new genus for the former.

Doubts are entertained whether the horse is not derived from several different stocks. The unlimited productiveness among the different varieties has countenanced the idea that they all sprang from a solitary pair, of Mesopotamian origin. Hamilton Smith has, however, by his researches overturned this superannuated idea. He separates horses into five primitive stocks, existing as the remnant of a previous creation, represented by the fossil bones of horses exhumed from the tertiary. Some of these races have been entirely subdued, such as the Tarpans, the Kirguise, and Parmere, woolly white race, and the wild horse of Poland.

204. Britain had a race peculiar to itself, described by Cæsar as having bushy manes and tails of a dun color, with a black stripe on the spine. It was the ancestor of the Shetland and Scottish ponies. A wider difference exists between the Shetland pony and the Arabian courser than between the fox and the wolf. They must be referable to widely remote stocks, yet they are prolific *inter se*, as are also their offspring.

205. Hybridization occurs in the ox tribe, (bovine.) The ox stands in exactly the same position in this respect as the horse, the best naturalists contending for plurality of species. The origin of our domestic cattle is wholly unknown, and at least antedates the oldest Egyptian monuments. The American bison produces hybrid offspring with the domestic stock, which reproduce without limit, when coupled with either parent stock.

206. Dr. Morton has proved that the domestic goat and sheep are derived from a plurality of species. When the goat and sheep are coupled together, they produce the most prolific hybrids. This example is very important, from the fact that the sheep and goat not only are different species, but belong to different genera, while they produce hybrids which also breed prolifically. These facts are sustained by indisputable authority.*

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* Buffon, Quadrupèdes, xxii. p. 400; xxx. p. 230.

207. Still more extraordinary is the hybridity of the deer and ram.* Hellenius gives the following synopsis of his experiments: —

"I have thus from this pair (female deer — *cervus capriolus*, and the male sheep — *ovis aries*) — obtained seven offspring, viz.: four from the ram and deer, two of each sex; two from the deer's first hybrid male offspring, viz., by crossing the latter animal with the Finland ewe, and by crossing this same male with the female offspring of the deer and ram; one, a ewe, by pairing the Finland ewe with one of her own progeny, from the first hybrid male derived from the deer and ram."

It is evident that, with little care, or in a state of nature, by bringing together many pairs, a new race, intermediate between the deer and sheep, could be unlimitably propagated. Molina, in his Natural History of Chili, records that the inhabitants of that country have, for a long time, been in the habit of crossing goats and sheep to improve their flocks; and he also says that the offspring thus obtained are unlimitedly prolific. All well-read naturalists maintain that the dromedary and camel are distinct species,† and they were figured on the monuments of Nineveh, at least 2500 years ago, precisely as they appear at present. But they and their offspring propagate unlimitedly together.

208. Perhaps no question has caused so much controversy as the origin of the domestic dog. The best authorities promulgate doctrines diametrically different. One class refer all varieties to a common origin

* Carl R. Hellenius, quoted in Types of Mankind, from the Memoirs of the Royal Swedish Academy of Stockholm, as sanctioned by Dr. Morton.

† Linnæus, Smith, Cuvier, Lessing, &c., and sustained in Types, &c.

in the wolf; another class suppose that they are derived from various species, created in different countries; and still another refer them to domestication of the wolf, fox, jackal, &c., and the infinite hybridization between the races thus produced. This is a question having a direct bearing on the transmutation of species. If it is proved that the poodle and Newfoundland dogs have a common origin, all boundaries to the limitless modification of species are removed, and if the last theory be resorted to, the fact that all the canine species are prolific *inter se* demolishes the limitation of species.

209. It is probable that the domestic dog of our day is derived from several species, and also from the wolf, fox, &c., which have been domesticated. Pallas observed in Moscow the offspring of the dog and black wolf, which were prolific among themselves. The Australian dingo is a fine example of a wild dog, and is undoubtedly a distinct species. The Indian dogs of America were probably derived from the American wolf by domestication. Richardson remarks that his men, while engaged in his famed arctic exploration, often mistook the wolf for the Esquimaux dog. He also observes that the Indian hare-dog so nearly resembles the prairie wolf, that on comparing live specimens he could detect no difference in form, fineness of fur, or position of spots. All races of dogs are prolific when bred together, and their offspring are unlimitedly prolific.

210. What has been said of dogs might be repeated of our domestic fowls, our cats, and our swine. We are entirely ignorant of their origin, but they probably are derived from blending of several distinct species, which have become lost in amalgamation.

211. The amalgamation occurring among plants is still greater than among animals. The fertilizing pollen is transferred from one to another by insects, and undoubtedly many of our reputed species are only hybrids originating in this manner. Let it be proved that hybrids are fertile, and we have an explanation of the creation of many of the intermediate species and genera. But I would by no means lay as much stress on hybridity as some have done. It is one among many causes which operate in effecting changes of specific character.

212. There is one fact connected with hybridization which has not received the attention it deserves as a cause of specific change. Hybrids may or may not be fertile; but if being impregnated by another species forever after influences the succeeding offspring, then a new argument presents itself in hybridity. Dr. Harvey says that an Arabian mare, being covered by a quagga, gave birth to an offspring with the distinctive characters of the male parent. She afterwards was covered by a full-blood Arabian horse, and produced three successive foals all bearing the marks of the quagga. Another mare, after having produced a hybrid by a zebra, was afterwards bred with the horse, but always after her offspring were distinctly marked like the zebra. Such facts are still more distinctly seen when different breeds of the horse, ox, dog, &c., are bred together, and are likewise seen in human generation. If these facts be admitted, then the fertility of hybrids can be rejected; but it must be admitted that the mother is capable of impressing her full blood offspring ever afterwards with the marks of the hybridizing male, and such offspring, being fertile, will transmit such characters; and thus new races may originate,

which will become species as soon as their source becomes lost.

213. Equally great are the effects of conditions. They mould plastic life into whatever channel they work out, and such is the harmony which exists between organic forms and their environing conditions, that philosophers have ever supposed that in this harmony they saw the evidence of design, and that living forms were created in reference to the conditions in which they were to be placed. In this dogma we perceive no vestige of law. It is wide of the field of philosophical research, and could issue from none other than a theological source. In strict induction, if a changeable form is placed in unchangeable conditions, it must either conform or perish.

214. Let us pause for a moment in our deductions, and introduce facts having direct reference to the subject under review. If it can be proved that species permanently change by any concurrence of circumstances whatever, then the theory of their primordial creation and special design in their adaptation goes by the board. The influence man exerts over domestic animals is very great, and it is interesting to observe the great variety he has produced by varying the circumstances which surround them.

215. Gardeners and agriculturists are well aware of the influence exerted by favorable conditions on plants. They know that so often as they furnish these they reap a rich harvest; the result following given influences takes place with mathematical certainty. Many single wild plants, when furnished with a superabundance of food, have their stamens converted to petals, and become double, as the poppy, peony, &c. Others change their color, as the hy-

drangea; when planted in compost, they have red flowers; in bog earth, blue; and in loam, yellow. In the primrose a more remarkable change occurs. It was Linnæus's opinion that the primrose, oxlip, cowslip, and polyanthus, between which there are specific differences, were varieties of one species. This opinion is confirmed by experiment. Still greater changes have been produced by cultivation, which show that when the true knowledge of cultivation is thoroughly understood, almost any desired change can be procured. A salt and bitter plant, like the chardock, with green, wavy leaves, was taken from the sea side and transplanted into a rich soil, where it became changed into two plants, between which exist specific distinctions — the cabbage and cauliflower. The apple was derived from the sour crab, which ornaments the banks of rivers, and by variations in its culture, runs into the countless varieties which add value to the orchard. The influence of culture in this remarkable instance is forcibly shown by comparing the greening or pippin with the crab apple.* The plum was derived from the bitter slow; the luscious peach from a poisonous shrub of the Persian deserts. The sour, red currant, by culture, is changed into a new variety, larger and sweeter than the cherry. The wild strawberry, by the same process, becomes of enormous size and of exquisite flavor. Equally great changes are effected in the blackberry and raspberry.

216. By the total extinction of the original types of the cereals, it is evident that they have so widely departed from their original form as to be no longer recognizable. These transformations must antedate

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* Lyell, Principles.

the age of the pyramids, as wheat precisely like that of the present has been obtained from exhumed mummies. Even at that remote era cultivation had wrought nearly its ultimate change of form. Wherever man has trod, he has carried the cereals with him; yet nowhere do they occur wild. It will not appear singular or strange that a rough weed is transformed into wheat, when to the facts previously stated we add others equally conclusive. The inestimable potato is derived from a diminutive root growing wild in Chili. The carrot, in a wild state, is a slender, dry root, unfit to eat. The delicate cauli rapi, is, when wild, a dry stem. Professor Henslow's experiments confirm this position as to the mutability of species. He proves that the centaurea nigra and nigrescens pass into each other by cultivation, as do the species of rosa, primula, and anagallis. The garden daisy is only the cultivated wild species. Future botanists will continue to multiply these facts.

217. The derivation of wheat has been reduced by M. Fabre, of Agae, France,* to a certainty, by direct and careful experiment. He took the seeds of the ægilops ovata, a rough grass, native of Southern France and Italy, and after twelve successive years' cultivation it became perfect wheat, and not a single plant ever reverted to its former ægilopic character. He conducted his experiments in an enclosure, surrounded by a high wall, which silences the objection which might arise, that the ægilops hybridized with neighboring wheat. Each year effected a slow change, advancing the plant one step nearer the true wheat.

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* For a full delineation of this remarkable experiment, see Agricultural Report for 1857, quoted from Journal of Royal Agriculture, p. 574.

This experiment reconciles the vague traditions which refer the origin of the cereals to the East, where the ægilops is a common wild grass, and, under favorable circumstances, might have assumed a wheat-like appearance. If wheat is thus derived, it is probable that the other cereals had the same origin. This is supported by the statement of the noted botanist, Lindley. He says, "At the request of the Marquis of Bristol, Lord Hervey, in the year 1843, sowed a handful of oats, and treated them in the manner recommended by continually stopping the flowering stems; and the produce in 1844 has been, for the most part, ears of very slender barley, having much the appearance of rye, with a little wheat and some oats." "How then can we be sure that all the cereals are not offshoots from some unsuspected species?" The surmise of the great botanist has been verified and established as an important fact of botanical science.*

218. So great have been the changes effected in domestic animals, that their origin is obscured or totally lost. It is probable that the dog, horse, ox, and sheep were derived from many sources, and the great variety now existing undoubtedly came by the blending of the various stocks produced by them. The savage tribes of the primitive ages each strove to domesticate the wild animals of the forest; and when the tribes united in nations, their domesticated animals became common property, and mingled together. This is far more rational than to suppose one tribe first domesticated a particular animal, and from them it was disseminated to all others. The dog, for instance, of the Esquimaux is a northern

* For a full delineation of this remarkable experiment, see Agricultural Report for 1857, quoted from Journal of Royal Agriculture, p. 574.

wolf; of the western Indians, a prairie wolf; of the east, a domesticated wolf, fox, or jackal. By blending these various stocks the great variety observed is produced. These variations are very ancient, dating back at least five thousand years, as the mastiff, hound, &c., are faithfully delineated on Egyptian monuments.

219. The horse has been discovered as a fossil of the tertiary, and even then existed as two distinct species.* The present races are probably descendants from these original stocks. Climate and culture has also greatly affected them. There is a specific distinction between the Shetland pony and the Arab steed. It is stated that the common horse, transported to Arabia, in time becomes better formed. Climate has a great influence on animals. In 1764 the French introduced horses and cattle into the Falkland Islands. The horses have increased, but greatly degenerated, and, although in good condition, are so small and weak that they cannot be used in taking the wild cattle.

220. Darwin remarks that "at some future period, the southern hemisphere probably will have its breed of Falkland ponies, as the northern has its Shetland breed.†

Although but one breed of cattle was imported, yet, occupying a territory of only one hundred and twenty by sixty miles, they have separated into three distinct varieties. Those on the high lands are of a mouse color, and calve a month earlier than those on the low lands. On the north of Choiseul Sound they are dark brown, while south of it they are white,

* Lyell's Elements. De Labucks, Geological Observer.
† Darwin, Voyage of a Naturalist, vol. i. p. 247

with black heads and feet. The various herds do not mingle, and it is remarkable to see one variety of the ox thus producing three essentially new branches. It has been conjectured the wild and fierce auroch was the original parent of our domestic stock, and it may be one of the roots from which they are derived, but they cannot be referred entirely to this source. They manifest too mixed a type to be derived from a single stem.

By culture the Devons, Durhams, &c., have been, as it were, created out of the original stock, and made permanent. What are termed improvements in stock consist in adding to those parts of the animal most valuable as meat, and lessening the less valuable portions. This has been almost reduced to a science, and breeders successfully strive to perfect their animals in these points. There appears no limit to their success in this direction, as each year produces a nearer advance to the ideal. The same is true of horses, which are bred in reference to different purposes. The draught horse becomes the strongest of animals; the racer the fleetest; the hunter endowed with surefootedness, and capable of leaping fences and hedges which would confine most other animals. Each variety has been bred with reference to an ideal, and by long and patient care that ideal has been obtained.

221. Ofttimes man has taken advantage of accidental peculiarities, and by proper care made them permanent. As an illustration, in 1791 a ewe, belonging to a farmer in Massachusetts, produced a male lamb, which, from its singular length of body and shortness of limbs, received the name of the *otter* breed. These peculiarities, disabling it from leaping

fences, &c., seemed to render the breed desirable, and determined the owner to make an effort to propagate it. The first year he obtained two with the same characteristics, the second a greater number; and when these were bred together a new and strongly-marked race was permanently established.*

222. A new breed of Merino sheep, distinguished for their long, smooth, and silky wool, has been established in a similar manner.†

It has been objected that man has only taken such species under his care as were capable of the greatest degree of education, or transformation. This, however, is entirely an assertion. As the origin of all domesticated species is lost, we do not know what were the species man first reclaimed. Nor can we ascertain the amount of change six thousand years' domestication would produce on any of the present wild species. Man annuls time by producing the concurrence of the most favorable conditions. His influence is not arbitrary or unnatural, as has been supposed by those who have been blinded by the dust of controversy, but is simply a condition whereby change is effected. By understanding the causes he can induce such effects as he pleases, and rule the animate world with iron sway. But enough has been stated to show how potent is his influence. It is too well known to be disputed, and I turn to the operation of natural causes.

223. Often have I remarked the dwarfed appearance of stems of grain which had accidentally strayed from the border of the field. None feel the effects of degenerating causes as much as that lover of the rich

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* Philosophical Transactions, 1813.

† Owen, in a lecture before the Society of Arts, Dec. 10, 1851.

and cultivated soil, the Indian corn. It can be seen by the side of fields, or when choked with weeds but a few inches high, and maturing but a few grains.

224. An English botanist states, that "on the chalky borders of a wood he gathered perfect specimens, in full flower, of the centaury, not half an inch in height. By tracing the plant towards the wood, it gradually increased in size until it became a glorious plant, five feet in height." As it is certain that the conditions of the parent are transmitted to the offspring, how long could the plant be thus dwarfed before a new and smaller species would result? I have seen specimens of the nightshade, usually three feet high, growing in a cleft of rock, which were not one inch high, and matured but two flowers and one seed. The influence of soil and climate cannot be disputed. When pines and firs grow up the mountain side, meeting the increasing cold and more barren soil, they become smaller and smaller, until covered by almost perpetual frost.

225. Fungi and lichens are more affected by the circumstances of their growth than any other vegetation. In their classification exists the greatest difficulty in fixing their characters. Fries asserts that out of the different states of one species (*telephora sulphurea*) more than eight distinct genera had been constructed by different authors. It would seem, then, that the absolute number of species among the fungi is not nearly so great as has been supposed, and the kind produced by a decomposing infusion, or a bed of decaying solid matter, will depend as much on the material employed as upon the germ itself which is the subject of it." * The Haarlem Academy of Sci-

* Carpenter's Comparative Physiology, p. 62.

ence proposed as a question, "According to some botanists, algæ of a very simple structure, placed under favorable circumstances, develop and change into different plants, belonging to genera more elevated in the scale of organic being; although these same algæ, in the absence of such favorable circumstances, would be fertile and reproduce their original form." * This statement has never been disproved. It is stated by the greatest of living physiologists, that while young, the lichen is a perfect alga, but as it matures, a dry habitat is best suited for it. In every respect it is an alga, except that it grows in the air, while the other grows in water. Knowing as we do the susceptibility of the cryptogamia to extenal influences, we are justified in predicting an unlimited amount of change when the proper influences are applied.

226. Darwin records in his journal many interesting facts having a direct bearing on the question under discussion. He records, unknowingly, the tendency of species to conform to the conditions which surround them. The changes the damp climate of the Falkland Islands had effected on the horse and ox have already been referred to, but they are far from completing the list. The rabbit has been imported into the same inhospitable clime, and succeeds so well that it abounds in a wild state. The rabbit is a native of Northern Africa, and would not be supposed capable of enduring the extreme transition it has done in being removed from its torrid home into the damp climate of the Falklands, where there is so little sunshine that wheat ripens only occasionally. But, instead of becoming extinct, it has originated three varieties,—black, gray, and piebald,— so very distinct that even Cuvier,

* Charlsworth's Magazine of Natural History, ii. p. 448.

unacquainted with their origin, judging by the skull, thought they were distinct species.

227. The common hog has run wild on the island, and has become of a jet black color, the boars having enormous tusks, and being extremely fierce.

228. The only native carnivorous animal is a large wolf-like fox. On the authority of Darwin, this fox is the only instance on record of so small and broken a fragment of land having so large an indigenous quadruped peculiar to itself. Those who believe in miraculous creation will find this fact hard to digest. With countless others it requires a special act of creation, ungoverned by law, and fortuitous as chance. How beautifully, however, is it in accordance with the theory we are supporting. The parent fox is brought to the island from some other land, perhaps America, on a floating raft, drifted by wind and current; and finding an abundance of food, and no enemies, multiplies, and after many generations is moulded by the new conditions which operate upon it, until it is no longer recognizable. It deceived even Cuvier on its origin.

229. Kneeling Island has but one quadruped—a rat, which was introduced by a ship wrecked on the coast. It is pronounced by Waterhouse identical with the English kind; but it is modified by its new home, becoming smaller and deeper colored. Oceanic birds straggle over the low Pacific Islands, as the rail shot on Ascension, a solitary straggler, proves. Becoming attached to particular haunts, they cease to migrate, and under the same influences which modified the ox, the horse, and the rabbit of the Falklands, originate new species. How else are we to account for varieties found on all these islands, and on every portion of the

continents? On Kneeling Island a snipe and a rail were found, not lovers of the water, but of the dry land, and feeding on dry herbage.

230. Perhaps nothing can be written so admirably illustrating and substantiating the theory that living beings conform to the conditions in which they are placed, as this naturalist's account of the Galapagos Archipelago. This group of islands lies directly under the equator, six hundred miles from the western coast of South America. Entirely of volcanic origin, they glitter in the vertical rays of a torrid sun, every height crowned with its crater, and the course of the lava streams still distinct. Each of the several islands has its own animals peculiar to itself, even the tortoises of different islands differing in size and character. Each island of the group has a variety of mocking thrush peculiar to itself; there are twenty-six species of plants found nowhere else. It has been a theme of speculation among scientific men, why each island should have a distinct flora and fauna from the others, when lying so near each other as to be in sight. A distinct creation was believed necessary for each. Here their theory, philosophy, and knowledge terminated. But are we necessitated to leave the domain of science? Not as long as *positive* knowledge can be acquired. These islands are of recent origin. They were upheaved from the profoundest depths of the ocean. Through the spaces between them, a strong current constantly sweeps, effectually cutting off all intercommunication, and the chance or possibility of an animal passing from one to the other would be far better, if five hundred miles of calm ocean interposed between them. All the animals and plants show a marked relation to those of the contiguous

South American coast. From such data I draw the inference that these islands have been separately planted and colonized by drifted seeds and animals, and, as in previously cited instances, these have changed until their parentage is obscured.

231. From the hot and arid climate of these islands the character of the plants may be inferred. Their leaves are so small that the dwarfed underwood appears entirely leafless, and except in places moistened by springs, this cheerless aspect is universal.

There is only one indigenous mammal, and that an inhabitant of but one island — a mouse closely related to the mouse of the new world. On another island a rat has been discovered, and from its being related to the rat of Europe, has been referred to that species, as a variety of the latter, imported in vessels, modified by climate.

232. There are twenty-six kinds of birds, all peculiar to the group, except a lark-like finch, a native of North America. They are composed of hawks, owls, wrens, doves, waders, &c., almost all of which, notwithstanding the tropical climate, are of a dusky color. They are generally smaller than the continental species, as well as duskier hued — a fact showing them to be immigrants, as transported species generally decrease in size. The plants have also degenerated, being forced to grow in this coarse and arid volcanic soil. All the insects also are small and dull colored, conforming to the weed-like vegetation on which they feed.

233. It is now established that fishes do not pass very great intervals of open sea. Hence they are nearly as much confined in their specific ranges as the land fauna. This group of islands has sixteen species

peculiar to itself, belonging to twelve genera, which are *widely distributed.*

234. Of mollusks they have sixteen species of land shells, ninety species of sea shells, all peculiar to them, except one land shell, a native of Tahiti, and forty-three sea shells, twenty-five of which are natives of the western coast of America; and the others are widely distributed. Eight of these are varieties.

235. "Why," exclaims the above naturalist, "on these small points of land, which within a late geological period must have been covered by the ocean, which are formed of basaltic lava, and therefore differ in geological character from the American continent, and which are placed under a peculiar climate, — why were their aboriginal inhabitants associated, I may add in different proportions, both in kind and number, from those on the continent, and therefore acting on each other in a different manner, — why were they created on different types of organization? It is probable that the Cape de Verd group resemble in all their physical conditions far more closely the Galapagos Islands than these latter physically resemble the coast of America; yet the aboriginal inhabitants of the two groups are totally unlike, those of the Cape de Verd Islands bearing the impress of Africa, as the inhabitants of the Galapagos Archipelago are stamped with that of America." *

236. Let us pause, and apply the present philosophy to the solution. A strong current sweeps past the Galapagos, drifting palms and terrestrial vegetation on their south-eastern shores.† This current furnishes a conveyance for the hardy seeds, which

* Darwin's Voyage of a Naturalist, i. p. 249.
† Colbett, p. 58.

are thrown into the ocean by the South American rivers. Rafts formed of floating timber are often met at sea,* bearing strange communities of organic beings. Voyagers on tropical rivers are often exposed to great danger by these rafts, which are bound downward to the sea. Martius, when ascending the Amazon, saw them in immense numbers. On them were very singular assemblages of animals pursuing their uncertain way. On one he saw a stork — probably having a nest — and a party of monkeys. On another a number of ducks and divers were perched beside a group of squirrels, and on the trunk of an enormous cedar were a crocodile and a tiger cat. If the large rivers have such extensive rafts, small ones, at least occasionally, would send them down to the sea.

237. Lyell remarks,† "It is highly interesting to trace in imagination the effects of the passage of these rafts from the mouth of a large river to some archipelago. Some of those in the South Pacific were raised from the deep, in a comparatively recent time, by the operations of the earthquake and volcano, and the joint labor of coral animals and testacea. If a storm arise and the frail vessel be wrecked, still many a bird and insect may reach by flight some island of the new formed group, while the seeds and berries of herbs or shrubs which fall into the water may be thrown upon the strand. But if the surface of the sea is calm, and the rafts are carried along by a current, or wafted by some light breath of air fanning the foliage of the green trees, it may arrive, after a passage of several weeks, at the side of an

* Sphix and Martius, vol. iii. 1011-13, quoted by Lyell.

† Principles of Geology, p. 642.

island, on which its plants and animals would be landed as from an ark, and thus a colony of several hundred new species may at once be naturalized."

238. This reveals the secret of the introduction of species into remote islands, without the assistance of a special creation. Let us delineate the above history a little farther. One by one, different species are imported to each island of a group, gaining thereby accessions to its species independent of the others; and if, as in the Galapagos, strong currents sweep between contiguous islands, the flora and fauna of each will remain distinct. Each island will possess a climate in many respects peculiar, being more or less elevated above the sea, arid, or moist, with equable rains or severe droughts, &c.; consequently, the influence exerted on the newly-arrived immigrants would materially vary. If the latter survive the change, and are sufficiently hardy to resist the detrimental causes, they will be forced to undergo modifications such as we have already observed would take place. The immigrants would be derived from the nearest continent, and, in opposition to change, they would retain their original peculiarities. Hence the aboriginal species of the Cape de Verds partake of the characters of those of Africa, and the Galapagos Islands of America, from which a rapid current sweeps past them.

239. A peculiarity of all island flora and fauna is their heterogeneous character, and the great number of genera compared with the number of species. They are composed of only the most enduring plants and animals — those which are capable of being transmitted without much injury. Why is this, if each island is peopled by special design? On the other

hand, if species are introduced by floating seeds, or animals transported on rafts, it would be a rare occurrence for more than one species of a genus to become established in its new home. These modifications occurring, would not only alter and transform it out of its original species, but its genus also, to another closely allied. Those species which are also natives of the adjoining continent have either not been naturalized a sufficient length of time to become modified, or they are endowed with a strong power of resisting encroaching conditions.

240. When animals which inhabit a cold northern latitude, and covered with a thick, warm coat of fur or wool, are transported to a southern latitude, they will gradually shed a considerable portion of it; but they will obtain it again if returned to the north. The color of the ermine and alpine hare changes to white during the winter. Cold and heat have a marked effect not only in the color, but in the quantity, of clothing necessary for their preservation. Diet, too, has its effect. When meagre and sparing, it has a tendency to produce hair — a fact which may help to explain the acquisition of the thick coats of fur by arctic animals. The fur becomes finer as the severity of the cold increases, for cold contracts the pores of the skin, and the hair takes the size of the aperture through which it grows.*

241. The vital organs are also changed by circumstances. This is wonderfully seen in the Peruvian race of men, who are noted for their enormous expansion of chest. They lived at a height of between seven thousand five hundred and fifteen thousand feet

* Goldsmith's Animated Nature, vol. i. p. 72; also Krantz's History of Greenland, vol. i. p. 72.

above the sea level, and hence a much greater quantity of air was necessary to be inhaled to supply the respiratory functions: in consequence, the lungs were enlarged, and the thorax from *infancy* abnormally dilated: in the lungs there was a kind of natural emphysema.* There was a time when the Incas did not dwell on those extreme heights, at which time their chests were not unusually developed: such enormous lungs would, if supplied with common air, injure, if not rapidly consume, the physical system. They removed to the rarefied and elevated stratum of air, and their lungs conformed to its peculiar influence, and after a few generations, the peculiarity became hereditary, and was possessed by the unborn child. Thus we see the production of one of the most prominent physical characteristics of the Inca race.

242. Organs are lost, or dwarfed, by inactivity. If they are enlarged by conditions bringing them into uncommon activity, they are decreased by influences unfavorable to their growth. Thus the mole rat, (*mus typhlus*, Pal.,) dwelling constantly beneath the surface of the ground, and consequently in total darkness, has no use for organs of vision, and they are in consequence undeveloped.† That such is the fact, and that it is not design, is clearly proved by this animal — having the rudiments of eyes — mere round black bodies — situated beneath the folds of the skin. They, however, serve no purpose, and are failures so far as special design is concerned in the structure of the animal. The common mole is a transitional form. It has little use for eyes while travelling in its dark subterranean passages, and hence

* Smith, Natural History of the Human Species, p. 38.
† Cuvier's Animal Kingdom, p. 116.

they have become so small that it was believed at one time that it was blind.

243. Fishes inhabiting cavern lakes are sometimes blind, as those of the Mammoth Cave, in Kentucky, U. S. — a result of similar conditions to those which destroy the vision of the mole rat.

Mollusks, when they inhabit water, strongly impregnated with carbonate of lime, acquire shells of great thickness; the presence or absence of a single element effecting such important changes that it is difficult to recognize the species. In water strongly impregnated with carbonic acid, — as the Lake Solfatara, in Italy, — the confervæ, and other simple cellular plants flourish so vigorously that they completely fill the water. Around springs where carbonic acid escapes, vegetation partakes of an almost carboniferous luxuriance.

244. There are conditions furnished by some countries more favorable to the existence of particular beings than others. Thus North America is the oldest land on the globe,* and we find its fauna remarkably harmonizing with its ancient character. In it the most ancient beings exist. It is in North America where the gar-pike lives, and the gar-pike is the only existing representative of that age when the gar-pike only lived.* The fishes of the North American lakes greatly differ, but live in *similar situations as allied European species.* There are fishes in Lake Superior with spines on their obercular bones, all the scales hard, and, what is never observed in existing hard-scaled fishes, they have fatty fins. These facts are set down by naturalists as strange. But they are in beautiful harmony with the

* Agassiz, Geology of Lake Superior.

theory here presented. The American continent was elevated above the ancient ocean, and its northern portion has never since been wholly submerged. It has fostered its ancient fauna, some of which have had power to resist the changes which have slowly occurred without being removed from the types to which they belong; others have completely changed; while others still, unable to withstand the opposing, changing influences, have perished. It is observed that the fresh water species of the North American lakes are allied to European species living in similar situations, proving that similar conditions ever reproduce similar forms.

245. Another illustration is found in the Australian continent, which does not carry us back to such remote eras as America, but ushers us into the oölitic epoch. By influences which are exerted in a manner of which we are at present ignorant, the flora and fauna of the oölitic period are retained. Marsupials occupy the place of the true mammalia, and oölitic rays and sharks swarm the adjacent ocean.

246. It is objected that animals cannot change, because their instincts are permanent, and hence are inadequate to maintain life under any other circumstances than that for which they were especially designed. But instinct is far from permanent. It changes with the organic modifications effected in the animal. A few facts only will be introduced from the innumerable instances where such changes have been produced. The wild hare digs a deep and intricate burrow, to protect itself against its enemies; but when tamed, and conscious of protection, it neglects to provide this security for itself.* It has been observed

* Darwin, vol. ii. p. 175.

that when a warren is stocked with tame rabbits, they and their immediate offspring neglect to dig burrows, and remain exposed to the weather; but after two or three generations they find the necessity of providing themselves shelter, and resume their former habits of burrowing.

247. On the Pacific Islands early voyagers and travellers found the birds and animals extraordinarily tame. They could be approached and caught with the hand, or killed with a switch. On the Galapagos Islands, which are but little frequented by man, they are very tame; in the Falklands they were, according to Pernety, once quite as tame. They have learned caution by experience. In early times, when all the other birds were tame, the black-necked swan was wild and sly: "being a bird of passage, it brought with it the wisdom learned in foreign countries."

248. "All the birds at Bourbon Island in 1571 and 1572, with the exception of flamingoes and geese, were so extremely tame that they could be caught with the hand. Again, at Tristan d'Acunha, in the Atlantic, Carmichael states that the only two land birds, a thrush and a bunting, were so tame as to suffer themselves to be caught with a net. From these several facts we are warranted in the conclusion, first, that the wildness of birds, with regard to man, is a particular instinct directed against *him*, not arising from any general caution originating from other sources of danger; secondly, that it is not acquired by individual birds in a short time, even when much persecuted, but that in the course of successive generations it becomes hereditary. With domesticated animals we are accustomed to see new mental habits or instincts acquired, and rendered hereditary; but with

animals in a state of nature it must always be difficult to discover instances of acquired knowledge. In regard to the wildness of birds towards man, there is no way of accounting for it, except as an inherited habit. Comparatively few young birds in any one year have been injured by man in England; yet almost all, even nestlings, are afraid of him: many individuals at the Galapagos and Falkland Islands have been pursued and injured by man, but have not yet learned a salutary dread of him. We may infer from these facts the havoc the introduction of any new beast of prey must cause in a country before the instincts of the indigenous inhabitants have become adapted to the stranger's craft or power." *

Such are the facts, and such the conclusions, of one of England's best naturalists. The instincts acquired by domestication are of such a character as to be easily referable to the influences brought to bear on the domesticated species. Lyell's objection,† urged against the unlimited adaptation of habit, because the instincts acquired by domestication have an intimate relation to the habits of the species in a wild state, when rightly considered, so far from being an objection, sustains the theory it is designed to disprove; for it is evident that the original habits should modify the influences of domestication to a greater or less extent. This author remarks, "It is undoubtedly true that many new habits and qualities have not only been acquired in recent times by certain races of dogs, but have been transmitted to their offspring." He might have extended the same remark to all domesticated species.

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* Principles of Geology, p. 594. † Principles of Geology, p. 593.

249. A race of dogs employed in hunting the deer on the Santa Fe table land in Mexico affords a beautiful illustration of a newly-acquired instinct.* The dog of pure breed will never attack a deer from before while it is running, but will step aside, and make his assault on its flank or rear. He watches the favorable moment when the deer rests its weight only on its fore-legs, and then by a sudden effort overturns it. The weight of the animal thus thrown often exceeds six times that of its adversary; whereas newly-imported dogs, though much larger, not having this instinct, often have the vetebræ of their necks dislocated by the violence of the shock.

250. A new instinct has been acquired by that mongrel race of dogs employed on the banks of the Magdalena, in South America, to hunt the white-lipped peccari. The address of these dogs consists in not attacking any individual of the herd, but keeping them all in check. These dogs, when first taken into the field, understand this mode of attack, but dogs of another breed will start forward at once, become surrounded and torn in pieces in a moment.

251. The English greyhound, when transported to the Mexican table land, situated nine thousand feet above the sea, where the mercury in the barometer stands at nineteen inches, was found to be unable to endure the fatigues of the chase in the attenuated atmosphere, lying down after a short time and gasping for breath. But the offspring of these same hounds were as fleet as the best in their native country, and not in the least incommoded by the rarefied state of the atmosphere.†

* M. Roulin, Ann. des Science Nat. tome xvi. p. 16.

† Principles, 594.

252. The peculiar habits of the pointer and retriever, first taught them by art, have become hereditary, and when first taken into the field their peculiar traits are manifested far more than in other races after long and patient teaching.* Shepherd dogs manifest a remarkable aptitude for their vocation, and dogs to which any peculiar trick has been taught often transmit the same to their descendants.

Instances are on record in which dogs, by design having been deprived of their tails, have transmitted this lack of tail to their offspring; but there are breeds of tailless dogs of a remote origin. There is a wide field open for investigation in regard to the extent the mental influence of the mother affects the offspring, for although many marvellous fables are related by credulity, the subject is of great importance. "And when it is borne in mind that the races of animals among which the so-called *spontaneous* variations are most apt to spring up, are also those which are most susceptible of the modifying influences of external conditions, it seems highly probable that these spontaneous variations are attributable to the influence of external agencies in modifying the constitution of the parent.†

253. I now turn to the consideration of another point in the influence of conditions. It has always been argued by philosophers, as well as theologians, that living beings were created by design, in harmony with the position they occupy, by an external force; thus inverting the true order of cause and effect, or rather totally ignoring the immediate cause. I desire to introduce a few instances which are said to show

* Experiment of Magendie.

† Smith, Nat. Hist. of the Human Species, p. 38.

the presence of design in the most remarkable manner, and apply to them the theory presented in this chapter.

254. Paley, in his Natural Theology, remarks that the similitude between the form of a fish and a boat "is not the resemblance of imitation, but the likeness of applying similar mechanical means to the same purposes." "In their mechanical use, the caudal fin may be reckoned the keel, the ventral fins the outriggers, the pectoral fins the oars," and we may now add, "the caudal fin the screw-propeller." Such are the supposed instances of design in the structure of fishes. Look still deeper, and answer the question how the form of fishes could be changed so long as they are inhabitants of the water. Whether they conformed or not to the conditions imposed, the nature of the aqueous element would soon induce the necessary changes to establish harmony between its inhabitants and itself.*

255. The same remarks apply to birds. In their organization are combined all the mechanical contrivances essential to aerial locomotion. Their form is the only one compatible with flight. As the elements through which transportation is effected are similar, except in density, the form of the two types is similar; but while the locomotive organs of one are exerted on a dense medium, those of the other are exerted on a very ethereal one; hence the difference in the size of the fin of a fish and the wing of a bird. Of course the body of the bird is constructed of so light a material, that it floats upon the water, and its limbs are readily converted into oars. The effect of its feet is further increased by the mem-

* See Paley's Natural Theology.

brane stretched between the toes, which expands when the foot is thrown backwards, and contracts when brought forward, and is further favored by the oar-like backward position of the legs — a position, however, unfavorable for walking.

256. Owen refers the existence of marsupials in Australia to special design. On account of the severe droughts of that country, and the extensive fires which follow, the native animals are obliged to make distant migrations, such as the young of the herbivora could not accomplish. But the marsupial dam has a pouch in which she conveys her young, and thus becomes adequate to transport them to great distances. He here shows as close reasoning in the relation of causes and effects as he has on another page, where he considers the vacancy between the incisors and molars of the horse designed to receive the bit of his master, man. As I have attempted to prove, on a preceding page, the existence of marsupials on that continent is referable to entirely different causes, and their adaptation to the mentioned peculiarities of the climate are incidental. Had they been natives of the prairies of the west, this author undoubtedly would have seen design in their relation to the fires which annually sweep over those vast grassy plains, enabling them to escape with their young; but it is found that the herbivora are enabled to escape destruction, and multiply in vast numbers, and when transported to the region for which the marsupials were *designed*, flourish with the same vigor as in their native clime.

257. Darwin * saw, on the Paranas of South America, a very extraordinary bird, called the scissor-beak,

* Darwin, vol. ii. p. 175.

which he considers as manifesting design in a remarkable manner. This is shown in its beak. It is flattened laterally, and is as thin and elastic as a paper-cutter; and, what is different from other birds, the lower mandible is much the longest. The *design* of this arrangement is shown by the use made of it by the birds. They fly like swallows over the water, with their lower mandible plunged beneath the surface, with which they plough up small fish, which are caught by the upper and shorter half of its bill. The experiment has never been tested, and consequently it is impossible to say how long a time must elapse before the bill of a swallow, or tern, would become thus flattened, were they to adopt the *habits* of the scissor-beak; but this can be inferred — that the compression of the beak would continue from generation to generation to augment, should such habits be adopted; and it is well established that the instincts of species, so far from being unchangeable, are frequently greatly modified. With every modification of instinct come new manners of life, and these, reacting on the organism, tend to make it conform to the given influences.

258. The same naturalist, speaking of one of the antarctic aquatic birds, — the steamer, — says, "It feeds entirely on shell-fish from the kelp on the tidal rocks; *hence*, its head and beak, for the purpose of breaking them, are surprisingly strong." Here he places cause and effect in proper relation; but the special design he would have his readers infer is wholly uncalled for. As the blacksmith's arm is developed by constant exertion, the beak, and the muscles which give it power, increase in strength by the constant straining they receive in detaching from the rocks and crushing the hard shells of their molluscous food.

259. For another illustration, take an instance from the great numbers which present themselves, — the embryonic growth of the human lungs, — and let the advocates of design give a philosophical explanation of its meaning, and of the class of facts it represents, if possible, or, if they cannot, confess the error of the hypothesis they maintain.*

260. The lungs are placed at first on each side of the spine, like the air bladders in fishes, and to carry out the analogy of the fish-like heart, branchial apertures appear on each side of the neck, like fishes' gills, and the aorta gives off a regular set of branchial arteries, some of which become obliterated, while some remain in the adult man. No one will maintain that the human fœtus is organized for aquatic respiration, or that a special act of God fashions each individual in this manner for no possible use. On the contrary, it better accords with the simplicity manifested in nature to refer to an immutable law all vital organizations, thus referring to a similar origin all tribes, races, and species, and forming of the diversified world of living beings a unit.

261. It were a useless as well as an endless task to catalogue the instances where design — adaptation — of structure is apparent. It meets us on every hand, exciting our curiosity and wonder. Were there no breaks, however, in this infinite network, the supporters of Final Cause would present a far more plausible theory. As it is, breaks occur, and still more, we see the equilibrium of species broken and restored before our eyes, and recognize the law by which harmony is produced. In such instances it is effected by the disturbed or newly-acting forces, not by special design.

* For further illustration, see chapter on Origin of Man, p. 238.

The mastiff transported into Denmark becomes the little Danish dog, and when taken to warm climates becomes the Turkish dog, almost destitute of hair. Are these changes the result of special design, by which the animal is adapted to the climate, or the results of the climate? Some countries are noted for the long, soft hair of their native animals, as Syria and Persia. The sheep, the goats, the dogs, and the rabbits of Syria are remarkable for the fine, glossy length and softness of their hair; and even the cat loses its savage color, and assumes the most beautiful appearance. Is this design, or the result of conditions with which we are but partially acquainted?

262. The objection resolves itself thus: If an all-wise Creator fashioned things as they are, why has he left so many waste places and deserts on the earth? Why did he not create the world perfect in the beginning, and not leave it to toil through an infinitude of ages to attain the position it might as well have occupied in the commencement. Man, when first seen on this earth, was a savage, and from that primal state he has arisen by slow and painful progress. Why did not an omnipotent cause create him perfect in the beginning? Not that I deny the existence of an omnipotent Divinity, but I deny the special manner in which he is supposed to act. If such theorists believe in the existence of an omnipotent, wise, and benevolent cause, acting on matter by special design, then it follows, as a clear and logical deduction, that the universe should have been created as absolutely perfect as its cause; and from this conclusion there is no escape. What are the facts? Rude and imperfect was the first rough model of creation. Amid the most awful convulsions, creation

after creation was destroyed, and new ones took their place; each succeeding one higher than the preceding. By a slow and painful progress, from the mollusk of the cambrian, the sauroid of the devonian, the saurian of the permian, the pachyderms of the tertiary, to man of the present, the silent but irresistible forces of nature have labored on. Here rest the pertinent questions, Why did an almighty and benevolent design permit so much waste of time and such infinite suffering, when by a word it could have been obviated? Why not have *created* man perfect, and not a savage, and thus have prevented the war, crime, and misery incidental to his advance from that state to one of civilization?

263. Reject it we may, yet it cannot be denied that there is something connected with the constitution of matter which has written the history of the globe; and so long as this remains unchanged, not a sentence of that history could have been written differently.

264. An omnipotent design, as interpreted by reason, would not give animals useless organs; but almost all species have such. Of what use is the fœtal transformations by which the mammalia approximate to fishes and reptiles before assuming their perfect form? Of what use are the branchial arches and openings to the human fœtus? Why have all mammalia the rudiments of organs developed in reptiles? Why do the males of all mammalia possess the sexual organs of the female in an undeveloped state, and vice versa? It were puerile to answer these questions by reference to mystery, when they so plainly point to the great principles which chain all living beings together, and make life in all its manifestations a unity.

265. The conclusions to which the facts here given

lead, may be concisely presented, and when expressed, form the theory of creation of organic beings we have labored to support.

(1.) Living beings are not adapted by *special design* to the conditions in which they are placed, but are modified by the conditions which surround them. The adaptation and harmony observed, is the result of the pliancy of life to physical influences.

(2.) All living beings originated from similar points, and species are only differences from common archetype, and have no more real existence in nature than genera.

(3.) The best established theory in natural history cannot be proved with mathematical certainty, and such clear proofs cannot be expected in a theory of such extensive application. All that can be expected is the inferential testimony of facts, analogy, probability, and induction. By such a course I have endeavored to arrive at and sustain a consistent view of organic creation. We have seen how unstable the characters of species are, conforming to the influences which bear on them. Lyell remarks, If once there appear grounds of reasonable doubt in regard to the constancy of species, the amount of transformation they are capable of undergoing may seem to resolve itself into a mere question of quantity of time assigned to the past duration of animate existence.* Linnæus asserted that "genera are as much founded in nature as the species which compose them;" but his observation was limited to comparatively few species, and so far from supporting this view, modern naturalists are confounded in the maze of existences,

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* Principles of Geology.

and are not only at a loss to assign the true character of species, but still more of genera, which "have no existence in nature." These latter divisions have become purely arbitrary, and science is fast proving that the former are also in a great measure conventional. Blumenbach observes that "no general rule can be laid down for the determining the distinction of species, as there are no peculiar characteristics which can serve as a criterion. In each case we must be guided by *analogy* and *probability*." We see on what trivial characteristics naturalists are obliged to rely for the determination of specific distinctions. Facts which we have recorded, not only clearly prove that species have not only been modified into other species, but even changed to other genera by the influences brought to bear on them.

266. In treating on this subject, vast periods of time are understood to have elapsed, through which enervating influences operated. Not understanding this well-determined point, numerous objections have been urged against the unitary view of life and its development. The changes in the organic as well as inorganic world are slow, and rarely are observable in the brief period of human existence. In the chronometer of nature, a thousand years is as a single swing of the pendulum — a moment of time. The number of sand-grains on the ocean's shore would be scarcely sufficient to express the duration of a single epoch.

267. It is objected that we never observe the birth of a new species. Setting aside the examples previously given, which incontrovertibly prove that we *have* seen new species produced before *our eyes;* and granting that the creation of new species were never

observed, of what avail is the objection? It is far more easy to prove that species once numerous have become extinct, than to prove the creation of a new race. Within the memory of persons now living, the number of known plants and animals has quadrupled in some classes. New and conspicuous species have been discovered in parts of the old continent long inhabited by civilized man. According to Lyell, it is impossible to determine whether a newly-discovered species has just come into existence, or is very old. He attempts to show how impossible it is to determine this point. Let us glance at the number and distribution of species. The phænogamous plants are computed at 80,000 species.* If we take the data furnished by the British catalogue of insects† and plants, there are nine species of insects for each kind of plant, or 720,000 for the globe — an estimate at least one half too small. The number of species of existing mammals known is 1200; ‡ of fishes, 6000; § of birds, 8000.‖ To these must be added the reptiles and the whole invertebrate series. The inhabitable surface beneath the water is computed to be twice that of the land, and of the denizens of this vast tract of marine wild we know scarcely any thing. Every portion, however, has its forms of life, even where the water is below the freezing point.¶ "Whether in lakes of brine, or in those subterranean seas hidden beneath volcanic mountains, or in warm mineral springs, the wide expanse of the ocean, the upper region of the air, and even the surface of perpetual snows, supports living beings." ** The number

* Lindley. † Catalogue of British Insects. ‡ Waterhouse.
§ Cuvier. ‖ Gray, Genera of Birds. ¶ Arctic Explorations.
** Darwin, Voy. Nat., vol. i. p. 85.

of polypes exceeds that of insects, and the sea swarms with innumerable forms of mollusca and zoöphyta. Parasites are supported by all animals, and *these* have *their* parasites. Without including the innumerable infusoria, we may safely estimate the number of species at present inhabiting the globe at 2,000,000. Hence, should one species become extinct every year, it would require 2,000,000 years to depopulate the earth. If this extreme rate was equally distributed over all classes, the lot would fall among the mammalia but once in 1666 years.

268. But only in this class would the loss be marked and obvious. The same course of reasoning equally applies to the introduction of new species. The lot might fall among the inferior classes, which are concealed from view beneath the ocean, for thousands of years, before a single change occurs among the more prominent occupants of the land.

269. The facts relating to the great changes effected in the dog are explained by some naturalists so as not to contradict the popular view, by saying that the dog is probably a domesticated wolf; and great as it varies in different lands, there is anatomically no difference between the fur-clad dog of the arctic zone and the almost naked dog of Guinea. This special pleading does not explain why the dog, when becoming wild, does not revert to the wolf, which it should do, were species permanent. The poodle left in the wilderness should become, not a wild dog, but a wolf! Admit, for argument, that all races of dogs had a common origin, —

270. The dilemma is equally unfortunate for the supporters of the popular view; for these races are permanent, specific, and will not revert to their original

type. So far as anatomical structure is concerned, the fox differs less from the wolf than the poodle dog from the Newfoundlander. Singular that one of the most conspicuous naturalists should introduce as an argument that the races of dogs anatomically agree. So do the lion and tiger agree so remarkably, that Cuvier found it difficult to distinguish their skulls. But they are of different species. It might be thought otherwise, however, were there any theory to support.

271. The mummies have been dragged from their resting place in the catacombs of Egypt, and with the pomp bestowed by a shallow philosophy, held aloft as settling the dispute forever! The mummied bulldogs, and cats, differ not more from the recent species than the mummied human beings differ from the present inhabitants of the Nile. Such is the decision of scientific men. With what species of dog were the mummies compared — the poodle or the greyhound? With what species of ox — the auroch or the devon? With what species of cat — the Syrian or American? Such vagueness shows rather haste in forcing conclusions, than scientific exactness. Were no differences observable, great ones might really exist, as Cuvier failed in pointing out any difference between the skull of the lion and tiger; and were one known only as a mummy, and compared with the other in a living state, the conclusions derived from such data would be very erroneous.

272. Viewed from one more point: Old as Egyptian civilization is considered, it by no means stood on the verge of time, and animals taken under the care of man had had ample time to assume the domesticated form, from which, as all the conditions usually bestowed had been applied, the departure is extremely

slow, until science lends its aid, and peculiarities are sought and obtained by bestowing the necessary influences.

273. It has been objected, that as every change in habit or organization was brought about slowly, before such species could become changed by new circumstances, others already adapted to such would supplant them. This may be true of the present, when almost every possible set of influences has produced its peculiar species; but it is not true of the ancient world when a few types filled the places of the countless number of the present. Then before there were other species to take the place of such as were undergoing changes to meet the requirements of new influences, it will be admitted that those influences could operate through an infinitude of ages undisturbed. Thus fall all the baseless objections of Lyell, and the facts he has recited become abortive.

274. Hugh Miller, in his three labored volumes, though the most popular writer on the theological side of this question, succeeds little better in establishing his own position than in defeating his antagonists. I hold the argument to the one cardinal point: Living beings are changed by, not adapted to, conditions. What has this author written to controvert this position? Nothing. Yet it is the cardinal point, and once admitted, the creation of organic beings is explained. He has found what he calls high forms, too low in the rocks to accord with this theory; and he has found all the four great divisions represented, when the zoöphyte should only exist by the theory. We limit our statements by our knowledge; and should an air-breathing reptile be found in the lower silurian, it would not invalidate the theory presented.

It would only show an error in the position assigned to the origin of that branch, and instead of saying reptiles originated in the permian, we should say they first existed in the silurian. What if pines were supposed to be first introduced into the coal era, and they should now be found in the silurian? A mistake as to time; that is all. Life is said to have begun where we first find organic remains; but it is very probable, nay, certain, that it existed thousands of ages previous to its leaving any trace on the rocks. What is more, all the great divisions should be found side by side, each ascending a pathway peculiar to itself.

275. I have not space to review the above-mentioned works, which are remarkable for the effrontery which pervades them, the bold and unscrupulous statements, garbling and misconstruing the words of his opponents. He has blended the weakest statements of Oken with a man-of-straw theory he has framed, and made Lamarck responsible for its folly; and with a juggler's art confounded both of these with the theory of creation by law, as it stands revised to-day. But many facts can be found in his works of great weight against the hypothesis they were designed to support. Lyell, in controverting the progressive theory, states, that when a body of salt water is slowly converted into fresh, the salt water animals are invariably killed outright, and never make any advance towards fresh water species. Miller, however, much as he has at stake, admits that at the Lake of Stennis, on the Isle of Stromness, great changes occur in plants and animals, when they ascend from the sea into the fresh water of the lake. The flounder ascends the highest, and is changed the most. It

becomes thicker and more fleshy, than in its native habitat, the sea. The sea weeds greatly change as they enter the brackish waters of the lake. Some of the hardier kinds become so dwarfish that they resemble confervæ, and only by tracing them through the intermediate forms is the indentity of species established. On the other hand, when fresh water species approach the salt water, they are dwarfed, until flags and aquatic grasses are but little tufts a few inches only in height.

276. Another objection has been urged: that if conditions modify species subjected to their influence, all species thus operated on should be similarly modified, which it is said, is not the truth. The European subjected to the climate of Negroland never becomes a negro. The animals of the old world, if transplanted to the new, never become like the indigenous species, and vice versa. It is asked, If climate modifies the species peculiar to it, why is there such a diversity of kinds in the same country? This appears at first a very plausible and weighty objection, but it is baseless. The European is not changed to a negro by the climate of Africa, because of a superior condition which he personifies, and which reaches back to the birth of the Caucasian race. That the African climate may produce a negro race, it must operate on such a stock as it did when that race sprang into existence. When two species are subjected to identical conditions, it is not to be inferred that they will produce identical offspring. Every species stands the representative of all influences which have ever operated on it since its birth, and these become a condition in determining the transformations which a similar climate will produce. The reasoning which sustains the contrary is like that which would

assert that an equal blow would drive a ball weighing a thousand pounds the same distance as a ball weighing a single ounce. The primordial conditions by which species originate have greater power than external circumstances, and changes are the combined result of both. The dog taken to the arctic circle becomes covered with long and thick fur; if to the tropics, he becomes almost naked — varieties resulting between which specific distinctions exist. The objection here urged would presuppose that in one case it must become a lion, in the other an arctic bear, thus totally rejecting the influence exerted by specific character, and primordial difference in the life principle. The European may be greatly changed by African climate; but instead of becoming a negro, those peculiarities which constitute his race will divert external influences into another channel, and a *new* variety will be the result.

277. As a necessary consequence, as the doctrine of creation by law conflicts with that of miracle, its combatants are of the theological school. Hence the denunciatory and egotistical style which even their greatest and best champion assumes. But even *he* cannot remain consistent. In one place he states,* "Every individual, whatever its species or order, begins and increases until it attains to its state of fullest development under fixed laws, and *in consequence* of their operation. The microscopic monad develops into a fœtus, the fœtus into a child, the child into a man; and however marvellous the process, in none of its stages is there the slightest mixture of miracle: from beginning to end, all is progressive development

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* Footprints of the Creator, p. 49.

according to a determinate order of things." Contrary to this, he devotes several pages to prove the possibility of miracles when he asserts, miracles "'are thus evidently not impossibilities, but even not improbabilities." Such is the conflicting reasoning of this author, who maintains the immutability of law in one place, and its suspension in another. In the latter opinion he is sanctioned by Agassiz, who, unable to account for the existence of life otherwise, refers it to the grand miracle of creation. The harmony of nature proves the immutability of law; miracle presupposes the suspension of law; hence nature utterly repudiates all miraculous interference in her domain, where every thing, from the mote that dances in the sunbeam to the intellect emanating from the congeries of the human brain, is governed by established principles.

278. Leaving for a time the discussion as based on observation of the living world, I pass downward to the beginning of life on this planet, and endeavor to give, by tracing the history of organic beings through the vast epochs of the fossiliferous strata, the causes which have swept from earth existing races, and ushered new creations into existence.

CHAPTER VIII.

DAWN OF LIFE.

The primitive States. — The primitive Ocean. — Dawn of Life. — Gestation of the Globe. — Difference of the great Divisions. — Progress of Life. — Preservation of Organic Remains. — Traces of. — Mingling of the extremes of Classes. — Permanency of Type. — Reproduction of.

279. Reposing on the gneiss is the vast system of primitive strata. They are composed of finer material, and were consolidated at a lower temperature than the rock on which they repose. During the myriads of ages which slowly passed away while they were depositing on the floor of the ocean, the great cooling process went on. The silent forces of nature labored amid throes of volcanic fury, breaking in fragments the thickening crust, or belching out the fiery lava from every vent or opening, preparing the angular and unprogressed world for the reception of living beings, which as yet were absent from this desolate planet. Life was absent, except the all-pervading essence, filling the atmosphere and the sea, beaming in the rays of the sun, ready to spring into identified existence.

280. The primitive ocean, beneath which the early stratified rocks were deposited, was not impregnated with the same mineral ingredients as the present sea. It must have held in solution a greater variety of elements, and in greater quantity. It was hot, but not boiling, as was the ocean of the gneiss. The light which fell into its shallow depths was softened and changed by penetrating the thick, vapory atmosphere.

In this stage of the infant world, all those conditions necessary for the evolution of life are observed — a subdued light, warmth, a solution of aliment, and intense electric currents excited by the solution and precipitation of vast quantities of matter!

281. As the dawn of life is fixed at this point, it were well to extend our subject, and bring all possible light to bear on the mysteries of its origin.

282. In placing the beginning of life in the last ages of the metamorphic — or primitive stratified — rocks, I am well aware of the opposition the view will receive from the professors of geological science. However it may be in opposition to established theories, it is not opposed to received facts. In the lower silurian rocks we meet with low organized mollusks, and these extremely rare. Below the silurian is a vast thickness of what might be mistaken for non-fossiliferous rocks, called the cumbrian and cambrian systems. These are ten thousand feet thick, and hence must have been millions of years in forming, as the accumulation of sediment at the bottom of the ocean is very slow. That vast series of deposits has recorded all that was possible of the first denizens of the ocean. In the lowest portions of these rocks the indications of life expire, and there is no record to tell us that the earth, before that time, was otherwise than a bleak and desolate waste. Let us consider how remains are preserved in the rocks. The shell, or hard envelope, is all that is ever preserved, and if the animal has not this covering, or an equally durable framework, not a trace of its existence will escape the decomposing action of the vast interval of time we contemplate. Animals like the slug, the unprotected mollusks, the hydra, and the jelly-fish, could not be

preserved. Does not this account for the absence of fossils in the lower cambrian? If we continue in a straight line backwards beyond the last fossil imprint, as guided by the waymarks we have observed, the unprotected mullusk, the zoöphyte, jelly-fish, and such lower forms alone, must have peopled the ocean of the slate. They could not leave any impression on the strata forming beneath the ocean in which they dwelt, and though they swarmed in the deep, no record of their existence would be left. The only method by which to learn the existence or form of life in this non-fossiliferous period is by induction from the facts we have given. By such reasoning we infer, or rather prove, that living forms must have made considerable advance previous to the silurian period. There was time sufficient for great progress. Every foot of the cambrian is equivalent to thousands of years, and during all that vast interval of time the great principle of progression was continually active.

283. The latter ages of this period are marked by the remains of a few shells, indicating the advance of the unprotected mollusks in the acquirement of protecting organs. Uncertain traces of other organisms are also stamped on the rock. These were marine vegetable forms, of the fucoidal character—sea-weeds. Vegetable food must have been in existence, or rather coexistent, or the first animals could not have been sustained. Vegetable and animal life undoubtedly appeared at the same time. That either division of life could exist on earth without the other, would be inconsistent with facts every where else observed. The identification of a single fucoid is evidence of the contemporary existence of animals. These have not left a trace of their existence, except in the

last ages of the silurian system. But dim and faint as these traces are, they establish the theory here advocated, by proving, even at that early day, that the plan of organic being was well determined, and that representatives of all the diversified classes existed. *Radiata*, *mollusca*, *articulata*, and *vertebrata* were then represented.

284. One subject more remains for consideration here — the CELL reproduction. As life advanced, it could not be unfolded so as to produce higher and more perfect forms by spontaneous generation, and hence the necessity of parentage. As a law of nature, what is true to-day is true for eternity; the method of increase in the lowest forms of life now, would be the same as that in the early silurian period. In the PROTOZOA, and kindred species, reproduction is performed by division. The little sac of vitalized matter commences to contract about its centre, and continues to be more and more divided, until the two portions break asunder, and each becomes as perfect as the original. There is no confluence or action of the male and female principles, both being united in the same individual. Reproduction by *division* is common to all the lower tribes. In the *protozoön*, (microscopic animals of the lowest kind,) as in the mineral, if it be divided into any number of parts, each will give a perfect idea of the animal. In higher types, as the HYDRA, if its gelatinous body be minutely divided, each part will become as perfect as the parent. The same is observed in the plant; a twig reproduces the perfect plant, and a single bud generates a tree. This is the first and lowest form of reproduction. The parent subdivides, and it is difficult to say which part is the parent, which the offspring. The next step is taken

by nuclei forming in the cellular mass, which attract a portion of the material in which they are embedded around them, and then bursting the cell walls, become independent existences. Both of these processes are imitated in the tissues of all living beings. The animal and plant grow by the multiplication of cells.

The extreme rapidity with which they multiply is astonishing, a single cell often increasing in a single hour to a million, each being equally perfect as the first.*

285. It is probable that life has been produced spontaneously in all ages; but when so produced, it must necessarily begin with a simple cell, similar to those first introduced on earth. The cell is the beginning of all forms of life; even in reproducing life in any manner, as by division or parentage, the cell is the first form, and from this simple beginning all the infinite series of vegetables and animals have proceeded. Having discussed the origin of life, we shall endeavor to detail its history, by the light of science and the revelations of the rocks.

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* General Physiology. Carpenter.

CHAPTER IX.

THE HISTORY OF LIFE THROUGH THE SILURIAN FORMATION.

The Age of Mollusca. — Conformity of all living Beings to one Archetype. — Silurian Life. — Sea of the. — Groptolites. — Polypes. — Corallines. — Crinoidians. — Lily Encrinite. — Mollusks. — Cephalopods. — Crustaceans. — Trilobites. — Nautilus. — Vertebrata. — Silurian Scenery.

286. WHEN the SILURIAN FORMATION is examined, it will be observed that the great tribes of the invertebrata are all represented by types of their *lowest existing forms*. This is a highly interesting and conclusive proof of the previous reasoning, and renders untenable the theory of one line of ascension, and the transformation of one *class* into another. Starting from the same point and era of time, they continue side by side, each perfecting itself after its own plan of being. Conditions ever varying in the turbulent state of the nascent planet would greatly change the mode of development, but not beyond well-defined and narrow limits, which the universal causes of life imposed; and hence the resulting resemblance of structure.

287. The plan of the RADIATA is not essentially different from that of the MOLLUSCA. As the infinite variety of crystalline forms can be reduced by cleavage to a very few primitive geometric figures, so when the external and superficial organs of the endless series of species are lopped off, a few types only remain; and these, at their beginning, meet in one. The diversity of species, is the result of external acquirements; but

all are true to one type, and it is readily seen that all conform to a single plan or archetype of growth. This conformity has misled the naturalist, and in attempts to generalize he has inferred that as the mollusk approaches so near the fish, it must have been their parent. But observation refutes this view, as there was not sufficient time for such changes before fishes appear; and still more, nature does not wait for the mollusk to become perfected, but ushers both into existence in the early silurian, in their lowest state. The true place of the lowest mollusk is not below the lowest fish, but by its side. So all the highest forms of the four great classes should be arranged side by side, and their lowest types should be arranged in the same manner, just above the GELATINIFERA.*

288. The tendency of each type is not to change into the next higher, but to perfect itself after its own plan. The mollusk does not attempt to transform itself into a low organized vertebrate. This, from its plan of structure, would be impossible; but it changes by degrees to a more perfect mollusk. The cephalopod, in its way, is a perfect animal. It is perfect after its own plan of organization. No form could be more admirably adapted to the demand made upon it. It is entirely above whole groups of fishes, and is evidence of the wide divergence of its line of development from the fish into which it has been said to be transformed. It is a perfect mollusk, the ultimate of its class. The same holds good in the other divisions, and the branches given off by these, whenever they reach their ultimate of progress, become

* The lowest form of the cell life.

extinct. The germinal impulse given to the first types was to reproduce their own peculiarities, and throw off branches of a higher grade of the same class. This is a grand generalization, and is supported by established facts. Let us now turn to the early strata of rocks, and observe how well their testimony accords with the present theory. Already it has been remarked that slight indications of organized forms are found in the *cambrian*, beneath the silurian. It is thus rendered certain that the earth was peopled with organic beings for an immense period previous to their leaving any trace. To contemplative science the beginning of the series is deficient. It is, as in the arithmetical series of figures, 1, 2, 3, to infinity, when the first terms are deficient, and the series begins with 4, 5, &c. But these terms can be readily calculated from the terms given by the law of numbers. So can the first terms of the organic series which the past presents, be determined from the terms given, by the laws of life. To do this has been the aim of the reasonings and inductions of the preceding pages, and we find that the results, theoretically ascertained, harmonize with observed facts. That part of the series which has been determined by a course of reasoning based on the forces of nature, agrees with the positively determined progress of life, presented by accurately observed phenomena of the present era — an interesting evidence of the correctness of the course of reasoning pursued.

289. The silurian sea was far from teeming with life. Profound silence reigned in the animate world; the wild cry of the sea bird, and the dashing of monsters in the ocean foam, did not enliven its desolation. The dash of the billows, the howl of the storm,

the volcano with its flames, and earthquakes, were the only sounds which rolled through the atmosphere, and these only spoke of turbulence and destruction. Huge craggy rocks were thrown in wild confusion every where, and between the rugged islands the shallow sea spread its black and desolate waves. Such were the scenes surrounding the infancy of life. At this early period of time, the innumerable cells composing gelatinous life had branched off into the four great classes, as we have observed. The beings that inhabited the dark waters were such as our theory infers should dwell on an infant planet. They combined in one being the characters represented in several distinct species in after time.

290. The Graptolite, half sea weed, half coral, rooted itself in the floor of the sea, and waved its branches, teeming with offspring, in the flowing tide. In it is exemplified the great law, previously referred to, of a progress from the compound to the simple, whereby the first types were compounds of several characters afterwards separated into distinct types. This principle is universal and will be often referred to in future pages, as the primitive types of plants and animals are always the aggregation of two or more genera, which, perhaps, in the next period are separated. Thus in the sponge the vegetative principle predominates over the animal. In the graptolite the animal was not separated from the fucoid. In the earliest types the greatest complexity existed, and classes and families are mixed together in apparently strange confusion. Such are the conditions, our inductions inform us, which should exist in the infancy of vitality. Polypes, as the lowest types are called, were the first to stamp their impress on the rocks, and they

have changed but little under all the varying circumstances by which they have been surrounded. They are organized for resisting changes, and have thus been capable to abide the mutations which have swept all the other contemporary tribes from the globe. It is not astonishing, then, to find the identical species of polypes, in every period, and inhabitants of the present ocean. The corallines, however, were lower than the existing species.

291. Among the most beautiful forms of these was the chain coral, still represented in tropical seas. These corallines built up their cystalline skeletons on the rocky elevations beneath the waves of the ocean, extracting particle after particle from solution, and depositing in the form of solid rock. They possessed the power to extract calcareous particles from water containing so small an amount of lime, that no chemical test can reveal its presence. The lime rock has all passed through the laboratory of life, and has been principally deposited by zoöphytes. This may appear startling when its vast thickness and extent are considered, and the cause referred to an insignificant, almost lifeless mass of jelly; but when the unceasing labors of these world-architects is duly considered, doubt will be dispelled by admiration. In the present sea, where their labor is greatly circumscribed, and they possess few of the advantages of former times, they have debarred the ships of commerce from access to large areas, by reefs hundreds of miles in extent, and have converted oceans into archipelagoes by the countless islands they have reared from the crests of submarine mountains. Polynesia embraces an area of several hundred thousand square miles, thickly interspersed with islands, of their architecture; and they

are now depositing a thick stratum of limestone over the whole of that area. By contemplating such wide-spread results from apparently insignificant causes, the mind in a measure grasps the idea of the astonishing activity of life in the ancient world.

292. If, instead of the mineral particles being deposited on the inside of the polype, we suppose it to be arranged on the external surface, there will result an animal of the same grade of organization, but widely differing in its form and habits; and these circumstances would tend to make it diverge from the original, and in time become a totally distinct being. We then have a stony plant, a soft molluscous animal, invested with a cup-like shell, or what is called a CRINOIDIAN. A few unimportant species exist at present, but at their first introduction they occupied a very conspicuous position. The lily encrinite was very beautiful, resembling a lily; and as the supporting stalk was flexible, it could move in the water in search of its prey.

293. The MOLLUSKS were similarly protected by an exudation from their previously unprotected skins, of mineral particles.

The CRUSTACEANS were represented by the *trilobite*, a singularly formed being, resembling the young lobster. It had only the rudiments of feet, and those seemingly unnecessary organs, the antennæ, were but just budding forth. Its eyes were immovable; but this inconvenience was obviated by their elevation on foot-stalks, and formed like those of the dragon fly, that it might see in every direction.

294. The MOLLUSCA were represented by their lowest types, in conformity to the views already expressed; but many of its genera attained a much greater state

of perfection. A variety of cephalopods swarmed the ocean. Their highest type, the *nautilus*, exhibited a great advance in the structure of its organs and its habits on univalve mollusks. It has a powerful muscular system and regular organs of life. The rudiments of a true internal skeleton and the nervous centres are enlarged and concentrated in the head. The organs of prehension and locomotion, though simple, are powerful. Its mouth was furnished with beak-like jaws, and an extensible tongue. In some varieties of mollusks designed to float in the water, the shell is so thin that they can scarcely be said to have a covering; the nautilus was furnished with an apparatus for rising and falling in the water, controlled by its will; showing that it had an instinctive intelligence — an inference supported by its large nervous centres.

295. Bivalve and univalve shells were extremely rare, and those which existed were such as were able to abide the great changes in surrounding conditions. The rocky character of the early seas was not adapted to their support. These, with fucoids, the stony coral, the encrinite, and the trilobite peopled the silurian sea. The trilobite was an exact representation of the embryo lobster. This presents curious reflections on the advance of life. The lobster begins at the same point where the early crustaceans leave off, perfects the plan they foreshadow, and acquires organs of locomotion, movable eyes, antennæ, and more complicated organs of life. The same principle is observable here as in the embryos of all higher animals, which have a strong resemblance to lower types.

296. Thus is presented the history of the dawn of life. We are astonished at the predominance of the

invertebrate orders, and the total absence of the vertebrate. I say total absence, for throughout the long duration of this era not a form of this class, sufficiently high to be preserved, flourished in the marine wilds. But it must have begun in the same era with the others, and preserved a parallelism of development, though not, until nearly the close of this period, was it sufficiently developed to be capable of preservation. The first trace of a vertebral column — the distinguishing characteristic of this class — would be nothing more than a thin line of cartilage. This would enlarge, but would not immediately ossify. Even in the Devonian period fishes had only a cartilaginous skeleton, and even at this day the conspicuous family of sharks, sturgeons, and rays have not a single truly ossified bone in their skeletons. But this line of cartilage could not be preserved, as it would readily decompose; and this accounts for the apparent absence of vertebrata in this period. Subject to the law of eternal progress, the simple cartilaginous being gave off, as branches, the osseous tribes, and perpetuated itself in the cartilaginous orders. The deposition of mineral particles in the cells of the cartilage of the skeleton is as simple as their exuding from the surface of the body and forming a shell, or internally, and producing a radiate structure. The same law governs all these examples, and is seen at work in the vertebrate embryo, ossifying the cartilaginous framework. Ossification would proceed gradually, and in consequence all degrees of transition would result from the *amphioxus* to the solid frame of the mammal.

297. Having thus glanced at the types of the silurian age, the mind is enabled to comprehend the first steps in the ascension of life, and the beautiful philoso-

phy of its progress. This age may be appropriately styled the reign of mollusks. They were the predominating type, and the cephalopods that roamed the marine wilds of the silurian seas unquestionably held the first rank of the beings which peopled the ancient world. Large, strong, and voracious, they were the aquatic carnivora, preventing the too great increase of the more peaceful forms. They were the kings of their age — what the sharks are in the present sea; and no contemporary animal was their equal in fierceness and courage, or the strength of their arms.

298. The landscape was wild and stern. The waving forest, the beautiful green mead, formed no part of the scene. The softness, the mildness, and loveliness which enter into the present landscape, were not seen, but all was rugged and terrific. The dark ocean spread around the globe, intersected with innumerable islands, which reared their rugged heads above the waves. Continents then slumbered beneath the ocean, and on their surfaces the thick strata were depositing. The earth was a desert waste of broken rocks and volcanic fragments. But beneath the waves the fucoids waved their long, green leaves, and converted the silent abysses of the ocean into gardens of beauty. There they exhibited their variegated hues, and furnished exhaustless food for the myriads of strange forms of animal life in that early age of wonders. It was a bleak and desolate world where the ocean concealed the germs of life. The sea was dotted with islands, covered with rocky crags, on which not the least vestige of life appeared; and here and there a higher projection or ridge gave prophecy of future mountain chains, or marked the configuration of continents. Its color was not the splendid blue of the

reflected sky, but black and leaden — a fit covering for the ragged surface it concealed from view.

299. The silent and invisible forces of nature were aided by the storms and tornadoes that drove the murky and dense atmosphere with tremendous fury over the waste. The earthquake rocked the yielding crust to and fro in great undulations, and from the deep fissures of the broken strata the molten lava flowed out, spreading its fiery contents over the bottom of the sea. On such scenes the sun and stars looked luridly down through the hazy atmosphere, and from the murky sky the red moon threw her portentous light. The awful, the sublime and terrific were mingled confusedly together in a period transpiring but once in the life of a planet.

300. From the wide extent of aqueous surface, — the sea covering nearly the whole globe, — and the internal heat of the earth, there existed an almost equal temperature over the whole globe, and consequently a unity of type in all latitudes. Hence we do not meet with zones of peculiar fauna or flora, for a nearly uniform torrid temperature every where prevailed. By these means life in all the early periods, from the poles to the equator formed a single flora and fauna.

CHAPTER X.

THE OLD RED SANDSTONE SERIES.

Blending of the Formations. — Definition of the Term *Period*. — Duration of. — Disappearance of Species. — Reign of Fishes. — Ganoids. — Cephalaspis. — Pterychthys. — Coccocteus. — Placoidians. — Devonian Scenery. — The Law of Progress.

301. ONE leaf of the volume is read; turn it back, and the next in the series is the OLD RED SANDSTONE, or DEVONIAN. Here let us pause to correct the common error, that a strong demarcation exists between the formations. This is so far from correct, that it is impossible ofttimes to decide on the exact point where one terminates and the other commences. In nature there are no arbitrary divisions, as in the books, but the formations are found running into each other by insensible degrees. A PERIOD, in geology, does not represent a given time, but an immense interval, or an almost infinity of ages. The beings which flourish when it commences may die out, or change entirely in appearance before its close. To say that such an age was distinguished for the high order of its fishes, or its reptiles, is extremely vague; for at its commencement there may have been nothing more than the feeblest traces of those orders, while they may have swarmed the sea at its termination, the duration intervening between the dawn and eve of a great epoch being almost incomprehensible. Understanding this, we are not confounded when told that the silurian was distinguished by the development of cephalopods, as though

they all at once sprang into existence. This only applies to the last ages of that period when it changes into the Devonian.

302. The cartilaginous fishes had given origin to a few species of shark; but this is not anomalous, as the duration from the dawn of life to the time when the latter were introduced, is as incomprehensible as the number of leaves in the forest. By almost insensible differences the silurian rocks pass into the Devonian, and the development of its living forms as gradually takes place. It is those only, who, blinded by prejudice, seek to sustain the traditionary notion that each era is a day in creation, at the end of which all existing forms were swept away, and then, by a mandate of God, new races sprang forth, who make violent demarcations between geological periods. Species disappear one at a time; new ones are introduced, and the whole goes on in such a quiet, insensible manner, as far as life is concerned, that all ideas of confusion, disorder, or arbitrary rule are wholly out of place. The mighty operations of Nature may work on in ruin and desolation; but her greatest effects occur in the slow but sure movements which silently labor through decades of centuries. A steady advance takes place each day, but these advances can only be determined by comparing periods of time thousands of years asunder.

303. The duration from the dawn of life to the commencement of the Coal period, has not inappropriately been called the Reign of Fishes.

304. During this long course of ages, fishes were the highest forms which peopled the vast but shallow ocean. As has previously been stated, *mollusks* predominated in the silurian; but near its close the ver-

tebrate kingdom was represented by some low forms, of which the shark was the highest branch, and next the ganoid fishes, hereafter to be described. These two tribes flourished to the almost total exclusion of all others. The ganoids are represented by the North American pike and sturgeon. They were much more numerous than the placoidians, sharks, or rays. In fact, the ganoids attained their maximum of development, and immediately began to decline. In the direction of their singular organization, they attained the limits of perfectibility, and consequently died out, to give place to other families with larger progressive limits. It is a universal law that species exist as long as they advance, but the moment they become stationary they begin to decline, and eventually perish. The inorganic world is perfecting, and unless species advance in the ratio of its advancement, the conditions become unfavorable to their existence. This is a law to which reference will be frequently made, as it permeates the entire dominion of nature.

305. The peculiarity of the ganoids is their compound character. They were allied to the archetype of the fish on one hand, and to the insect on the other; and not until ages after, were these two characters separated. They were covered with bony plates, possessed a rudimentary cartilaginous skeleton, and in the arrangement of their organs, their eyes and head, were combinations not now seen in distinct species. These large plates were formed by the consolidation of scales, which, in after ages, became distinct.

306. Of all the ganoids, the Cephalaspis was the most singular. It was a compound of fish and trilobite. Its head, or rather body, was shaped like a saddler's knife, while its tail was like the trilobite's. It

was more crustacean than fish, having all the habits of the former. It approached in many particulars the ray. Rendered, by its slow motion, incapable of escaping its enemies by flight, its fine armor formed a defence which was undoubtedly impregnable to the strongest of its antagonists; for the soft-bodied cephalopods, from which it had most to fear, would find it difficult to crush its knife-like shell.

307. The Pterichthys was another species, allied more closely to the insect in the articulations of its fins, and its head connecting with the body by a very small articulating surface. The neck of fishes — if they may be said to have any — is as large as their body, while that of insects is so small that the head is almost severed. Such was the neck of the pterichthys. Its body was covered with large enamel-coated plates, beautifully articulating together, both serving as a protection against its enemies, and for the attachment of muscles, the osseous system being so imperfectly developed that it was useless as a support to the muscles. Such is the unique combination of characteristics in this being, which was mistaken by eminent naturalists for a beetle, then for a crustacean; and not until after great research and study was its true position determined.

308. The Coccocteus was still higher in the scale. It approached the fishes in the greater development of its skeleton and the position of its organs. The articulation of the head was like the insect. It was very large, and its jaws powerful, covered with enamel, and set with sharp, conical teeth. Its body was protected by enamelled plates. Its tail was long, and had two fins at its extremity, and from its flexibility gave its possessor great locomotive power Protected by

its enamelled covering and swiftness of motion, it had no enemy to fear.

309. Another group, of similar organization, differed only in their envelopes, or covering, which, instead of being plates of enamel, were of the minutest scales, giving their skin the appearance of shagreen.

In another tribe the fins were very much enlarged, and armed with spines, and the scales were so enlarged that eight or ten covered the whole body.

310. While the ganoids swarmed the sea, the placoidians, in their infancy, were few in number. They were, however, fleeter and more voracious than their contemporaries, and from the remains of their spines and teeth preserved in the rocks, their number was large, and several species flourished. The rays or scates kept them company, and were nearly as perfect as at present.

Such were the inhabitants of the Devonian oceans. The trilobites had almost expired, and many other curious forms of the previous age had become extinct, or advanced to a higher plane.

311. The land becoming more elevated, and its area enlarged, began to be clothed with a green mantle, as vegetation advanced out of the sea. Those species which were capable from the constitution they received from the primordial CELL of progress, emerged from the sea, and clothed the shores with verdure. They planted themselves on the tide-washed shore, and gradually extending, at length passed beyond the reach of the tides, as they became more and more adapted to their new mode of life. At this time, and from this source, originated the terrestrial CRYPTOGAMIA, that clothed the rocks and shores of the waning Devonian period with dark-

green verdure. The moss attached itself to the rocky surface, the fern grew in the low places where the dampness of the soil furnished a favorable condition, and the fungi, the mushroom, puff balls, &c., germinated every where. It has been previously remarked that the mushroom is one of the simplest aggregations of cells. Its germ is a simple cell, and when this becomes subject to the proper conditions, it contracts on its axis, and produces two similar cells. These again divide, and this process continues, until the germinal force becomes exhausted. This multiplication occurs with such rapidity, that a single cell multiplies into billions in twenty-four hours.* The conditions for the complete development of the cryptogamia (flowerless plants) were extremely favorable. Warmth, moisture, and intercepted light all contributed their influence, and they flourished with a luxuriance they never have since attained; and the gigantic forms which then towered in forests of unrivalled grandeur, strike the imagination with wonder at the concurrence of conditions which could develop its huge trunks from the lowly rush, the puff-ball, and the moss.

312. The lowest forms of the vegetable and animal kingdoms here first attained their maximum of growth, and then declined, giving place to the next higher tribes, which in turn were displaced by others higher formed constitutionally for advancement. How ever imperfect this vegetation would be in the present age, it was perfectly adapted to the period in

* This curious subject is illustrated by numerous experiments, in article "Endosmosis," in the Cyclopedia of Anatomy and Physiology, in Dutrochet's Mémoires Animiques et Physiologiques, and in Matteucci's Lectures on the Physical Phenomena of Living Beings.

which it flourished. This reveals the fallacy of that reasoning which speaks of the perfect organization of these ancient forms. True, they were perfect for their time and place, but far from perfect in the absolute sense.

Subject to higher conditions life will gradually conform, and a new flora and fauna will be evolved from the old. Thus are we prepared to see the forms described in this section unfold in the next age, under the stimulating conditions of the carboniferous period, into the grandest forests that ever clothed the earth.

313. Whenever an animal or vegetable type has attained its highest state, and is becoming extinct, and another of a similar type is taking its place, the last is always higher in the scale of being than the first, and is caused by intermixture with some other genera, or species allied to it in its form and habits.

CHAPTER XI.

CARBONIFEROUS OR COAL FORMATION.

Conditions of. — Origin of the Coal. — Lepidodendron. — Stigmaria. — Arborescent Ferns. — Calamites. — Norfolk Island Pine. — Carboniferous Scenery. — Luxuriance of Vegetation. — Islands of the South Sea represent the Coal Era. — The marine Depths. — Fucoids. — Orthoceras. — Cepholapods. — Terrebratula. — Productus. — Ammonites. — Fishes. — Ganoids. — Sharks. — Sauroids. — Terrestrial Reptiles.

314. The coal era may emphatically be termed the reign of plants. The islands were low, and the climate, still feeling the influence of the external heat,

was extra-tropical, and warmer at the poles than at present. The general diffusion of the ocean, and the entire absence of continental masses, greatly contributed to this result. The atmosphere was damp, and of a high temperature. Its thick and murky character moderated the scorching heat of the sun. It contained a large amount of carbonic acid. Thus combined the best possible conditions for the growth of cryptogamic vegetation, and it came, clothing the low islands with gigantic forests.

315. Fossil coal is unquestionably formed from plants, after a somewhat similar manner as peat forms in the bog. The vegetation from which it was formed was succulent, and easily decomposed, and has left slight traces to the eye of the organic origin of its product. To the microscope it reveals its vegetable structure. But the characters presented are not those of the present. The observer discovers a new world. He is ushered among lepidodendrons, sigillarias, and arborescent ferns, plants combining the characteristics of several species in a single form.

316. The LEPIDODENDRON was a large forest tree, allied to the pine, and still closer to the club-moss. The club-moss of the present is a very small plant, but a few inches in height; but this ancestor of the present plant was a noble tree, rearing its fluted and scarred trunk sixty feet or more without branches. Then it sent out numerous arms, leaving the trunk at an acute angle, and covered with moss-like leaves, forming a delicate and somewhat beautiful foliage. When stripped of its leaves it resembled a decaying pine.

317. The STIGMARIA were the roots or types of another forest tree, half pine, half cycadea, or palm.

It closely resembled the zamia in its internal structure, and the palm in appearance. The leaves, like the palm, were attached directly to the trunk, and fluted the trunk where they grew, and scarred it where they were attached. It was one of the few woody plants, and entered largely into the production of the coal.

318. The humble fern, or brake, we left on the borders of the silurian sea, added frond to frond, until it became a forest tree, rivalling the palm in beauty, and dividing into innumerable species, spread in dense jungles over marsh and plain. The brakes of our swamps and marshes seldom exceed a few feet in height, and at the present time, even in the torrid clime, but few species attain a height of more than four feet. The gigantic carboniferous ferns were thirty or forty feet in height, and supported a crown of leaves rivalling the palm.

319. The scene presented was gloomy and sad. A sombre hue pervaded the dense islands covered with ferns, interspersed here and there with gray rocks. The sooty blackness of the sky was similar in character and appearance to stone coal smoke, casting a gloom over the whole landscape.

320. All the low lands were clothed with tree ferns, forming the densest and most impenetrable jungles. Beneath these the humble ferns found shelter. The more barren and sterile places were occupied by the tapering spires of the Calamites. Above these the lepidodendron bore aloft its splendid coronal, singularly disproportioned, however, to its huge columnar trunk. Above these, in the forest, "the *sigillaria* elevated its crown of leaves on its fluted and gracefully tapering column. More than a hundred feet above all of these, the Norfolk Island pine reared its pyramid of

foliage, rising, tier above tier, in a magnificent cone of vegetation."

A dark, sombre green pervaded the whole scene, unenlivened by the bright and brilliant coloring which, by contrast, constitutes the chief attraction and beauty of the present vegetable world.

321. From these dense forests the coal was formed, and stored away in the earth's great garner house for the use and advancement of man. The extreme luxuriance of vegetation during the deposition of the coal can be faintly appreciated when it is considered that a century's growth of a tropical forest would not produce more than a stratum of coal one or two inches in thickness. The total thickness of the English coal beds is one hundred and fifty feet, and it cannot be less in America. To produce this great thickness, it thus appears, would require eighteen hundred such forests, each requiring a century's growth, or *more than one million of years.* A single stratum of coal, four feet in thickness, would be produced in a tropical region, if the material could all be saved, in about five thousand years. The esculent coal plants were not as productive of coal as the tropical forest trees, and hence the time of their formation must greatly exceed this estimate.

322. The greater portions of the forests were in the valleys and basins, partially covered with water. The plants grew, and, falling down, became the soil for the next generation; and although decomposition went rapidly on, the growth was so rapid that a stratum of organic matter slowly accumulated, and when the whole became submerged beneath the waves a covering of sand or mud was thrown over it. When the land again emerged from the ocean, it was prepared

for the support of a new forest. The organic material thus collected, subjected to the enormous pressure of the superincumbent strata, and acted on by the internal heat, formed the crystalline coal, which is so necessary to the progress of civilization. To obtain an idea of the coal plants, and the aspect of the earth while they clothed its surface, we must go to the low islands of the Indian Ocean, where a uniform temperature and a moist atmosphere prevail. New Zealand and the neighboring isles furnish the best examples of the coal flora: there it yet lingers, still resembling its former appearance. The lepidodendron, club moss, and fern, are nearly the only plants in their forests. There we observe the same sombre hue, the same death-like silence, uninterrupted by a warbler's note, or the least stir of animal life. With its coralline seas, and islands clothed with cryptogamic forests, this region of the South Sea is a miniature of the coal era.

323. Dense as were the terrestrial forests, the fucoids which covered the floor of the deep flourished with equal luxuriance. They furnished sustenance and protection for innumerable aquatic animals. The ammonite, the orthoceros, and other cephalopods, were in their decline. Terrabratula spirifer and productus are characteristic types.

The fishes of the silurian were small and clumsy. The predominant tribes of the Devonian were much larger, and more numerous; but, from the first, they were accompanied by a cartilaginous tribe, the plan of whose structure was wholly different, and aiming at higher results.

324. The ganoids of the Devonian attained their maturity. They had reached the end of their line of

progress, and now the bony pike and sturgeon alone survive the depressing influences which have blotted out their more gigantic progenitors. The sharks rapidly increased in numbers, and became the terror of the deep. Their hardihood and endurance adapted them to all circumstances and places. The contemporary family of sauroids were a compound of fishes and reptiles, or rather, half-developed reptiles from the fishes. The analogy between them and the reptile has not been allowed, and much dispute has occurred in assigning them their true place. They were larger and more powerful than the shark. In the structure of their teeth they approached the crocodile, while the structure of their jaws was as truly lacertian. In them are found the first traces of ossification; which, singular as it may appear, is highly corroboratory of our theory. This commenced in those centres which first begin to ossify in the embryo reptile.

325. In the different species of sauroids which swam in the carboniferous sea are found all grades, from the fish to the imperfect reptilian; the former abounding at the commencement of the period, and the latter near its termination.

In some species are observed the wrinkled and knotty covering, the jaws and teeth, of the crocodile, and other reptiles. Thus the diffarreation between fishes and reptiles is actually presented to our observation.

Though the traces of terrestrial reptilian life which have been discovered are extremely dubious, yet, as they could live either in the water or on land, it is almost certain that some of the lowest species of reptiles inhabited the cryptogamic forests. They, however, acted a minor part in the earth drama.

326. While huge and insatiably carnivorous sharks

and gigantic sauroids swarmed in the ocean, the coral and associate zoöphytes were building their island homes, laboring on from century to century, rearing the groundwork of continents yet unborn. The sea-weed waved its delicate fronds around the continental germs, and in its unique foliage forms of fishes and mollusks found their home. In the reign of fishes, no higher forms (except near its close) disputed their supremacy, and their different types and modifications filled all the offices, performed all the functions, now executed by manifold classes of beings.

The coal, emphatically, was the reign of gigantic cryptogamic vegetation. There was nothing, however, but what was in strict accordance with the conditions of the earth. Law ruled as sternly then as now, and was unfailingly producing order and beauty from the wildest confusion.

CHAPTER XII.

PERMIAN AND TRIAS PERIODS.

Changes of Conditions. — Permian Flora. — Magnesian Limestone. — Fishes. — Reptilian Fishes. — Plants. — The Sea. — Grand Convulsions, and Change of Level. — Inference and Proof. — Confirmed by the Trias. — Ideas of Perfection. — Mollusks. — Sauroids. — Petrified Sea Beaches. — Office of the Ocean. — Sand Rock of the Connecticut Valley. — Nature ever the same. — Chelonians. — Birds. — Ornithorhynchus. — Labyrinthodon. — Saurians. — Rhinochosaurus. — Extinction of the Coal Flora. — Distribution of Plants and Animals. — Convulsions the Exception. — Gypseous Deposits. — Salt Beds. — Scenery of the Trias.

327. Having glanced over the first ages of life, and from its origin traced its history, we enter another

vast period of duration. It will be readily comprehended that better conditions prevailed on the earth for the maintenance of animal life after the renovation of the atmosphere effected by the deposition of the coal. The carbon, which before had prevented the existence of any high order of animal life, was stored away in the coal measures and limestone rocks, and the atmosphere approached its present composition or state.

328. The vast interval of time under consideration may be divided into the Permian and Trias. The Permian flora was little more than a continuation of the coal.

The deposition of the magnesian limestone was accompanied by too great convulsions to allow the working of the peaceful energies of vitality. The deposit immediately above the coal is apparently formed of the debris of worn-down granite, and is a proof of the powerful disintegrating force of the Permian ocean. The coal strata were closed or covered up by volcanic convulsions and sedimentary deposits.

329. On this deposit of coarse, sandy material, the magnesian limestone reposes. This undoubtedly was formed by chemical precipitation. The precipitating agent must be looked for in the volcanic exhalations, which must have been thrown out during such great disturbances, as the conditions of the strata indicate. If it is considered as a precipitate, — and it can be accounted for in no other light, — it must not be supposed that it took place suddenly, or in a year, or a century, but was slowly deposited, during which time generation after generation of mollusks and corals, and the little animalcula of the deep, flourished, and at death were entombed in this great charnel house, by the fine sediment cast down by the waters.

330. The fishes of this period were small in size and slow of motion. The reptilian fishes were also small and feeble, compared with their ancestors, although numerous in some localities, charging the entire rock with animal matter arising from their decay. A remarkable feature of all the fishes of the early ages is the formation of their tails after lacertian models; and only in later times do we meet with fishes with a tail formed of two equally divided parts.

331. There was a dwarfish tendency in plants, and few large species existed. There is nothing, in fact, remarkable in this portion of the earth's history, except the convulsions which prepared it for the predominance of reptilian life in the next. It was an age of renovation, when antagonistic conditions were removed, the atmosphere purified, the sea cleansed of its surplus magnesia and lime. Life remained nearly stationary until all this was accomplished, when it branched out in different channels, and advanced with great rapidity towards its ultimate state of perfection. The sea has been the great nursery of animate existence.

332. During the first periods of time, when the earth was nearly covered by the ocean, and only islands reared their unstable heads above the waters of the deep, the germs of life grew, and matured, and sported on the crests of the billows. When the desert land turned its desolate front to the scorching sun, the sea swarmed with living beings. The ocean is the stimulating element, the great storehouse of cellular life.

333. The Permian is remarkable for the changes effected at that time in the position of the strata of the earth. The convulsions which prevailed through-

out its duration, have left their stupendous impress, deep and wide, on the rocky framework of the globe. Vast upheavals and corresponding depressions occurred, whereby the relative positions of sea and land were wholly changed. Even in large areas, the strata of rocks were forced up in dome-like elevations, like blisters. Fissures, hundreds of miles in extent, were produced, which gave vent to lava, that overflowed the surface in extensive sheets. These fissures, however, did not always discharge lava, but simply produced anteclinal ridges, descending on either side. The earth's crust was broken by the most terrible and tremendous convulsions, and the fissures thus formed were filled and often overflowed with volcanic matter.

334. After these changes, new conditions were presented to living beings, and stimulated by them, they commenced a rapid advance.

From the waymarks observed in the sauroid fishes and reptilian forms, and remembering the principle, already advanced, of the extinction of a lower order as soon as it has attained its ultimate development, and the introduction of an order having a greater progressive limit, we should now infer the existence of reptiles. Turning one leaf over, the Trias is brought to view, and confirms the correctness of our inference.

335. The Trias. — After the igneous force had spent its energy, contorting and twisting the strata in every possible manner, filling up the fissures with trap, and pouring out rivers of basaltic lava, there came a period of repose. Magnificent results had been accomplished by the vast forces called into activity. The thick beds of magnesian limestone, produced by chemical solution, had been precipitated, and the puri-

fied sea, exerted a new influence by the inorganic elements that were presented to the beings that made it their home. The oscillation in the earth's surface, and the new disposition of land and water, produced climatic changes, which reacted in modifying the various terrestrial types of life.

336. The past age was one of change and renovation. It introduced few new species, but modified the inorganic elements. It prepared the way for the TRIASIC fauna, which came as prophesied by the sauroid fishes and reptiles of the preceding era, and which the changes wrought by the convulsions of the Permian proclaimed would be produced. From the changes wrought in the sea we infer that as it was capable of sustaining a higher order of beings, they would occupy the new field it afforded. How correct the inference! How in accordance with the theory that conditions essentially change or modify living types! A few feeble reptiles, and a few small marine types of the same order, but a little above the sauroids, sported on and near the fern-clad islands of the coal. These survived the wreck of the Permian, and when nature again exerted her creating powers, when the equilibrium was established, they began a rapid advance. The purified sea greatly affected the *radiata.* The *lily encrinite* grew in splendid groves, and all the allied species attained their acme of perfection. The lily encrinite has been often produced as an illustration of the perfection of ancient animals, and as proof that, instead of progressing, the world is at present at a stand still, or is retrogressing. This encrinite's shell was composed of over thirty thousand distinct pieces, set together in an admirable manner o meet the wants of the enclosed animal. It was

provided with a long, flexible stalk to support it, jointed like a vertebral column, and allowing the encrinoid to search in every direction for its prey. But it is a question whether complexity of structure is an indication of development. On the contrary, the most complex beings are often the lowest. Animals are always adapted to the conditions which surround them, and in this aspect, and this alone, may be regarded perfect. A fish is perfect in its adaptations to the element in which it lives, but is very imperfect in regard to terrestrial conditions. Man is perfect for his sphere, but unqualified for an aquatic life.

337. The encrinites were perfect in their adaptations, as are all other types. They were the scavengers of the deep, feeding on decaying substances which floated within their reach. Their bony armor shielded them from enemies. Their complexity, however, does not show advancement. Some writers, in speaking of the ancient beings, always refer to their extreme complexity as perfection, and some go so far as to consider bulk a measure of advancement. The ichthyosaurus is pronounced the highest form of lizards, as its structure was complex, and its size extremely large. It is now known, however, that several contemporary forms were altogether superior to it in every respect. This method of reasoning, into which many fall, is fallacious.

338. The mollusks of the Trias show a marked approach to those in the present seas; and this approximation is also seen in its fishes. As previously intimated, the ganoids, placoids, and sauroids were the predominant inhabitants of the deep. All of these had the reptilian conformation of their tails. The same is found in the embryo of the fishes of the pres-

ent time. This fact has an important bearing on the progressive theory. The mature shark is on the same plane where the white fish *begins* its life, or the white fish begins where the shark leaves off. We cannot too strongly impress this principle, derived from researches in embryonic growth; for the fact that the embryos of one age represent the beings of a former age, shows a close connection between all the members of the animal kingdom, and is a strong evidence of their unity of original form. The fishes of the present have almost without exception equally lobed tails. The sauroids of the trias were small and voracious. They had parallel teeth and strong jaws, with which to crush the shells of mollusks, and the harder portions of their other prey. The external row of teeth were long, and pointed inward, enabling them to take sure hold of and preventing the escape of their slippery prey. They had attained their glory long before, and were slowly expiring.

339. In many localities the ancient sea beach has been fossilized, preserving the minutest traces of the beings that flourished when it was sand or mud, and washed by the ebb and flow of the tides. The impressions that arise while viewing such a formation are indescribable. Here was once the shore of the ocean, now hundreds of miles away. Here was the ancient coast line, against which the wild storms drove the mad billows in ceaseless strife, to wear down and disintegrate the rocky breastwork. Here is the labor of millions of ages. And an appreciation of the powerful agency of the waves breaks on our minds. The ocean has been the great leveller by which hills and mountains have been washed away and strewn over its coralline floor. Its waves never

rest. Ceaseless as the march of time, either in gentle calm or angry storm it labors on in its self-appointed task. The lunar influence is constantly disturbing its repose; and thus is the moon made the instrument of developing the capabilities of our planet. Yes, here the blue waters rolled in wild freedom, and these strata of sand rock were then formed, with their markings and fossils, the whole consolidated into rock, and preserved as a section of earth's history, written by the rolling billows. Here the same appearances are observed as are now seen on the sandy shore — the ripple marks, the fossils, and the tracks of birds. When the tide ebbs, it frequently leaves large flats strewn with shells, marine insects and worms. The sea birds are attracted to these places, and cover it with their tracks in their search for food. Worms burrow along the surface, and crabs wander from one small pool to another. The whole surface is indented with ripple marks. This is precisely the appearance formed in the petrified sea beach of the Connecticut valley, and elsewhere. Undoubtedly the strata in which they occur when depositing were extensive flats left dry by the ebb, and covered by the flood tide. On these marine birds and reptiles would congregate, and would leave the impressions of their feet. The sea worms and crustaceans would each leave their peculiar track. The retiring waves would deposit a new stratum of sand over the whole, on which the same process would be repeated.

340. As we uncover and remove layer after layer of the sandstone, all these diversified markings are brought to view. The footprints of birds, reptiles, and turtles, the marks left by the sea worm and crustacean, and the ripple marks, are as fresh as those now

seen on the sea shore. And not only these, but the rain drops of the storm are impressed in the now solid rock. When these strata were a level tract bordering the ocean, when the birds and reptiles congregated there, the shower wrote its history also. Wonderful reflection, that so simple an occurrence as the falling shower should be permanently registered. Men may toil and strive with all their energies to write their names on the scroll of fame — their giant efforts are failures, compared to these. Here in the sandrock, the triasic shower has written its ineffaceable history, as a chapter in that of the globe. Not only this, but the direction of the wind is also recorded by the slant of the indentations. Thus are we reminded that the great laws of physical nature were ever the same as now. In those remote ages, the winds blew, the tempest raged, the shower descended, the ocean heaved restlessly by the action of the tides, as they rose and fell on its shore, or calmly rippled over the extensive flats. Birds and reptiles, guided by instinct, frequented their appropriate haunts in search of food; the marine lacertians crept along the oozy shores. In all her physical and instinctive actions, Nature was the same as now. Her laws were progressive as at present, and even tended to a higher plane.

341. We will now inquire what were the forms that frequented those banks, and what are the conclusions of geologists in regard to the fossil footprints. A great variety of species are readily determined; for such is the unity of nature in all ages, that from a footprint, a fragment of bone, a tooth, or scale, the form and habits of the species can be determined.

342. The same stock from which the carboniferous reptiles originated also gave birth to the CHELONIAN

or turtle tribe, and to birds. On the surface of the rock the marks of the turtles can be seen in connection with the footprints of gigantic birds. The turtle does not differ from the saurians as much as from the present birds, but it does quite as much as the primitive forms of that class. A turtle is little more than a lizard enveloped with a shell. The ribs of the lizard are flattened, the vertebræ consolidated into the shell, the breast bone is spread out on the under side, but the internal structure conforms to the reptilian archetype.

The primitive birds were of gigantic size. The length of a footprint of some species is over twenty-one inches, and the length of step five feet. To obtain an idea of birds of such enormous size, we must take the Australian emeu and its congeners, to which they approach in structure. They have not the power of flight, are roughly shaped, and have strong analogies to mammals on the one hand, and to reptiles on the other.

343. The ornithorhynchus of the Australian continent, where the ancient fauna, as well as flora, appears to have been regenerated, marks the gradation of the bird into the lizard and the mammal.

344. These primitive birds were low in organization. There were waders, half aquatic, half terrestrial. Their heavy bodies were not calculated for flight, and, like the ostrich, they had small wings, useful for running, but not for flight. I would not be understood as saying that the ostrich, emeu, and their congeners are on the same plane as these ancient birds. They have advanced very much from that stock. The birds are a branch thrown off from the principal trunk; but I shall not trace out their analogies, except as far as necessary to establish their origin.

345. The haunts of birds being on the land, and their bodies so light as to float on the water, they could hardly escape being devoured; or should they by chance or accident be carried or fall into the sea, few remains, of course, could be preserved. Geologists do not recognize the existence of birds from the trias to the chalk. Their remains could not be preserved on dry land, though it cannot be doubted but that they did exist through all that vast period of duration. They had not multiplied so greatly as now; and if one of their carcasses should float down into the sea, and sink, and should escape the million chances of being devoured by some ravenous shark or reptile, and become invested with sediment, which is hardly possible, how infinite the improbability that the geologist should strike the exact spot, and exhume its remains! Where the remains of an animal are found in two ages, but not in an intermediate one, it is the simplest induction of philosophy that it existed in the intermediate time. Though not the least indication of birds has been discovered from the trias to the chalk, yet they must have certainly existed during that almost infinite number of ages, and advanced towards their final destiny; for, in the chalk period, birds like the albatross sailed over the deep; and its allied types peopled the earth. This advance must have occurred in this unwritten interval. Bold as this proposition may appear, it is fully borne out by analogy.

In connection with the other markings in the trias, or new red sandstone, are the curious impressions of the feet of a quadruped. These resemble the impression of a gigantic hand. The fore feet were extremely small, while the hind feet were disproportionately large. They belonged to a huge *batrachian*, which for size and structure ranks the first of its class. It has received the name of *labyrinthodon*. It was not wholly frog, but partook strongly of lacertian (lizard-shaped) characteristics, as did all the types of the primordial world. In it we see the batrachian, separating from the saurian, just as in the tadpole we see it separating from the fish. Its jaws were greatly prolonged, broad and flattened like the alligator, with a deep-sculptured exterior. They were thickly set with irregular conical teeth, prolonged in front into tusks, like the alligator's, and the analogy was continued in the warty covering of some species, and the conformation of the ribs. On the other hand it approached the fishes. In the smallness of its fore extremities and extreme development of its posterior, it approached the marsupials, as also in the internal structure of its bones. An eminent comparative anatomist affirms that one species actually leaped about on its posterior extremities, like the kangaroo. At this point we date the advent of the marsupial type of MAMMALIA in which began this extensive order, which now stands preëminent over all others.

346. SAURIANS were stated to have been contemporary with the unique beings already described. These were of the composite character so often remarked. At present the saurians are isolated, and there are but few intermediate species connecting it with other orders. This gap is supplied by the extinct fauna so completely that not a link in the chain is wanting, nor a vacancy left unsupplied. The PHYTOSAURUS was allied to the bird and the mammal, while it was closely related to the CHELONIA, or turtle, and had the general form of the lizard. Its jaws were converted into a horny beak, like the bird, or turtle, and whol-

ly devoid of teeth. It was terrestrial and herbivorous.

347. The DYCINODON was a closely allied genus. Its relations were with the poisonous serpents, the carnivorous quadrupeds, the tortoise, and the true lizards. Its jaws, or rather beak, had sharp, cutting edges, and from the upper grew two long tusks, like the fangs of serpents. It was carnivorous, and probably used them in attack and defence.

348. These saurians and their congeners form a curious and remarkable group, in which we see a union of beings now widely separated. They constituted at that era of time a waymark by which to trace the ascent of life, slowly but surely, urged on by perfecting conditions, until it mounted upward to superior forms.

349. There was a gradual extinction of the coal flora, and the substitution of higher species. The climate yet remained tropical farther north than at present. The ocean was not yet divided by continental masses, and by its circulation preserved a more equal temperature than at present. As islands enlarged and mountain chains became elevated, marking the outlines of the present continents, the oceanic circulation became impeded, and, combined with the elevation of the land and decreasing temperature of the interior of the earth, served to depress the temperature of the atmosphere. As different localities began to have widely diverse climates, the fauna and flora also changed so as to conform to the new state of the earth. Animals and plants nearly resembling each other, but of different species, are found on both continents, as the wolf, bear, deer, ox: how came they so nearly to resemble each other, and yet not identical?

The question is answered by considering the time and conditions in which they flourished up to the Permian or new red sandstone, allowing the types then in existence to universally diffuse themselves; then, as the climate and conditions changed, they conformed or became extinct. This view does not do the least violence to established science, as the modifications assumed are slight, perhaps only requiring a change of color, or the acquisition of a shaggy coat, or a few spots and markings. Each continent has now its own fauna and flora, distinct, yet resembling each other, and differing only as much as the climate and other conditions of the localities vary. The influences which have been exerted on living beings have been slow and silent, but have acted through millions of years, and are fully sufficient to account for the gradual change of species.

350. Nature labors slowly and silently. Convulsions and disasters are the exceptions. The catastrophes some writers have pictured by their imaginations have been much exaggerated, or have no reality. Great changes and stupendous oscillations have occurred, but most of them with the comparative stillness and with the ordinary forces of nature.

At intervals the booming of the earthquake, or the thunder of the volcano belching out its igneous flood, interrupted the general calm; but such were exceptions to the silent, onward movement. It is customary with popular writers to speak of universal commotions, disasters, and convulsions, as though the elements of the globe held a very unstable equilibrium. This is very true of its infancy; but from the silurian upwards, comparatively few terrific convulsions, changing materially the surface of the earth, have occurred, and these have been separated by vast intervals of time. Some of these, however, must have been of the most awful and violent character. The oscillations of level that occur in the course of ages, are so slow that long periods of observation are necessary to detect them. In different countries this is now occurring on the most extended scale, as in Greenland, Scandinavia, and South America, elevating or depressing at the rate of a few inches only in a century; but no disorder is observed. Disturbances as slight as these, acting through long periods, would produce great changes.

351. The mysteries of geology have been made the stronghold of those who desire to see confusion and the miraculous interposition of Deity in every thing they cannot comprehend; but as the light of facts increase, they are driven out of this position.

352. The sulphate of lime or the gypseous deposits, interspersed through the saliferous formation, originated by the exhalations of sulphuric acid gas from the earth acting on the carbonate of lime. This origin is indicated by the total absence of organic remains; also that wherever it comes in contact with limestone, the latter is corroded and changed from a carbonate to a sulphate of lime. At this era of time, the earth emitted vast quantities of this acid; hence the gypseous deposits are mostly found in this formation.

Salt, (chloride of sodium,) though occurring in connection with the beds of gypsum, had not a common origin. It was formed in the early epochs of earth's history, intimately combined with water and many other substances, and is evidently of marine origin. Some authors have asserted that the salt found in the ocean is of terrestrial origin, and was washed down and deposited there by rivers. This theory is not sustained by good evidence. Of the many rivers that discharge their contents into the ocean, but few of them have the least trace of salt. And the very small quantity so found can be satisfactorily accounted for in the rivulets and springs that take their rise in beds of salt, the porous saliferous rocks, or of earth impregnated with salt in consequence of its being in a recent period of time covered by the ocean, and also from the millions of tons annually used by the inhabitants of earth.

The beds of salt were undoubtedly formed by arms of the sea being cut off by bars formed across their entrances, and also by portions of the sea being raised above its surface, taking with it a large quantity of salt water in its basins, or depressed parts. If the water running or falling into these places is less than the evaporation, salt would soon be deposited. Much of the salt of commerce is made in this manner in artificial beds. When an arm or bay of the sea is cut off, and rivers run into it loaded with mud or sand, but not equal to the evaporation, the sediment would mix with the salt, and in time a saliferous rock be formed. The sudden falling or sinking of these salt-beds and rocks, and their being covered over with deposits of earth, are well understood, and need no further description.

353. All the deposits of salt in the earth testify to their marine origin. Many examples of this kind are now going on. In the eastern continent, between the Black Sea and the Sea of Aral, is an extensive tract of country showing abundant evidence of its being but a short time since, covered by an arm of the ocean. The basins, or depressed places, are filled with

salt water; some of them are fully saturated, and depositing salt, while others are being mixed with sediment carried into them. The wells dug in this tract are brackish, and often very salt. This large extent of country, including the Black Sea, the Caspian Sea, and the eastern end of the Mediterranean, is probably more than one hundred feet below the surface of the Atlantic Ocean. According to Humboldt, the Caspian has a depression of near two hundred feet. Lakes in different parts of the world are found with the water salt at the bottom and fresh at the surface; they receive and discharge fresh water, without mixing with the heavy salt water at the bottom. Onondaga Lake, in the State of New York, is an example of this kind. Further evidence of the depression of these seas, and the causes of their being so, will be found in another part of this work.

354. The scenery of the trias, and saliferous periods, was wild and beautiful. On the far extended flats, washed by the tides, and strewn with sea weeds, gigantic birds congregated. The marine turtles, leaving their briny homes, crawled over the oozy or sandy shores, and the unique labyrinthodon slowly moved among the wondrous group. On the higher grounds, the zamia and palm sheltered the rhynchosaurus, the parent of the oölitic marsupials, and in the thick forests reptiles fought their battles of extermination.

Let us now turn over another leaf, covered with the dim hieroglyphics, which we have endeavored to read, and the Oölitic page is presented to view.

CHAPTER XIII.

OÖLITE. — LIAS. — WEALDEN.

Lias. — Pentacrinite. — Cuttle Fish. — Belemnite. — Sauroids. — Lepidoteus. — Port Jackson Shark. — Rays. — Marine Reptiles. — Nothosaurus. — Ichthyosaurus. — Plesiosaurus. — Oölite Proper. — Corals. — Description of a Coral Isle. — Terebratula. — Insects. — Gavial. — Cetiosaurus. — Megalosaurus. — Plan of Vertebral Articulation. — Pterodactyle. — The Wealden. — Iguan odon. — Heliosaurus. — Dawn of Mammals in the Marsupials. — The Saurian Age. — Scenery of this Era.

355. For convenience, the oölite is divided into three sections — lias, oölite proper, and wealden.

The Liasic sea was muddy and unsuitable for the growth of corals. The zoöphyte cannot exist in water the least muddy; and this fact reveals the agency which has suddenly extinguished whole banks of polypes in the ages of the past. They can only live in the clear, pure sea. The mud-like series, at the beginning of this age, plainly indicates why there were no corallines. Their place was occupied by the crinoids, animals of the same class, but higher in structure. We have already become familiar with some of its genera, for they were long ago introduced, and their habits were traced in the encrinite and stone lily.

356. The Pentacrinite of the lias, from the crystalline growth of its shell and its perfection, is the most interesting. The long, supporting stem was built up of rings, enveloping a thin line of flesh. On this stem the body rested in the exquisitely cup-shaped shell. The mouth was surrounded by numerous arms, enveloped nearly to their extremities by the same shell-like covering. Its shell was composed of 150,000

pieces. Its stem was usually attached to floating timbers or other floating bodies, like the barnacle, which attaches itself to the bottom of ships, and depended entirely on winds and tides for locomotion. From the luxuriance of the entire group, and their abundance, and the absence of other tribes, which had previously acted as scavengers, they must have subserved the latter purpose, and cleansed the sea of many of its impurities.

357. Of the CUTTLE FISH there are two divisions, represented by the sepia and the nautilus, or its ancient prototype, the ammonite. The ammonites were provided with a shell not unlike the spiral univalves, except that it was divided into chambers by partitions, while the sepia had no other external protection than its dense dermal mouth. It had also the rudiments of an internal skeleton, and was higher in its organization.

358. The BELEMNITES combined both these characteristics so uniquely, that it has long puzzled the researches of the paleontologist. The chambered shell was straightened out into a cone, and instead of being on the outside, was placed within the animal. This shell acted as a float, by which the animal could sink or rise at will in its native element. The belemnite was strong and rapacious, and its powerful tentaculæ could sustain successful warfare against much larger fishes. Standing upright in the water, it rapidly ascended from the marine depths, and unperceived seized its fishy prey, and dragged it down into the sea caverns, to devour at its leisure. When pursued, it ejected a black and acrid fluid, which blinded its enemies and concealed its flight. This animal had all the characteristics which now belong to all the

species of the family, exemplifying the plan before alluded to, that the compound always came before the special.

359. Of the higher groups of fishes, a few species of sauroids still lingered — the lepidoteus, resembling the bass, and other types resembling those of the Australian seas. The Port Jackson shark, a family found nowhere else but around the shores of that strange land, would almost seem a direct descendant from the fishes of the lias. Its mouth, as in all other sharks, is on the under side, and so far back of the nose that it cannot seize its prey without turning on its side. To do this with requisite rapidity while in motion, requires a firmer apparatus than the simple fin; and this is supplied by long and bony spines, deeply-rooted in the flesh, and moved by powerful muscles. Its fins are large and numerous, and are erected or depressed by spines. These spines are the only remains preserved of these fishes, for their soft bodies rapidly perished, and by their size and markings, and by remains of teeth, the various species are determined. We are to hope that the science of comparative anatomy will yet attain a perfection sufficient to enable the expert investigator from seeing a single tooth, or fragment of bone, to give a full description of the beings to which they belong, their habits, &c. This certainly is attainable; for all science can be reduced to an absolutely positive state.

Rays were introduced during this period. They are a singularly formed family. The eyes are on one side of the body, and the mouth on the other. They are colored like the sea bottom, to avoid their enemies, and steal unperceived on their prey.

360. Reptiles became the rulers of this age. While

the reptiles of the trias inclined to, and partook of, the character of birds, batrachians, and crocodiles, those of the lias inclined to the type of marine lizards. Of these only one species is at present known, the *bliryn-chus cistatus*, a small lizard of the recent volcanic Galapagos Islands.

361. The NOTHOSAURUS was exclusively marine, of large size and insatiably carnivorous. Contemporary with this were the PLESIOSAURS and ICHTHYOSAURS. The plesiosaurus was beautifully formed. Its body was slim and gracefully rounded, resting on the water like the swan, which it closely resembled in the arched and serpent-like neck. Its neck was longer, in proportion to its body, than that of any other animal. The giraffe has but seven vertebræ in its neck, and the swan has but twenty-three; but the plesiosaurus had between thirty and forty. This long and slender neck supported a small, serpent-like head, so that this reptile resembled a large serpent, joined to the smooth body of a lizard. Four strong paddles, representatives of the four limbs of quadrupeds, propelled it through the waves. It was, however, a sluggish animal, and preferred the estuaries and shoals, where it would lie motionless; or, being drifted by the tides, with its neck arched backward, it was ready to dart its head at any fish that chanced to approach sufficiently near.

362. The ICHTHYOSAURUS, or fish-lizard, as its name imports, was a compound between the fish and lizard, as the preceding was of a snake and lizard. Its body was like the porpoise, its head and jaws were like those of the crocodile, its tail like that of the fish. Its head was very large, its jaws long and slim, and provided with a terrible array of conical, curved, sharp teeth. This class of animals seized their food

by suddenly snapping their jaws together — this being necessary in order to obtain a firm hold of their slippery prey. The eyes were very large, and gave the monster a hideous aspect. They were formed somewhat like the eagle's, a series of scales surrounded the pupil, by which the sight could be greatly contracted or expanded, and the eye flattened, so that the reptile could see as well under water as above. The Ichthyosaurus was thus adapted to all depths, and moved as freely in the darkness of the deep as in the broad sunshine. Its small brain indicates feeble instinctive cunning and stupid habits. Its vertebral column was precisely like that of the fish, opposing concave surfaces to each other, the borders being united by cartilage.

363. The greatest freedom of motion was thus given, by which it could propel itself through the water by the use of its tail alone. The latter was formed like the heterocircal fishes. Like the whale, it was provided with large paddles, differing, however, from the cetacea, in having four instead of two, thereby approaching mammals. These enormous paddles were wielded with great muscular force. The ichthyosaurus must have excelled the shark in rapidity of motion. To make its analogy still closer to the cetaceans, its skin was smooth, and it inhaled air by breathing; and to make its adaptation to its home and mode of life in the great deep still more perfect, by a peculiarity of its organization, it could swallow its prey while under water, and remain for a long time deprived of air. This completes a hurried view of the liasic fauna. Its flora was nearly the same as that of the preceding period, but there was a remarkable development of cycadea, palms, pines, fir, and other conifera.

364. Oölite. — This formation is characterized by the deposit of calcareous matter, either in the form of mud or pure limestone. In the labors of world-building, the corals again flourished, not as luxuriantly as in previous ages, but still sufficiently * to rear extensive reefs, and fill up large areas entirely with their remains. In examining fossil islands formed by these corallines, the same habits are observed which characterize the corallines of to-day. They built their structures in the shallow parts of the ocean, where the sea was warm and the waters calm. And in the same manner they grew or worked in a circular form, and when they reached the surface of the water, a beautiful lagoon was enclosed, in which the quiet fishes and the delicate denizens of the deep congregated, free from the rough billows without.

365. There the coral-feeding fishes dwelt within the purple branches of the living grove, and at death their remains were embalmed in the fast-forming rock.

366. The sea urchin and its congeners floated without, and the sea weed lodged on the jagged coast, as the little architects piled up their rocky skeletons in defiance of the waves. Fishes of innumerable kinds here sported in the calm waters, waiting for the rough ocean without to become tranquil and clear.

367. The coral family teach us one of the processes of world-building. The zoöphyte attaches itself to the rocky apex of a submarine mountain, and slowly its stony framework rises above the waves. Ages pass away, and an earthquake elevates the isle above the surrounding waste. Now the sea weed drifts up on the glittering beach, and a soil gradually accumulates,

* Smith, Nat. Hist. of the Human Species, p. 38.

in which seeds, drifted by currents from distant climes, could spring up and clothe the coral beach with vegetation. In the Pacific, the palm first rears its splendid coronal of leaves above the rocky isle, while yet the waves dash by its side. Now a reptile, from a distant continent, after a long voyage, alights on the beach, and terrestrial animal life begins to flourish in this little world.

368. This process is one way or form of world-making, except the animals and plants are already in existence. The order of their introduction, however, is the same by necessity; for if animals were introduced before plants, they would inevitably perish. Plants prepare the way for animals. Time sufficient does not elapse for development and growth, and under the prevailing conditions that would be impossible. Nature introduces certain types, and ever after takes them as archetypes, ever reverting to the original stock.

369. On the coral banks, where the sea weed waved and the purple polype spread out its arms in search of food, crustaceans,— descendants of the trilobite, the lobster, the crab, the shrimp, and limulus— sported on the sparkling sands, and there too the mollusca and other aquatic forms congregated. The hardest and most vigorous of these, the terebratula, found as congenial a home as among the wave-washed rocks of the silurian wastes. It is a fine illustration of the theory presented. It attained a high degree of perfection early in the morn of creation; but by its native vigor it has met all the changes which have overtaken and destroyed contemporary races. It became modified, however, by every new condition, yet remains essentially the same to the present day. In-

sects began to sport with tiny wings through the forests. They were mostly of the beetle tribe, but they are too unimportant to require more than a passing notice in this general survey.

370. Marine reptiles were multiplied by the introduction of a huge GAVIAL, of exclusively aquatic habits. The cetiosaurus presents a compound of the whale and the carnivorous saurians. Although it had a whale-like body, it was covered with a thick, warty skin, and had four crocodilian extremities, armed with long, sharp claws, and was web-footed, like aquatic birds. Its head was like the gavial of the Ganges, with long jaws and conical teeth, enabling it to dash through the water with extreme rapidity and seize its finny prey.

371. The terrestrial saurians approached very near the lowest of the thick-skinned mammals; and as this occurred myriads of ages before the birth of those quadrupeds, it is a strong indication of the developing process silently at work. Never has the lizard so nearly approached the mammal; and where these approximate types die out, the true mammal begins.

372. The megalosaurus represents the carnivorous genera. It is difficult to obtain an idea of the colossal proportions of this monster. The crocodile could sport between its limbs, and would furnish it with a slight breakfast. Such is the plan of creation, that the first individuals introduced advance in size for a certain period, and then decrease as they approach a more developed state. The body of the megalosaurus is short and barrel-shaped, covered with a smooth skin, and supported on huge, elephantine limbs. Its tail, though reptilian, was much reduced in size and length. Its head, though long and laterally compressed, was

in appearance quite mammalian. The shortening of its head and tail, and the swelling out and shortening of its body, and its elevated position, were approaches to the mammalian type. The bones of the extremities were round and hollow, like quadruped's, and its vertebræ were united by flat surfaces. The different classes of animals are distinguished by the manner in which the vetebræ articulate. The vertebræ of the fish's spines are concave, uniting only at their edges; those of reptiles are ball-and-socket articulation; those of mammals unite by flat surfaces, with intervening cartilage, allowing the least motion and greatest strength. Between these extremes exist all shades of conformation. This distinction is a certain index of the position of the animal. The vertebræ of the megalosaurus opposed merely flat surfaces to each other — a strong indication of its close alliance to quadrupeds; an analogy carried still farther by five vertebræ being united to support the hind part of the animal instead of two, as in reptiles.

373. Another strange form of this age of wonders was the pterodactyle, or flying lizard. In the bird the wing is of the same form as the fore arm of quadrupeds, and the necessary resistance to the air is furnished by long, stiff feathers. In the bat, which is the only truly flying quadruped, the bones of the fingers, by their extreme prolongation, furnish a framework over which a thin membrane is spread as a sail is extended over the yards of a ship. But the pterodactyle was formed on a different plan. The prolongation of the little fingers of the fore limbs furnish the framework by which the membrane of its enormous wings was extended. Its neck was long and slender, supporting a crocodilian head, with large eyes like the

ichthyosaurus. It was the cormorant of the oölite flying over the sea and darting down on its finny prey. It was at home on the billows of the sea, and moved with great celerity through the waters. It would dash the spray from its powerful wings, and fly away like a huge condor to some jutting crag, where its young were nestled.

374. The Wealden is not divided from the previous deposits by any sharp line of demarcation. It is a local deposit, the delta of a great river which probably poured its waters across a vast continent, now beneath the Atlantic Ocean. A few new species of reptiles were introduced, having close analogies to the mammalia.

375. The Iguanodon, now represented by the little iguana of the tropics, roamed through the dense forests, browsing the tender shoots of the trees. Like the megalosaurus, its body was short, and supported by huge legs. Like the hippopotamus, it possessed a short, thick head, and a short, vertically-flattened tail. Its teeth were at first sharp and conical, then knife-like as they were worn off, thus becoming admirable instruments to clip off the twigs and herbage on which it fed.

Before the true affinities and relation of parts of the animal to the whole were understood, from broken vestiges of the iguanodon it was assumed that it must have been at least seventy feet in length. Now, however, as this intricate subject is better understood, its length has been determined at twenty-five feet, and its height eleven feet. The head and neck were one fourth its length, the tail one third, leaving fourteen feet for its barrel-shaped body. In it we see the pachydermal type strongly represented both in external appearance and internal organization.

376. The heliosaurus, the wood-saurian, and the saurian of the wealden roamed the wild forest.

377. The dawn of mammalian life in the MARSUPIAL type has already been adverted to. Unmistakable traces of its existence occur in the oölite. Three genera are there represented, and are related to the kangaroo and the opossum. The marsupials are the lowest mammals, and are allied to the batrachians of the trias, as has been already shown. Slowly had those primordial types progressed through the millions of years which elapsed from that time to the first indications of marsupials in the oölite. If time is all that is required for such changes, time sufficient elapsed for greater ones to take place. But something more than the lapse of time is required. *The great principle is, that life is altered by conditions, and every modification in those conditions modifies the organic beings which they originate.* Thus marsupials were like those of the recently-formed Australian continent. The structure of their bones was like the batrachians, from which they are removed only by a single stage of progress.

378. Such are the animals which roamed the landscape of what has appropriately been called the *saurian age*. They attained their maximum, and from this point gradually declined. The low, flat country was their favored haunt. There the iguanodon trampled down the tree fern and the cycadea and fed on their tender leaves, and the huge megalosaurus pursued its prey with thundering roars through the forest. Out on the deep the ichthyosaurus plunged through the foaming billows with the swiftness of the wind, while by its side the cetiosaurus sported in the foam, or engaged in fierce conflict. In the quiet estuaries, where the small fishes congregated, the plesiosaurus watched

with eagle eye its unsuspecting prey. Over the oozy shore reptiles of monstrous form and terrific aspect drew their slimy bodies, or, emerging from the sea, basked in the rays of the sun. The ichthyosaurus often left the deep, and straggled up the beach to enjoy the warmth, as the seal is now often seen to do. High above, flapping the air with its enormous wings, the pterodactyle screamed over the watery waste, or suddenly darted down on its prey, dashing the white foam from its breast, and arising with the velocity of an eagle into the upper air.

379. Land and sea witnessed the terrible encounters between the gigantic and ferocious denizens of the forest, and the equally voracious monsters of the deep. Viewing nature as it now is, as the ideal of beauty, — trained as our minds have been to recognize nothing but nice adaptations and perfection of design, — it is impossible to contemplate the wildness of the ancient world without awe. The uniqueness of its forms, their gigantic proportions, the fierce and savage disposition pictured in strong jaws and jagged teeth, impress us more with fear than beauty. Their colossal bones were made for deadly struggles, and their strong claws and jagged teeth were made to tear and rend their prey.

380. The booming roar which rolls through the forests skirting the Ganges or the Mississippi, or terrifies the timid animals on the banks of the Orinoco, was echoed by a thousand voices, rolled in thundering tones over the sea, and reverberated through the forest. There too were cries of combatants in the agonies of death, as those huge reptiles grappled in deadly strife, breaking down forest trees in the encounter, and rivulets of blood flowing from their lacerated veins.

381. Death has always existed. Carnivorous races, with their instincts of destruction, were always present, as the police of nature, to keep within proper limits the herbivorous tribes which otherwise would, by their own increase, die out by starvation. The capabilities of life necessitate those of death. The conditions of life are such as presuppose death. The same conditions which build up one organization compel the destruction of another. The existence of the carnivora necessitates the death of the herbivora. All things grow old and decay. The period of their existence is terminated by death, when the atoms of their structure enter new organizations, and perform the offices of life in a perpetual state of progression towards its ultimate state of perfection. Thus life and death are balanced in perpetual oscillation.

CHAPTER XIV.

THE CRETACEOUS OR CHALK PERIOD.

A Transition Age. — Existence of Species. — Origin of the Chalk, — Now forming. — Of Flints. — Birds like the Albatross. — The Polyphychodon. — Mososaurus. — Ichthyosaurus.

382. This was a transitional period, like the Permian. The conditions which supported the reptiles of the oölite were slowly changing to those best adapted to mammals. The rocks, however, are silent here, and it seems that this link in the chain of beings was wanting; but because the relics of mammals are not yet discovered, it does not necessarily follow that they did not exist. As the record now stands, a great abyss

exists between the reptiles of the oölite and the mammals of the tertiary. A section of the history is wanting; but further research may supply it at any time, and until then, analogy must fill up the gap. Because the transition types of mammalia, which the chalk should contain, are not yet discovered, they are not to be considered wanting, any more than the interval elapsing between the sandstone deposits of the Connecticut valley, in which the tracks of birds exist; and the chalk should not be considered destitute of birds, although there are no vestiges of their having existed during that vast interval of time. Reason and analogy teach us, that from the first introduction of a race, or species, until its last appearance, it must have existed. *A species cannot exist after it has once been extinguished;* but it may be dwarfed by unfavorable circumstances, and remain undeveloped until stimulated in succeeding ages. Though we have no certain indications of these transitional quadrupeds during the chalk period, they must have existed. The marsupials of the oölite must have continued, and the conditions of the mamalian reptiles would lead to the conclusion that they only changed their forms to reappear in the pachyderms of the tertiary.

383. The chalk undoubtedly originated in the decomposition of mollusks and corallines. But the intensity of this process has been greatly overrated. The growth of zoöphytes was not more luxuriant than in the Pacific Seas at the present time, where the identical chalk-forming process may be seen in the lagoons of the coral isles in the deep ocean.* Whole genera of fishes are expressly adapted to feeding on coral, and

* Metteucci, Lectures, &c., pp. 5, 73.

in the clear waters of the blue lagoons they may be seen quietly browsing the tender branches, like a herd of herbivorous animals. The fecal matter of these is pure carbonate and phosphate of lime, and from it the great mass of the chalk is formed. Specimens of this recently-formed chalk cannot be distinguished from that of the cliffs of England. In the chalk, the petrified fecal matter of these coral-feeding fishes is found in great abundance, clearly indicating a common origin with the beds now forming in the Pacific and Indian Seas.

384. In the lower chalk, singular beds of flint occur in stratified bands, like water-worn pebbles on the beach. Fanciful conjectures have been formed of their origin, but are only conjectures, except that of crystalline aggregation, by which it is supposed that silicious particles were separated and drawn together, while the chalk existed in a semi-fluid state. On careful microscopical examination, it is found that the basis of the pebbles is usually a sponge. Sponges flourished in the chalk seas in great abundance, and we can readily comprehend how a growth of sponges followed a growth of corals. Their skeletons are admirably calculated to catch the floating particles in the water, or the silicious shells of animalcula, and bind them together; and we often find that the flint-pebbles imitate the sponges in their grotesque forms. Meagre as are the relics left us, we readily discern that there was a manifest approximation to the present forms of life. Could all the beings which flourished during the chalk period be exhumed, it is certain that there would be no blank, but a complete gradation from the wealden to the tertiary pachyderms. The positive traces which we do possess are the remains of some aquatic birds

like the albatross, of the polyphychodon, of a huge marine saurian, and of the mososaurus, allied to the existing monitor. The ichthyosaurus and plesiosaurus still lingered, with many of their congeners; but the great reptilian day had passed forever, and mammals were to take the place of the iguanodon and the ichthyosaurus, and marine reptiles were to be supplanted by sharks. In the never-ceasing revolutions of organic nature, the lower must give precedence to the higher; the superior always tramples on the inferior.

385. But we will not longer contemplate the expiring period of the huge reptiles which we have so long observed with feelings akin to awe. Guided by inductive reason and the chart furnished by analogies, we are now prepared to fold back another leaf in our history, and enter on the examination of the higher types of the tertiary period.

CHAPTER XV.

THE TERTIARY.

Eocene. — Miocene. — Pliocene. — Drift. — Climatic Changes. — Zones of Temperature. — Origin of Flora and Fauna. Eocene Fauna. — Lophiodon. — Palæotherium. — Rhinoceros. — Anaplotherium. — Gracilis. — Cetaceans. — Zeuglodon. — Scenery. — Approach to the Present. European Fauna. — Mastodon. — Mammoth. — Dinotherium, &c. Indian Fauna. — Sivatherium, &c. South American Fauna. — Gigantic Sloths. — Megatherium. — Mastodon. — Glyptodon, &c. — Theory of Drift. — Causes of, — Now forming.

386. The convulsions which occurred near the dawn of the tertiary substituted a new equilibrium for the old.

387. The elevation of mountain masses, and the

increasing height of mountain chains, produced great climatic changes. Land and water were divided by deeper channels from each other. Continents were reared from the waves in such forms as the mountain chains had previously determined. The currents of the ocean were changed. These forbid the wide dissemination of species, and mountain chains and oceans prevented their free access to all countries. Thus cut off in detached provinces, each country, presenting different conditions of climate or soil, fashioned its inhabitants to suit the circumstances it presented. Each continent took the same types, and modified them into its own, differing from all others in proportion as its conditions differed, or, if the circumstances were unfavorable, the species or race became extinct. Look at the bear of Europe and of America. For an almost infinite period they must have remained distinct, yet how slight the difference presented! Does not this point to a common origin at some period in the past? And the wolf, the fox, and a large number of other animals, how near is the resemblance of the different species of both hemispheres! This certainly indicates, if it does not prove, a common origin in the past.

388. This change of climate, although favorable to the growth of mammals, was the death knell to the great saurian tribe, and they passed away, and in their place came the tertiary quadrupeds, the huge pachyderms, the ancestors of the elephant and the hippopotamus.

389. EOCENE.—The flora of the lower tertiary was composed of palms, pines, and cycads. It was the flora of the tropics, and indicates a diversity of low, moist, hilly, and mountainous land. In its forests the gigantic pachyderms found sustenance and shelter.

There roamed those types nearest approaching the wealden reptiles, the iguanodon and dinosaurus. There the LOPHIODON, an extinct tapir, and the PALÆOTHERIUM, allied to the tapir and rhinoceros, dwelt in the dense jungle.

390. The ANAPLOTHERIUM was still farther removed from the tapir towards the ruminants. As yet there were no true ruminants; and these indications of their dawning existence are remarkable and interesting. Like the hippopotamus, it traversed the bottom of rivers, feeding on the aquatic herbage.

391. Approaching still nearer the ruminants, the ANOPLOTHERIUM GRACILIS possessed all the elegance and rapidity of motion of the gazelle.

In the marine fauna we discover the advent of the CETACEANS. The zeuglodon, a whale-like animal, having reptilian affinities, indicates an arctic climate, as warm water to some species of the whale is like fire. In the cetiosaurus, the whale, the porpoise, and crocodile were united. These animals were still further separated and individualized in several species.

392. The scenery of the older tertiary had all the sublimity and grandeur of the weald. The billows sang the requiem of the intombed monsters, it is true; but equally gigantic mammals supplied their places.

In the marshes these singular forms waded through the oozy soil, browsing the succulent herbage in company with the alligator and the gavial. The cry of foxes and wolves rang through the forests of pines and palms, proclaiming the presence of the destroyers of the herbivora. Perhaps bears and hyenas were there to assist in the work of destruction.

On the uplands species were intricately blended — the opossum and kangaroo dwelling by the roots of trees, amid whose branches troops of monkeys sported in company with birds of gaudy plumage. Over the extensive plains strewn with flowers, and teeming with insects, the gracilis flew with the rapidity of the wind.

393. NEWER TERTIARY. — The higher we ascend in the strata, the nearer the forms approach present existing fauna. We no longer observe one fauna on each continent: by causes previously explained, each had its own.

394. In Europe the lower lands were inhabited by the hippopotamus, rhinoceros, mastodon, mammoth, several species of elephant, ox, deer, horse, and antelope. In the rivers, half buried in mud, the colossal dinotherium, or *terrible beast*, wallowed in search of aquatic herbage. It was several times larger than the elephant, and was a compound of the tapir, the elephant, and hippopotamus. The most bulky of any land animal that ever dwelt on the globe, it wielded its huge carcass with difficulty on land, and was at home only when buoyed up by the waters of stagnant rivers.

395. The Indian fauna was distinguished by the sivatherium, which combined the characteristics of the tapir and hippopotamus with those of the RUMINANTS. Its tapir-like head was surmounted by two pairs of horns, one like those of the ox, the others palmated, like the deer's.

The South American continent was remarkable for its gigantic sloths. The little sloth, which now climbs among the branches of the trees, cannot be compared with its elephantine ancestors that with their powerful claws tore down large forest trees. The megatherium and mylodon are the most prominent genera, connecting the sloths with the pachyderms.

396. The glyptodon connected the sloth, the pachyderms, and armadillo, and like the mylodon, was covered with the scaly envelope of the armadillo, and like it attained the same colossal proportions.

397. Contemporary with these was a species of horse, since become extinct. The ox, deer, lion, tiger, hyena, bear, wolf, all were represented by their prototypes. The landscape was almost like that now presented, for nature had put on its present aspect with the introduction of advanced beings.

398. The Drift. This period of time was marked by excessive cold. It commenced near the close of the tertiary formation, and continued until a comparatively recent period of time. The whole earth was affected by its influence. A climate similar to what is now found within the arctic circle existed as far south as the thirty-fifth parallel of latitude, embracing most of the space now occupied by the temperate zones. The equatorial portions of the earth had only a temperate climate. These statements are fully borne out by the following facts: Immense bodies of rocks, stones, and earth are found in various places in both continents, and in both hemispheres, deposited on earth and rocks totally different in character from each other. Granite, gneiss, trap, sienite, and various other substances, are now found lying promiscuously on limestone, shale, clay, &c., often in great quantities. These substances are often worn and grooved, bearing similar marks of transportation that are now found within the arctic circle. The nearest places where these boulders are found, in their proper place, in connection with rocks of like character, are often many hundred miles distant. These boulders, or lost

rocks, as they are often called, are found in North America in considerable quantities as far south as the Ohio River, in nearly all parts of Europe, in Asia near Mount Sinai, in Arabia, and in India. In Africa they are found in Liberia, within a few degrees of the equator. They are also found in the southern hemisphere in corresponding latitudes. We see the same process now going on near the north pole; and as like causes produce like effects, we are justified in ascribing the removal of the rocks, stones, &c., to this cause, especially as no other theory is adequate to account for these effects. The drift came on gradually, and left in a similar way. It was geologically of brief duration, compared to the tertiary and earlier eras of earth's history. It, however, probably continued at least forty thousand years. A few great convulsions evidently took place during this period, especially the one that ended the tertiary. The evidence of this is seen in the different degrees of elevation the drifted materials are found above the ocean, or any large body of water. These substances are found at all elevations, to more than a thousand feet above the sea, and near to many places that evidently prove a sudden and violent upheaval, they being found below as well as above these ruptures.

399. The large lakes of North America were in the early period of the drift connected together, forming an immense body of fresh water. Much of this extensive area was covered with shallow water, which is proved by the long, narrow depressions, or hollows, that are found through this region, made by icebergs, as attested by the many boulders left in them. In no other part of the world is stronger evidence of the arctic character of the climate than in this. The

grooves worn in the solid rock are larger and more numerous than are found any where else, many of the transported boulders weighing more than one hundred tons and coming from many hundreds of miles. As this area of country is elevated several hundred feet above the ocean, containing no marine fossils that belong to this period, it fully refutes the theory advocated by some persons, that the drift was produced by strong currents of water wafting icebergs from the Polar Ocean to more tropical regions.

400. The position of the drift on the earth's surface is an interesting subject of inquiry. As the formation of transporting masses of ice, and the generation of the currents which bore them towards the equator, were polar phenomena, and only extended so far as the heat of the tropics permitted, we can infer that at the equator, and on either side to a distance varying between twenty and thirty degrees, a mild and beautiful climate prevailed, even during the severest portion of the drift. The parching heat of the tropics would be mitigated by the winds and currents from the colder regions, and an eternal spring-time would prevail in the favored zone. Here the scattered remnants of the tertiary fauna could seek refuge, and abide the coming of a more propitious age. The terrific movements of icebergs, and the coldness of the atmosphere, undoubtedly blotted out every vestige of life on either side of this tropic zone. Whole tribes of animals became extinct, and but the seed of other races preserved a precarious existence by flying to the equatorial regions.

401. This tropical zone did not correspond to the present equator. Facts strong and conclusive prove that great changes have taken place in the position of

the poles, and hence of the equator. Geological observations show that during the drift the tropics in the new world were removed north of the present equator, while in the old world they were removed to the south. Lyell * records the existence of drift, composed of sand, pebbles, and boulders, at the mouth of the Ganges, four hundred feet below the surface. While he admits that these boulders could never have been transported by the water of the river, he loses himself in idle conjecture. By only one method can the existence of drift in this situation be accounted for. When it was deposited, the Ganges must have flowed from an arctic country, and borne on its bosom masses of ice, with these pebbles and boulders frozen into them. The river in no other manner could have formed this deposit, flowing as it does for several hundred miles through a level alluvial country, formed of rocky masses torn from the Himalaya Mountains, and transported nearly a thousand miles. This fact is almost a positive proof that an arctic climate prevailed along the course of the Ganges, and perhaps to the south of its mouth. The stratification of the four hundred feet of superincumbent deposit unmistakably shows the great length of time since such a climate prevailed. Judging from the premises, it is rational to suppose that here the drift began, and we observe its first ages, while in North America, on the shores of the lakes, its last or closing ages are observable. Between these periods the north pole had changed from its position, — which must, probably, have been near the Sea of Aral, or the Caspian, to its present position, — and the equator swung round con-

* Principles of Geology, p. 280.

formably, bringing the Indias into the tropics, and giving North America a temperate clime.

402. The closing of the drift period is strongly marked on the southern shore of Lake Erie, and all the great North American lakes, and it is clearly indicated that they had assumed nearly their present form at that period.

403. No more favorable position of land and water can be conceived of for the production of powerful currents than that of the present Atlantic Ocean. The American continent checks the great equatorial current, forcing most of it north, through the deep Atlantic, into the polar basin, as an under current, when it rises and becomes a surface current, carrying with it immense quantities of ice to a more southern clime. Yet in no place south of the sixty-fifth degree of latitude is exhibited any thing to prove a climate of equal intensity to the drift, as it appeared at this period very much nearer the equator.

404. As to the cause of the extraordinary depression of temperature, unique in the history of the globe, several theories have been advanced, none of which, however, offer an adequate explanation. One conjecture only approaches probability. This hypothesis is, that the solar system, in its journey around the great central sun, passes through regions of space of widely varying temperature. This is an extremely plausible conjecture, but is wholly unsubstantiated by facts.

405. During the drift, little progress was effected in the vegetable or animal worlds. Life in all its phases appeared almost suspended. It was comparatively a long Sabbath of rest. A large proportion of the animal kingdom disappeared forever. The earth, how-

ever, was far from tranquil. Several violent convulsions occurred, materially changing its surface. But however cheerless the aspect our planet then assumed, it was essential to the great plan of its development. It prepared the way for the brilliant and important era which succeeded it, when man became the ruler of the world.

CHAPTER XVI.

A CHAPTER OF INFERENCES.

406. After the foregoing brief survey of the structure of the earth, we are ready to discuss the meaning of our observations. As mammalian vertebrata stand at the head of the animal kingdom, if we trace their origin to lower types, the argument will be sustained without entering into the detailed account of the origin of the other branches and kingdoms. In this course of reasoning we shall be guided by analogy and the relations subsisting between the different groups of beings examined.

407. It will be remembered, if we examine existing beings only, that many of the connecting links are lost, and a far greater isolation is observed than really exists. The connecting links are buried in the rocks; that is, the transitional forms have become extinct. Of these our knowledge is extremely limited; for although a great number have been entombed, each era may be supposed to have had as great a number of beings as the present, and meagre indeed is the whole number discovered, compared with that of existing beings. If,

then, the material appear so unsatisfactory and inadequate, it is not surprising, but rather the amount of testimony the rocks unfold is astonishing. All that they tell us sustains the progressive development of living beings, and we feel assured that were they fully examined, they would continue to confirm our position, and never furnish a contradictory fact.

408. In this chapter we shall point out only a few of the analogies which exist — only those directly relating to the ascent of the main branch which terminates in man. It is a false idea that infers progressive development teaches that all animals stand directly related to each other in a line of progress, and were derived one from the other. That this is false will soon be made apparent. The frontispiece represents the theory here advocated. The dark shaded line is the main branch, having its roots in the primitive state, and ascending upward through all the different strata. It begins with sauroid fishes, but in the coal saurians assume the supremacy, and the sauroids, continuing in another direction, at length expire. In the coal another branch is thrown off — the batrachians — which, at the termination of that period, gives rise to birds, and in the oölite to marsupials. In the mean time, the main branch has continued on, slightly diverging, and in the beginning of the tertiary period the saurian stock gives birth to pachyderms. The main branch, continuing upwards, gives off the herbivora, carnivora, quadrumana, &c. The sauroid fishes were the first vertebrata of high organization which were introduced. As their name implies, they united the reptilian character with that of the fish. They did this in all degrees, and so remarkably that Ansted, in his Ancient World, page 104, remarks, "So intimate is

the resemblance, and so nearly perfect is the passage between fishes and reptiles through these sauroid fishes, that very little is wanting to complete our knowledge of the extinct forms, notwithstanding the variety of existing species with which to compare them." In the old red sandstone, fishes, it would seem, "attained their maximum of development in point of vigor, and in some respects in structure; and it is not a little interesting to find, that at this point, so far as we can tell, the true reptiles were introduced." Some of the sauroid fishes in the Devonian attained the size of the largest reptiles, to which they approached in almost every point of structure. Immediately after, we meet with reptiles as strongly approaching the sauroids—a character long retained, and appearing strongly in the ichthyosaurus, or fish-lizard. Now, I put the question to those who believe in special causes, Why is this, if no great principle is concerned? Why is this blending at the very point where inductive reasoning places the divergence of the reptilian character from its combination in the sauroids? The theory presented offers a plain and philosophical explanation, and on no other grounds can a rational cause be presented. The saurians point to the sauroids for their origin, and nowhere else is the analogy observed. The inference is, then, strong, and to our mind certain, that they originated there.

409. It will be seen by the diagram, that we have made the batrachians (frogs) a branch of the saurians, and the marsupials and birds diverging branches of the batrachia, and that the era of this division is placed in the Permian. The reasons for this theory are, the analogies presented by the intermediate members of the groups under consideration. The tracks of

batrachians and birds are found in the strata of the new red sandstone; the reptiles have left a few fragments of bone, from which their affinities can be deduced; but of the birds nothing but the tracks remain. According to the great osteologist, Owen, the batrachians of the Permian, of which the labyrinthodon may be taken as the representative, were superior to the present batrachians, because they approached nearer the saurians — a higher type. This objection rests on the assumption that each succeeding branch must be superior to the preceding, while, on the contrary, the reverse is often true. The branches represent lines of separation of peculiar characters, and not necessarily of progress. If the present theory be true, and the batrachians really sprung from the saurians, the first batrachians should be saurian in character. Such is the fact; the labyrinthodons were like the saurians in the form of the head, the teeth, and the position of the breathing apparatus at the end of the snout, as in the crocodiles, allowing them to drag their prey under water, and devour it without ceasing to respire. Its affinities with the reptile is still further shown by the bi-concave form of the vertebræ, — a characteristic of *fishes*, — which Owen affirms indicates a decided "aquatic, if not marine theatre of life."* The present batrachians have the ball and socket articulating vertebræ, but in their embryonic state they have the bi-concave, thus reverting in the same remarkable manner to the original labyrinthodons, as the lobster to the trilobite of the early ages.

410. The marsupials and cursorial birds show a remarkable affinity to the batrachia. Rymer Jones†

* Owen On the Reptilian Fossils of South America, Phil. Trans., 1845.
† General View of the Structure of the Animal Kingdom.

considers the former the connecting link between the oviparous and placental vertebrata. The affinities of the bird and the marsupial is shown by the small size of the brain, the exposure of the cerebellum, the absence of the septum lucidum, and corpus callosum; in the great development of hind limbs at the expense of the fore extremities; in the tendency of the feathers of one to the hairy covering of the other; and in the rudiments of the pouch in birds, which is developed for the protection of their young in marsupials. I do not understand these similarities as proving so much the development of one from the other as their common origin. If both are considered branches of the batrachia, the similarity of organization is readily explained, as each would partake more or less of the original stock.

411. What do the rocks say on this point? In the Permian the tracks of batrachians are preserved, having all the characteristics of the marsupials. There is the large and strong hind foot and limb, the small and weak fore extremity, the walking and leaping locomotion. In the next age the true marsupials appear. If intermediate forms teach any thing, or if comparative anatomy is of any value, the origin of the two groups under consideration is clearly referable to the saurians. It will thus appear that the mammals were not developed from batrachians through marsupials or birds, but the latter had taken a course peculiarly their own, and progressed upwards in a channel parallel or slightly diverging from the former.

412. The marine mammalia — whales, &c. — also pursued a path peculiar to themselves. The first advance is made by the ichthyosaur, in the form of its body and shape of its paddles; then, after several

intermediate forms, each approximating closer to the cetacea, in the oölite the cetiosaur, which is decidedly whale-like, and in the tertiary the true whale make their appearance. Can a more beautiful illustration and proof of the theory of development be presented?

413. The origin of the pachyderms can be traced to the dinosaur of the oölite and wealden. In this line of progress first we have the fish saurian, then the true saurian, next saurians advancing to the pachydermic mammals, and lastly, true pachyderms, even before we leave the age remarkable for its reptilian types.

414. By tracing out such analogies the herbivorous mammals are referred to the herbivorous saurians, and the carnivora to the carnivorous saurians of the oölite. The quadrumana, in the form of their teeth, general structure, habits, &c., approach the carnivora; and, as will be shown in the next chapter, their highest species closely approach the lowest of the human race.

415. How can these facts be explained? Is not their testimony conclusive in establishing the supremacy of great principles, and the government of nature by an established order? I leave the reader to judge. I would not befog his understanding with words, but present him the plain, ungarnished facts on which the theory of law reposes.

416. Before I do so, however, I would render him such assistance as he requires to a full understanding of the position entertained, by the following series of engravings: —

The amphioxus, (Fig. 4,) standing at the foot of the vertebrata, almost worm-like, and only determined to be a vertebrate by characters traced upward through intermediate groups.

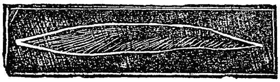

Fig. 4.

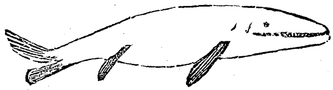

Fig. 5.

The different species of sauroid fish, typical form, (Fig. 5,) present an uninterrupted transition from fish to reptile.

In the ichthyosaurus, (Fig. 6,) we see the characters of the reptile slowly predominating over those of the fish.

Fig. 6.

The cetiosaurus, typical form, (Fig. 7,) is the original of the whale.

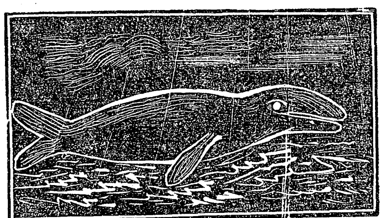

Fig. 7.

Carnivorous and herbivorous saurians, typical forms, (Fig. 8 and 9.) Here we see the dawn of the herbivora and carnivora.

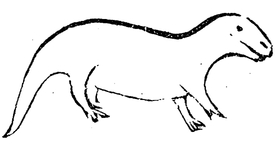

Fig. 8.

Fig. 9.

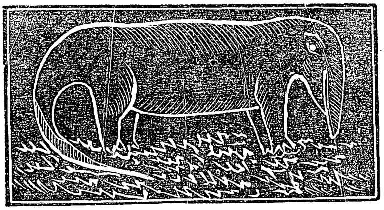

Fig. 10.

Pachydermoid Saurian, (typical form,) (Fig. 10.) The original of the Pachyderms, or thick-skinned animals, as the elephant, hippopotamus, &c.

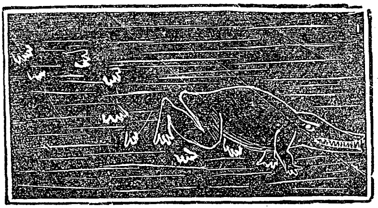

Fig. 11.

The Labyrinthodon (Fig. 11) is the earliest batrachian type, indicating its origin by its strongly-marked saurian character — the original of the oviparous and implacental vertebratæ.

CHAPTER XVII.

ORIGIN OF MAN.

Embryonic Growth of. — His Relations to the Animal World. — From whence derived. — A Savage. — Human Fossils. — Their Testimony. — Caucasian Civilization. — Its Origin. — Disseminated from the Highlands of Asia. — Earlier Period still. — Number and Origin of Races. — Primitive History of.

417. As the crowning work of creation, and the ruler of the alluvial age, man, by his prominent position, appears isolated from the animal world. But this separation is only apparent, for in reality the closest relation exists. As life in its ascension has left, as

waymarks along its pathway, all gradation of species from the cell to the most perfect animal, it has left a gradation from the animal to the most perfect human beings.

418. He is the perfection and personification of the grand archetype of creation. In him are combined zoöphyte, fish, reptile, and mammal, and he acknowledges this relationship in bone and muscle, in digestion, nutrition, and reproduction. In one respect, and only one, does he rise above the animal. He possesses morality and spirituality. In every other respect, whether organic or functional, man is an animal.

419. His embryonic growth proves this in a conclusive manner. Man commences at the foot of the scale, and advances over the whole vast interval that life has traversed since its early dawn. Let us not revolt at the facts of fetal growth, nor evade the sublime generalizations it supports. Man at first is a zoöphyte. The embryo is a confused gelatinous body, without the least appearance of different organs. Gradually this primordial model is transformed, first to the rank of the fish; not agreeing in external form, it is true, but in the conformation of its brain, its nervous and circulating systems—relations of vital importance. It next ascends to the rank of reptiles, then to that of mammals, and lastly its brain is still farther developed, and it arises to the grade of a human being. It passes through all the grades of life, from the lowest to the highest.

420. The numerous cases of monstrosity, or fetal deformity, furnish incontrovertible evidence of man's near relationship to the animal world, as well as of the progressive theory advanced in this volume.

"It will be found," remarks Knox, "on examining the mass of mankind, that some cannot extend their limbs and arms to the proper degree; that some have webbed fingers and toes; that some have no arms, but merely hands, (like the whale,) others no legs, but merely feet; or the thighs or arms are too short; in some the back is straight, not curved and arched; some have the nails round, others pointed like claws; some have hair lip and cleft palate. On the best formed neck of man or woman the finest openings may occasionally be seen — the remains of branchial arches, or gills, which all animals, man not excepted, have in their fetal state." *

If the laws of embryonic growth act unimpeded, the human fœtus grows out of the lower stages; but if impeded it retains a trace of its transition, or remains permanently at some lower stage, which should be only temporary in man, but permanent in the animal.

421. It is an axiom universally true that "nothing is made in vain;" but if we accept the common view, that man originated by special act of creation, innumerable instances are furnished in his organization of atrophied organs which are of not the least use to him, and as much out of place as organic remains would be in the rocks if the world were created, as it now is, by a fiat of divine will. For instance, "in man the third eyelid is readily seen as a minute scale, serving no possible use whatever; and did not birds exist, we could scarcely conceive of its high organization. In the latter it is of essential service, and is always present, but developed only in those tribes which require its aid. Why is the nodule of bone in the arm, where it can be of no possible use — the two small additional bones occasionally found attached to the sternum — the signifi-

* Knox, Races of Men.

cation of the two small folds which loosely traverse the knee joint?" "Man has three bones in each toe except the first. In birds we meet with four or five bones in some of the toes. But we would say wrongly that the toes of birds were formed on a different plan from man's. In the embryo bird and man each of these bones are composed of two, which coalesce in man, but remain distinct in birds. In man there is a little cartilage, scarcely perceptible, connected to one of the bones occupying the nostrils, (called *tubercle* bones,) which serve no possible use. In the horse these shut off the great cavity of the nostrils from the *vestabular* cavities in front, thus protecting them from foreign bodies: in the whale they acquire their greatest development, growing to the size of bolsters; returning, after breathing, into the vast nostrils from which they are momentarily withdrawn, sealing them against a thousand fathoms of water as the animal plunges into the abysses of the ocean." The thin lines of cartilage in the abdominal muscles of mammals and man are remnants of the sternum and ribs of the saurians. In the herbivora a strong muscle supports the head while grazing. The same exists in man, but as it is not required, it is only a thin white line of cartilage.

422. Man has no caudal extremity; but in this he departs not from the mammalian plan, for in him, as well as in the apes and orangs, the caudal vertebræ become united in the os coccygis, and more or less in those animals which approach nearest to them. In the marsupials and edentata — which recede from him, and approach the reptile — they increase astonishingly, and the alliance is carried still farther by the form of the spinal articulations and processes.

423. Thus what is irregular in man is regular in lower animals. The webbed hand and foot are prominent in the beaver and otter, constant in the human fœtus, sometimes but rarely seen in the matured man. The fold of skin found at the inner angle of the eye of the Esquimaux and Bosjesmen is not found in the mature Caucasian, but is always present in the Caucasian fœtus. One is arrested in its development, the other advances.

424. The philosophical Lamarck * seized this clew, and wrought from it the startling generalization that man derived his existence from the orang. Whether this theory be true or false, we know, viewing the subject with the calm eye of philosophy, we must look for man's origin in the laws of the physical and organic worlds. His form being natural, he must have been originated and sustained by natural laws. Then, if man was developed from the animal world, there must have been a common stock from which all races were derived. That stock must have been lower than the present orang, which is an undeveloped branch of its more complex ancestor.

425. Let us trace the remarkable approach man makes to the quadrumanous animals. The orang, of which many fabulous accounts have been given, undoubtedly, of all animals, is nearest related to man. The Angola orang is covered with short black hair, which is longest in those places covered with hair in man. It has the face of a man, with flat and contracted jaws furnished with teeth closely resembling his. Its ears are like man's in most respects. This external correspondence is continued in its anatomical

* Lamarck. Philosophical Zoölogy.

structure. In every thing but slight and unessential particulars they are entirely and exactly the same. Its organs of speech are quite perfectly formed, and it has a rude language, by which it can convey its wants and desires. From its large and almost human brain, it would be inferred that its intellect must be far above that of other animals.

This is true, according to the descriptions given of its manners. "I have seen it," says Buffon, "give its hand to show the company to the door. I have seen it sit at table, unfold its napkin, wipe its lips, make use of the spoon and fork to carry the food to its mouth, pour out its drink into a glass, touch glasses when invited, take a cup and saucer, put in sugar, pour out its tea, leave it to cool before drinking. It was gentle and inoffensive; it even approached strangers with respect."

426. "M. L. Brosse bought two young ones, that were but one year old, from a negro; and these at that early age discovered an astonishing power of imitation. They sat at table like men, ate of every thing without distinction, made use of their knife, spoon, and fork, both to cut their meat and to help themselves. When carried on shipboard, they had signs for the cabin boy expressive of their wants. The male was seasick, and was bled in the arm; and every time afterwards, when he found himself ill, he showed his arm, as desirous of being relieved by bleeding."

427. The pongo is an African orang, which also bears a close resemblance to man. Its face is human, being without hair, eyes deeply sunk in the head, the body almost hairless, and scarcely differing from the human, except there are no calves to the legs. It walks erect in its wild state. It builds itself a hut to

protect it from the sun and the tropical rains; makes use of clubs for attack and defence. They usually go in troops, with a leader at their head, whose commands they obey, and when one of their comrades die, they bury it with leaves and branches.

428. An almost equal intelligence is shown by an African baboon. "They are under a regular discipline, and go about wherever they undertake with surprising regularity and skill. When they rob an orchard, it is not singly, but in large companies, and with precalculated deliberation. On these occasions part enter the enclosure, while one is set to watch. The others stand without, and form a line reaching all the way from their comrades within to their rendezvous without, which is generally in some craggy mountain. Every thing thus disposed, those within throw the fruit to those without as fast as they can gather it, or if the wall or hedge be high, to those that sit on the top, and these hand the plunder to those next to them on the other side. Thus the fruit is picked, and sent from one to the other, all along the line, till it is safely deposited at their head quarters. The sentinel, during this whole time, continues on the watch, extremely anxious and attentive; but if he perceives any one coming, he sets up a loud cry, and the whole company scamper off. Such anecdotes might be unlimitedly multiplied; but those cited suffice to show how near the highest quadrumana approach man in intelligence." *

429. On the other hand, a series of facts present themselves showing how closely man approaches the orang. Take, for example, the type of the negro, and

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* Animated Nature, vol. ii.

compare it with the orang. The nose thick, flat, and confounded with the prominent cheeks; lips very thick and everted; jaws projecting, and chin receding; large facial development, and skull thick and heavy; the head compressed laterally, and the forehead low and retreating, which, combined with the prominent jaws, reduces the facial angle to seventy and even sixty-five degrees. The foramen for the passage of the spinal cord, and the articulations of the head and neck, are far back, like that of the orang, and unlike the Caucasian.*

430. Vorlik says, it is difficult to view the female negro pelvis, without the idea of degradation, so much does its form approach that of the simiæ. He considers the Hottentot pelvis as indicating greater "animality in comparison even with the negro." The uncivilized races, in their long, lean, and slender limbs, approach the animal much nearer than the civilized man. In the negro the bones of the leg are bent outward and forward; the calves of the legs are very high; the voice is feeble and hoarse; their intellect low, in some tribes quite puerile; thought is habitually dormant; war is a passion which in them excites the most brutal feelings, and they do not shrink from cannibalism. This is a true picture of the lowest tribes.

431. The Bosjesmen are often quoted for their extreme degradation. "They live among rocks and woods; have a keen, vivid eye, always on the alert; will spring from rock to rock like the antelope; sleep in nests they form in the bushes, and seldom pass two nights in the same place; supporting themselves

* Smith, Natural History of Human Species.

by robbery, and by catching wild animals, as reptiles and insects, which they use for food." Thus we perceive in these degraded beings an absence of almost every faculty peculiar to a human being. Their heads are large, but the mass of the brain lies in the occiput. Their foreheads are low and retreating, and the slenderness of their limbs, hairy bodies, and extreme agility closely ally them to the orang.

432. A noted traveller,* on encountering some boat loads of slaves from Dongola, observed their close approach to brutes, and their orang expression. He says that this was startling and painful, and he could scarcely draw the line of demarcation between the lowest of the negro races, and their near kinsman, the wild man of the woods. "Though made in God's image, there beamed no ray of divinity from their countenances, and they sat on the deck with their long arms wound round their knees, and their chin resting upon them, precisely as we see in apes; and as I have been electrified while gazing on these caricatures of humanity by a transient gleam of intelligence, so here I was struck by the closeness of man's approach to the inferior grades of animal existence." Almost every traveller in Negroland has remarked this approximation. It was observed in ancient times, and has never since ceased to be an object of interest, and has called forth the acutest discrimination of the naturalist, to draw the specific and generic distinctions between man and the brute.

433. To the views here presented it has been objected that the facial angle bore no relation between the most degraded race of men and the highest

* Stephens, Arabia Petræa and the Holy Land.

orang. Although the facial angle gives little idea of amount of brain, as a measure of intelligence, I do not think the argument suffers from the admission of all that is claimed for this measurement, which is the angle formed by a line drawn from the most prominent portion of the forehead to the most prominent point on the upper jaw, intersecting a line drawn from the occipital condyle to the floor of the nostrils. (See Figs. 18, 19.) A moment's reflection will show how valueless this measurement must be, as it bears little or no connection with the size, the lateral or occipital development of the brain: granting, however, that it has, let us submit to the test. In the dog this angle is 20 degrees; in the great chimpanzee it is 40 degrees; in the lowest Ethiopians 65 to 70 degrees, (according to Smith, Natural History of the Human Species, p. 18;) in the Australian it is 85 degrees; in the European it is 95 degrees; and the ancient Greek artists gave the lofty mysterious and shadowy grandeur to their sculptured gods by an angle of 100 degrees.* Thus this vaunted argument supports rather than conflicts with our theory, for it shows a gradual and perfect transition, such as should exist if the brain measures the amount of intelligence. Hence, if the brain serves the same purpose in animals as in man, they must in a greater or less degree possess all his faculties. They have reflective faculties, powers of observation, and remembrance of the same. They adapt themselves to circumstances, and profit by the same. The beaver builds a far more ingenious dwelling than the Hottentot; the dog is faithful, affectionate, and almost reasoning; the elephant adapts means to ends, cause to effect, with reasoning precision.

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* Owen on the skeleton.

434. The lowest races of men have no habitation but the clefts of the rocks, and have not even the foresight of the squirrel in laying up a store of food. The Patagonians have not the mercy or affection of brutes, for they destroy their parents as soon as they become too aged to be useful.*

435. Man in childhood has the brain of the animal, and manifests the animal's disposition and instincts; but he loses these as his brain matures. When this growth is arrested, he remains on the animal plane, as is witnessed in the criminal and the savage.

436. On the other hand, the higher animals have the moral region of the brain in an atrophied condition, as fishes have the lungs of mammals, but undeveloped. In them, that region of the brain producing morality is undeveloped. It is almost equally so in the lowest races of men, and it were as impossible to teach the Hottentot morality as the orang.

437. Perhaps the ideas here presented will appear in a stronger light if the eye is enlisted by aid of representations. The following engravings have been selected, with great care, from authentic sources, chiefly from the Types of Mankind:—

Fig. 21.

It is useless to point out the difference or the similarity, which exists between the ne-

* U. S. Exploring Expedition Report.

Fig. 13.

gro from types, (Fig. 12,) and the young chimpanzee, (Fig. 13,) as the likeness is too obvious. These resemblances are not superficial, but pervade every fibre of their organization. The skull, as the index of intelligence, as remarkably coincides, as will be seen by the following illustrations: —

Skull of a Chimpanzee. Skull of Negro — Types.

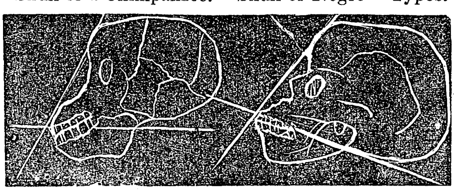

Fig. 14. Fig. 15.

In the negro (Fig. 15) we observe the same retreating forehead, protruding jaws, flattened nose, and full back head, as in the chimpanzee, (Fig. 14.) If the entire skeleton be compared, like affinities will be observed.

Skeleton of Orang and of Man.

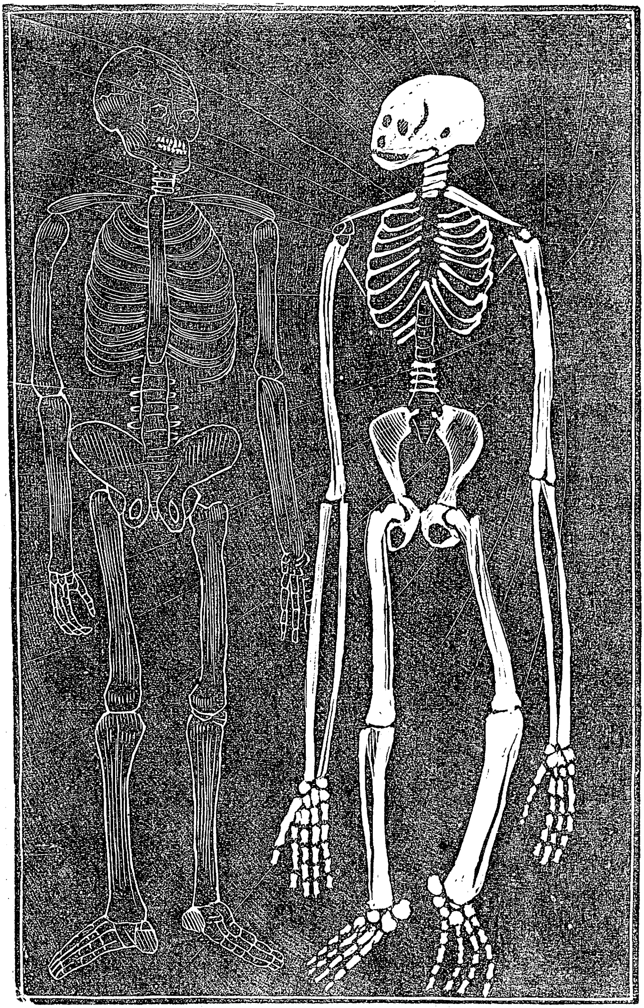

Fig. 16 and 17.

Here, likewise, the resemblance is too obvious to require a particular description, in all the general features being perfect. If the skeleton of the lowest negro were compared, instead of the Caucasian, the resemblance would be still more perfect.

438. Nor does the possession of language separate man from the animal. All animals have intonations by which they express their desires. Language is the expression of thought, and brutes assuredly do this to each other. The dog calls others to him by a peculiar bark; the lion roars; the tiger growls; the birds sing; each has a language of its own, to manifest affection, call its mate, or vent its rage. The elements of the organs of speech are present in all animals, and on their development depend the sounds employed by each species. They are quite imperfect in the orang, more perfect in the negro, yet not sufficiently so as to enable him to articulate difficult combinations of sounds. The sounds of a language depend on the form of the organs of speech, and hence the difficulty of one race speaking in a perfect manner the language of another. The negro and the Indian never speak Caucasian dialects without a brogue imparted by the peculiarities of their organs of speech. So the modification of these gives the growl to the tiger, the roar to the lion, and a voice of its own to each species of animal.

439. Man must have begun his existence as a savage. If we trace history backwards into the night of its traditions, we find all early nations to have been the rudest savages. In the dim twilight, mythology reveals its Protean form, and sanctions our conjecture. The farther backwards we go, the lower man becomes, until, lost by history, tradition failing, reason inductively concludes that he must have been extremely

low at the beginning. At every step we take in the opposite direction, man becomes better and wiser. At no period of the past has he been equal, either intellectually or morally, to his present attainments.

440. We are now ready to inquire where man originated. This has been a vexed question, and as it has usually been discussed theologically, and not scientifically, little knowledge has resulted. Mankind, when first they become historically known, were distributed over the greater part of the eastern hemisphere; yet they appear to have originated in a common centre, and traditions of different nations indicate that this centre of dispersion was located on the high central regions of Asia. From this region all man's dogmatical knowledge, early inventions, and traditionary records emanate. Here the dog, the horse, ass, camel, ox, sheep, goat, cat, and gallinaceous fowls were first domesticated, and in or around it many of these still exist in a wild state. Here must have been the seat of man's first development, or these high lands must have afforded protection to a portion of human beings, when a more ancient zoölogy was swept away by convulsions of which mention is made by the traditions of all nations. The latter is probably the correct opinion; for we find this region skirted by lofty mountains, such as a people fleeing from destruction would naturally seek; and these still bear the sacred names which a grateful people would bestow. To the south of these high lands, far into the Indian Ocean, every where are written the records of the grandest and most prolonged convulsions, which probably gave rise to the myth of the deluge. On the islands of the Indian Sea, which appear to be the crests of mountains, rivalling Dhawalaghiri in height, and which may have

escaped those convulsions which destroyed the then existing fauna, we find the *pithecus*, or orang outang, in statue as large as a man, and in strength equalling eight or more, which, from its strong resemblance, has received the name of "wild man of the wood," and which, of all brute creation, approximates nearest to man. Still more remarkable, on the eastern coast of this southern border, the transition from brute to man is made by degraded Papua tribes, cannibals, so low in the scale of humanity, in them gleams not a ray of spirituality or morality.

441. Man originated, probably, near the equator, where the climate was better adapted to his defenceless condition, and food abundant. If facts continue to support the present theory, that the simiæ of the oceanic islands are the remnant of an earlier zoölogy, the seat of man's original development should be placed on the submerged continent, the tops of whose mountains those islands alone represent.

442. If we admit that man derived his origin from the animal world, then that region whose fauna approaches nearest the human type should be the one to claim his birth. This fauna is the Asiatic, or Asiatico-oceanican. Thus the inductions of science beautifully harmonize with the sacred traditions of mankind.

443. To this point all races, except the black or negro race, are referred, and in so much are all races allied; but instead of originating from a common parent, they had each separate stocks, and originated in nations in many localities. To explain: the negro or woolly-haired race originated at a much later period than the others, under the influence of the moist and heated atmosphere of Africa, in the tropics, and, unawakened from their torpidity by the change of scenes,

and contentions of nations, were stagnated or arrested in their growth, and to this day remain low and undeveloped. On the contrary, the ancestors of the brown or Mongolian, and the white-skinned or Caucasian races, were forced to emigrate to different countries in Asia and Europe, and were subjected to a colder climate, to the vicissitudes of hot and cold seasons, to the contentions of clans or tribes, to hostile strife, for sustenance in a country which did not spontaneously afford it, all serving to stimulate and call into action the mind and the body. From these various but contiguous localities, numerous tribes or nations emanated to the north, east, south, and west; and, as before mentioned, when these were first recognized by history, they had already advanced to a respectable civilization.

444. Two races only are mentioned as originating in or near the continent of Asia, because the others, notwithstanding the prominent position given them by most writers, are considered secondary, and branches to these main stems. The Indian of America has too much resemblance to the Mongolian of the old world to be advanced to the position of a primordial race, and the Malay indicates a strongly mixed character. Thus we perceive that races of men originated in nations separated from each other and subject to conditions, the power of which we have previously established as irresistible. The Caucasian did not originate from the negro, nor is the negro a degraded Caucasian, but both came from orangs of different color and character; but while one has remained stationary, the other has advanced. Various types of mankind were in existence when the old world was peopled with a now extinct fauna.

445. It is the generally received belief, that all species of animals, man included, had a single pair of each species as their first ancestors, and that, consequently, all animals belonging to one species are descendants of this primeval pair. We find nothing in nature to warrant such a conclusion; countless millions of primitive cells had a spontaneous origin, before any animal form originated by paternal descent. There probably never existed two animals belonging to any type exactly alike. The gradual divergence from the first primitive cells was owing either to some inherent difference in the cells themselves, or to the various conditions with which they were surrounded. All the innumerable distinctions now found in the vegetable or animal kingdoms are owing to these two causes. No distinct family of animals ever originated from a single pair. The human race is no exception.

446. In accordance with these principles, the orangs, the immediate ancestors of the human family, were very different from each other. Some were black, some nearly white, some brown, &c. The different localities in which they lived, some on a mountain, some in a valley, some in a hot, some in a temperate climate, also produced a difference. An animal or vegetable diet would have a marked effect. The transition from the orang to man was gradual. No one could tell where the one ended, or the other began, any more than we can tell where the boundary exists between a hill and a valley. For example: we cannot tell when the different families composing the Anglo-Saxon race became sufficiently amalgamated to deserve the name. In like manner the human races originated. The great types, the Mongolian, the Caucasian, and negro, did not change from one to

the other, but descended from different types of the orang. The intermediate distinctions now seen in our race are owing principally to three causes: first, inherent differences from the most remote times, perhaps from the first primitive cells; second, from intermixture; and third, from different conditions to which they have been subjected.

447. Many of the facts connected with the discovery of fossil human bones are worthy of more than a brief mention. Where they occur mixed up with those of extinct species of animals, it becomes difficult to assign other than a contemporary existence.

In the caverns of Bize, in France, human bones and shreds of pottery were found in red clay, mingled with the *débris* of extinct mammalia. The celebrated Marcel de Serres found, in the cavern of Pondees, the remains of human skeletons and pottery in the same deposits with the bones of an extinct rhinoceros, the horse, and the stag. Human bones were found in caves near Liege, together with those of the hyena, elephant, and a feline, not much less than a lion, buried beneath a thick bed of stalagmite. Mr. M'Enery collected from the caves of Torquay human bones and flint knives from among a great variety of extinct species, such as the elephant, rhinoceros, hyena, &c., all beneath a crust of stalagmite.

In Upper Saxony, the gypsum caves and fissures in every direction are filled with red alluvial clay, containing in clusters bones of mammalia, rhinoceros, horse, hyena, &c., and man.

The burial place of the people who inhabited France when the Irish elk and the rhinoceros were indigenous, has been discovered. It is a cavern in the side of a calcareous mountain in Southern France, which bears traces of a vast amount of labor in preparing it for a sepulchre, and securing it from observation. Its entrance had been closed, and its existence was discovered by sinking a shaft fifty-six feet. In it were discovered great quantities of human bones, with those of the rhinoceros, reindeer, stag, horse, and a large bovine, probably the remains of offerings to the dead. This people must have lived long before the rude Celt dispossessed them, for the existence of these extinct mammals is not mentioned even by tradition.*

448. In English caverns, the bones of bears, hyenas, and of man mingle in such a manner that they must have been deposited contemporaneously. In some of them, the same osseous breccia contains the bones of elephants, hippopotami, lions, and man.† When subject to muriatic acid, no difference could be detected between the bones of the mammals and man, their age being so great that nearly all their animal matter had disappeared. The renowned Buckland does not admit that the bones discovered by him were of a former period, and fallaciously infers, without the least reason, that whenever the bones of man and extinct animals occur together, those of man must have been introduced at a recent period — an inference doubted even by Cardinal Wiseman.‡

Fossil human bones have been discovered in caverns of the Jura,§ and mingled with pottery and remains of the rhinoceros, hyena, bear, and other animals in the tertiary limestone at Cristolles.

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* Smith, Nat. Hist. of Human Species.

† M. Roblin, Ann. Dis. Science Nat., tome xvi. p. 16.

‡ Lectures on the Connection of Science and Revealed Religion, Buckland's Bridgewater Treatise.

§ Durfort Cave; Pirmas and Serres.

The Quebec and Guadaloupe skeletons, which were so summarily disposed of by scientific men, have all the characteristics of fossils. The stone in which the latter is embedded is harder than marble, and shows no signs of having its material disturbed since their deposition.

449. Dr. Schomerling observes, that the fossil human and animal bones which he discovered in France must have been contemporarily deposited.*

450. Human bones have been found in Belgium, mixed with those of bears, hyenas, elephants, horses, and deer, and identical with them in appearance, color, and fossilization.†

451. The distinguished naturalist Lund discovered fossil human bones in Brazil, in eight different localities, and so mingled with the relics of extinct animals that their contemporary existence cannot be for a moment doubted. In a cave, near the borders of a lake, called Lagoa Santa, he obtained specimens of thirty individuals, of all ages, from childhood to maturity. They were firmly incorporated in the solid rock, and were accompanied by the relics of an ape, and the usual extinct mammifers. Immense blocks of stone, with which nature has covered this mausoleum by the force of great convulsions, attest the antiquity of these fossils.

Agassiz estimates the age of a human foot and jaw, discovered by him in the coast limestone of Florida, from data furnished by the growth of the land, at 135,000 years.‡

In the blue clay underlying the bluffs of the Missis-

* Dr. Moultrie.

† Researches, pp. 56–66.

‡ In an Essay contributed to Types of Mankind.

sippi, human bones have been found below those of the megalonyx, perfectly fossilized by oxide of iron.

452. In making an excavation at New Orleans, an Indian's skull was found beneath four cypress forests. The time necessary to produce each of these cypress strata is estimated at 14,400 years. Between each was a period of rest, estimated at 500 years, or 57,600 years since the skull was deposited in the position where it was discovered.

Such is the geological testimony of the date of man's introduction—testimony which has steadily augmented, notwithstanding the derision bestowed on it by popular writers. One hundred and fifty thousand years ago, at least, the Indian propelled his canoe on the Mississippi's flood, the Gulf, and above the Florida Reefs. This conclusion is as legitimate as any deduction of science. If we would learn the date of his birth in the old world, to these 150,000 years we must add the length of time necessary for the migration of the Indian from the older world. To this period the duration of authentic history becomes but a moment. Such is the evidence of fossil records, whether found beneath the cypress forests of the Mississippi, the coral reefs of Florida, in the caverns of the Canary Islands where the Guanches and his faithful dog are entombed together, or in the bone breccia of European and Asiatic caves.

453. It may be objected to the date of the skull found at New Orleans, that at the time calculated, viz., 57,600 years, the place in question must have evidently formed a part of the Gulf of Mexico; also that some of the other instances are overcharged. This may be the case. Yet still the evidence of man's existing on earth a long period previous to the chrono-

logical period assigned, is clearly proved. We can hardly date his first appearance on earth less than 100,000 years previous to the present time.

454. Tracing the origin of the inhabitants of the new world to the old, or through countless decades of centuries to the high lands of Asia — from that common focus of the Caucasian type, nations went forth, or rather the germs of nations, in clans and tribes, as the unproductive territory became crowded. It was a hunter age; the arts were confined to the manufacture of the bow, the war club, and the spear, the canoe and rude dwelling; and the untilled earth gave a poor reward to the hand of the unskilled husbandman. Population must be sparse, must be clannish, roving, pastoral. Sparse, because a hunter requires a large territory for support; pastoral, because, seeing the importance of having food when game is scarce, he would attempt the domestication of the more gentle species; roving, because his flocks would require fresh pastures; and clannish, because only by uniting in tribes could he obtain safety from the wild beasts of the forest, and his more lawless fellows.

Such was man's origin. By migrations of clans along great rivers, or across extensive plains; by the union of tribes, or their ruthless wars; by the expulsion of the weaker to new or less fertile territory; from these various causes the world became peopled, and each grand division by a peculiar race.

PART III.

CHAPTER XVIII.

THE HUMAN BRAIN.

Comparative Anatomy.—Embryonic Growth of the Brain.

455. The brain and nerves have been universally conceded to be the organs of mind. Through, and by them all manifestations of intelligence and animal activity are exhibited. Without the nerves, the bones and muscles would remain inert, and not a motion would be produced by all the complicated fibres of the body. Without the brain the nerves could not transmit messages of intelligence, and although they stretched out in infinite ramifications through the body, there could be no beneficial result. They would be like telegraphic wires, totally useless until a battery is employed to transmit the messages.

The brain of man is many times larger in proportion to the bulk of his body than that of any other being, and not only larger in bulk, but larger in that region where experiment informs us the intellectual faculties lie. In all other respects his brain is like the typical brain of the animal. Even in this respect we do not perceive any departure from the general plan which we have, in the previous pages, endeavored to prove pervades all the realm of life. We have followed that plan in its general bearing; and now shall particularize by applying it to the brain and nerves. We wish to draw from this fount the weighty evidence it affords in support of the progressive development of mind, and to elucidate the vexed question so long agitated — What is the origin of mind? No study on which we can enter so beautifully unfolds the intimate relation between brain and mind as the comparative study of the vast chain of beings extending from the plant to man. In this first section, as an introduction to the sequel, this will be our investigation; commencing with the lower, and step by step ascending to the higher, delineating the successive advancement of the nervous system, and the accompanying advancement of intelligence in the animal, thereby not only proving that mind depends on brain for its manifestation, but delineating the rise and progress of that system, until man possesses it in the greatest degree, and in consequence manifests the greatest intelligence. The great hiatus supposed to exist between intellect and instinct will be thus filled, and mind brought under the jurisdiction of determinate laws.

This study forms an appropriate introduction to the investigation of mental phenomena in the light of physical science.

456. The zoöphytes are the lowest beings of the animal kingdom. The sponge and jelly fishes are as near plants as animals. Their entire economy is carried on by vegetative growth. Although attaining a large size, there is no trace of nervous fibres in their jelly-like mass. They, however, give indications of a diffused irritability, but there is nothing manifested like sensation or volition. They are also destitute of muscular fibres, and their movements are performed by the irritability of the cellular masses of which

they are formed, which perform the office of both nerves and muscles. The protozoa have not the least trace of a nervous system, and although some physiologists have suggested that it might exist in a "diffused form," yet, if we consider the office of the nerves, it will be readily seen that they would be useless to these beings. Nerves are employed to unite in harmony the various organs of the animal, and bind them together into one determinate action. If there are no organs to unite in this manner,—if the functions to be performed are all vegetative,—then nerves would be useless, as we see all the vegetative functions carried on in the plant without the assistance of nerves, by means of the circulating fluid which unites with the strongest buds, the roots, branches, and leaves. The irritability they manifest is the same as that exhibited by some plants, and unaccompanied by any consciousness whatever. This faculty is exalted, and supplies all the demands of the animal. The same is recognized in the tissues of all animals.

457. In the hydra, actenia, and their allies, lines of nervous matter are dimly traced; but the function they perform must be very limited, and is perhaps of no account in the economy of the animal, as the morbid irritability they manifest is fully explained by the foregoing, and by changes produced by light, heat, and other external causes. It is true that we can know very little of the degree of sensibility possessed by the lower members of the animal kingdom; yet we can estimate it from the amount of nervous influence on the functions of vitality, or, in other words, the amount of nervous matter they possess. The only motions which are at all referable to nervous action in the hydra and its allies, is performed in capturing or

catching its prey, and this is identical with the œsophagic muscles and stomach of higher animals. The comparison of these lower orders should be with plants, and not with animals, so completely vegetative are all these organs. The next higher step is taken by the rotifera animalcula, in which the nerves first show an unmistakable existence. In one of these, six or seven gray bodies exist, enveloping the dorsal portion of the œsophagus, closely connected together and clearly perceptible. The upper one, which may be considered as a ganglion, is the largest, and gives off slender filaments of nerves, which join in a ganglion at the back of the neck, forming a circle of nerves analogous to the mollusca. From these two nerves filaments are sent off to the head, and another branch off to the abdominal surface of the body. Muscular fibres also exist in these animalcula, showing the connection between the development of muscle and nerve.

Now, at the threshold of our investigations, we find the key by which the whole mysterious province of mind is unveiled — the nervous system. It is the step which elevates the animal above the plant. Until the existence of nerves, the animal lives wholly a vegetative life, and every function in its economy is purely vegetative. The acquisition of nerves places them at once above the plant, by bestowing, in the place of mere irritability, dependent on external circumstances, nerves, which convey sensation and thought. The step is not abruptly taken, but slowly through a host of intermediate forms; and we find traces of a nervous system long before we leave the domain of simple irritability. The transition is almost imperceptible.

458. The intestinal worms are among the lowest members of the animal kingdom. Confined within narrow limits, and surrounded by their food, they are nearly destitute of locomotive organs, and are little more than a digestive sac, or stomach. In them, however, nervous lines can be detected, remarkably like those seen in the embryo chick of the twenty-fourth hour. These perfectly correspond with the first appearance of the spine in all vertebrate animals, and affords a beautiful illustration of the law, that the higher classes of animals are developed through the forms perfectly retained by the lower. The embryo chick, at its twenty-fourth hour, has advanced to the plane of the intestinal worms, and its nervous system is identical with them. The type, or beginning of the nervous system, is a nervous centre or ganglion, to which gather sentient nerves, and from which nerves of motion lead to the muscles, over which it is necessary to exert nervous control. It is not an indication of consciousness when these ganglia exist. Motion resulting from them is the same as the contraction of the glottis, or the œsophagus in swallowing. The excitor nerves conduct the impression to the centre, and the motor nerves send the nervous fluid to contract the muscles.

In insects (articulata) this type is repeated in every ring of their bodies, but there is a tendency to concentrate several ganglia in the head. At the metamorphosis, when the fly advances from the worm, its superiority of grade is manifested by the concentration of three or four of the first ganglia in the head.

459. The large nervous centre in the oyster corresponds in position to the medulla oblongata in the brain of man. Surrounding the œsophagus are two other cen-

tres, which guard that passage, and exercise the functions of an inferior sense. All the consciousness of external nature the animal enjoys must be derived through these. They are analogous to the central ganglia in man.

460. The next step is taken by the gasteropoda—slugs, snails, &c. They are far in advance of the oyster, and enjoy the sense of sight and smell, and have organs of locomotion, to enable them to seek and select their food. In some species the centres observed in the oyster are very distinct, in others almost perfectly blended. This, too, has an important bearing on human anatomy, for the medulla oblongata, to observation, appears a single organ, but when carefully dissected, is found to be composed of two centres, so blended and bound together by intersecting nerves, that they are almost indivisible. The approach made by the four great divisions of living beings, as they ascended in the scale of life, has been previously noticed. This is beautifully seen in the cephalopoda, the highest of the mollusca. In them we see the concentration of the cephalic ganglia into one mass; and sometimes these are even protected by a cartilaginous plate, forming the rudiments of a nervo-skeleton. In them we meet with organs of hearing, and very acute organs of sight, and the entire surface of the body possesses sensibility.

461. The articulata not only have the simple excito-motor system, but they also have the concentration of ganglia, previously noticed, in the head. They have both the sympathetic and the motor systems, and these are disposed in such a manner that they can be isolated from each other.

462. Leaving the invertebrate, we enter the verte-

brate sub-kingdom. Here we find the same general plan; nothing is suppressed: we still find nervous centres, excitor and motor nerves; but there is a greater concentration in the head; on the sensory ganglia the cerebral hemispheres are placed, and on the medulla oblongata rests the cerebellum, in the mammalia, and form by far the largest portion of the brain, covering and completely concealing the brain of insects. In them it is also protected by a hard, bony envelope, necessary to its delicate structure.

In fishes, however, the primordial ganglia remain distinct, and the cerebrum is scarcely developed. Between these extremes, all degrees of development exist.

As in the early human embryo, so in fishes we can plainly determine that the brain is composed of several distinct ganglia, of which those representing the central hemispheres are the smallest. The cartilaginous fishes, sharks, rays, dog-fish, &c., have by far the best developed brain of any of the fishes; and by them is manifested the greatest degree of instinct, or rather intelligence. There are numerous anecdotes told of the cunning of the dog-fish; how they will bite a fish off from a hook, yet never get caught by it; and also surprising feats are told of the shark, all corroborating the statement that the amount and quality of brain determines the amount of intelligence manifested by an animal.

463. The brain of reptiles has a still greater development of the cerebrum, and a corresponding increase of intelligence is manifested. The tadpole of the frog has the brain of the fish, which changes to that of the reptile as its transformation is perfected.

464. In the brain of birds, our attention is at once attracted by the enlargement of the cerebrum, which

extends so far backward as to completely cover the ganglia, which, in previously described animals, were seen behind it. The cerebellum also is increased in size, as is also the medulla oblongata. The brain of the bird has a remarkable resemblance to the human embryo of the twelfth week. In thus ascending the scale, there is a gradual prolongation of the cerebrum over the cerebellum, and at length the cerebellum itself is wholly covered by the cerebrum. In the rodentia, however, it remains in view, thus placing them at a much lower position in the scale. In proportion to the increase of the cerebrum, all the ganglia connected with the organs of sense diminished; and this comparison holds good even with the spinal cord, so that in man it is smaller than in many animals of far inferior size. The higher we advance, the more complicated is the internal structure of the cerebrum, the deeper and more numerous the convolutions. In man all these convolutions exist in a far greater degree than in animals. It is only in the mammalia that convolutions can be said to exist, and only among the higher carnivora do we find any indications of the posterior lobes. The depth of the convolutions marks the grades of intelligence of the animal. These convolutions are so marked, that Professor Owen founds a classification on them, and states that the character and the amount of intelligence can be determined by them.

The general form of the brain of apes and monkeys, its development behind the cerebellum, and the degree of inclination of the fissure sylvii, is as perfect as the embryonic brain of man. The ape has the anterior convolutions and the super-orbital parts large and deep. They are much longer and deeper than in the inferior animals.

465. The brain of the chimpanzee approaches nearer to the human brain than that of any other animal, in the depth and disposition of its convolutions. It is broader through the back and narrower through the front, marking a greater degree of intelligence in man; it is not as high, because of the absence of the moral organs. It also approaches the human brain in the absence of the *carpus trapezium*. These convolutions are prominent. The brain is an organ exactly corresponding to the quality of mind it is designed to produce, and always producing the same quality of mind in any given form.

466. The amount of intelligence that man or animals possess is not altogether a question of size, for the brain of the elephant is much larger than man's; but it is a question of size of brain compared with relative size of body. The elephant's brain, in order to be compared with man's, must be reduced in the proportion that the body of the elephant is larger than man's body. Then, if the degree of development of the different organs is taken into account, the true amount of intelligence possessed by the elephant can be ascertained. Female animals have smaller brains, with fewer convolutions, yet are perhaps as intelligent as the males. The size of the body should correspond to the size of the brain.

467. Still more astonishing is the manner in which animals in their gestation pattern after the gestation of the first types of creative life. The brain of man, with his dependent nervous system, begins at the same point, and ascends to and surpasses the highest. For a moment let us turn to this interesting subject, as we not only approach the philosophy of mind by its investigation, but also reveal in still stronger light the mysterious network of organic life.

468. In the vertebrata the first germs of organic life are a mass of necleated cells. At first these are uniformly arranged, but soon collect around the circumference, leaving a clear space in the centre. These cells are arranged in two layers, from the internal of which all the organs of vegetable life are elaborated; from the external, those of animal life. The transparent line observed in the animal layer, and which is confined to it, assumes a pear-like shape. Its edges are then elevated till a gutter is formed, and gradually approach each other until they nearly join. These edges are dotted with square spots, the germs of the future vertebræ.

469. At this period there is no appearance of nervous matter. The parts corresponding to the head and spine are transparent, and filled with a clear, aqueous fluid. About the sixth week the pia mater is perceptible, so arranged as to form three vesicles, filled with a limpid fluid.

470. The bones of the skull are formed of three vertebræ, and hence three vesicles first appear. The anterior first becomes perceptible, and the other two soon follow, and are soon after divided into two others. The two front represent the olfactory ganglia, the two middle the optic, and the posterior the cerebellum. The spinal cord is represented by a long canal, connecting with these vesicles.

471. The spinal cord always appears before the brain. It is composed of two slips of neurine, which remain distinct in man until the fourth month, in the horse till the sixth, and permanently in birds and reptiles. They do not really unite in man; the space between them is filled with cellular neurine.

472. What is still more extraordinary, the spinal

cord in mammalia extends down into the caudal vertebræ; but at the third month it suddenly rises into the second lumbar vertebra, and the coccygis, previously formed of seven pieces of bone, which represent the tail of animals, is reduced to its permanent number by their consolidation.

473. The brains of fishes and birds have no corpus callosum; the same is true of the human fœtus till the third month, at which time it commences to form at the anterior, and slowly grows towards the posterior portion.

474. The commissure of the cerebellum becomes perceptible at the fourth month. At the fifth the cerebellum cannot be distinguished from the scates. The grooves then become perceptible on its surface, and at the sixth the stems and branches of the arbor vitæ appear.

475. The optic ganglia at the second month are but plates of neurine, uncovered by the hemisphere; but they are in opposition at the medial line, and unite during the third month. At this period they resemble those of fishes. Not until the seventh month do we see the characteristic divisions of the cerebrum, and then it scarcely covers the sensory ganglia, as in rodents.

At the second month we perceive springing from beneath the corpora striata, on each side, a thin, delicate tissue, composed of medullary neurine, which is reflected inward and backward, and scarcely covering the corpora, invested with pia mater; this is the commencement of the cerebral hemispheres. Towards the end of the third month, they extend over the thalami, but not to the optic tubercles. During this period they nearly cover them, and convolutions then appear in lines and grooves. The upper and lateral surface remains perfectly smooth.

476. At the seventh month the convolutions are all marked, but imperfectly developed, and the hemispheres cover the cerebellum. In the eighth month the hemispheres are prolonged over the cerebellum, the furrows deepen, and the convolutions gradually perfect, which process continues through the ninth.

477. The hemispheres develop from the forehead backward; and this is not only true of man, but of all vertebrata. The process of growth is the same in all, to a certain point; there the lowest stop; others go farther before their development is arrested; man goes farthest of all, and hence he is most intelligent. The brain is always formed on one plan; the period at which the development is arrested varies.

478. In the scate we find the brain of the vertebrate embryo. The rudimentary hemispheres are placed in front of the optic tubercles; but they never develop beyond their rudimentary form. Their cerebral hemispheres are hollow, with their walls formed of cellular neurine, into which the fibres of the crura expand, as in the human embryo.

The rudimentary hemispheres in reptiles are equally interesting. They begin as membraneous sacs, and slowly mature, to correspond with the human embryo of the third month, and then their growth is arrested.

The above facts prove conclusively that the brain is modelled after a great archetype, and that, too, by universal and immutable law. The plan by which embryos grow is that which is pursued by the birth of races and species. Nature, in her gestation of man, has left arrested developments all the way along the path of her progress. The same law governed, through the illimitable past, the saurians and mastodons of the geological world. Life has ever been the same, and living beings ever held the same relations to nature that they now hold.*

CHAPTER XIX.

STRUCTURE AND FUNCTIONS OF THE BRAIN AND NERVOUS SYSTEM, STUDIED WITH REFERENCE TO THE ORIGIN OF THOUGHT.

479. In the thin line of nervous matter of the hydra and amphioxus, we read a prophecy of the convoluted brain of the mammal and of man. It is a prophecy written in the constitution of things, and affords to contemplation a splendid survey, when it reads in the positive symbols of Nature the efforts she puts forth to work the perfected brain out of the crude elements. From matter we ascend to spirit, through the brain. It furnishes the only gateway through which we can pass. Here the living processes terminate in a cynosure of perfection.

480. The human brain is surrounded by a halo of power. It overturns mountains, dries up the sea, re-creates, improves, and revises the works of nature, and enthrones itself as a deity in the material world. The throbbing brain with every beat diffuses thought, — plans, improves, or models world-wide schemes for the emancipation of suffering and distress. It is the emblem of that eternal pulsating brain of the universe,

* For extension of the facts of embryonic growth, see Carpenter's Comparative and Human Physiology; of comparative anatomy and structure, see Siebold and Stannius' Comparative Anatomy, Wilson's Anatomy, and Solly on the Brain.

whose thoughts are immutable laws, and on whose magnetic streams fleets of suns and worlds, with their teeming intelligences, are wafted as toys on the ocean's breast.

481. Thus it is our first step, on entering the domain of mind, to describe the mechanism of this wonderful structure which bridges over the chasm between matter and spirit, by which the only access can be obtained to the mysterious causes, the effects of which are manifested as mind or spirit.

The brain is confined in a solid box of bones, cartilage, or other dense substance, the material of which the protective skeleton is formed differing widely in different classes of animals.

482. In the lowest tribes, the ganglia of which it is composed are small, and the vertebræ at the summit of the brain are not enlarged; but as the brain enlarges, the bony envelope must also enlarge, and at length it spreads out until it is difficult to recognize the primitive form of the vertebræ in the plates of bone of which the skull is formed. It may appear irrational that so hard and unyielding a substance as bone can be modified by the plastic and yielding brain; but this proposition is maintained by unanswerable facts. Even in the mature man, after the skull has attained its growth, if the brain changes its form, the skull is obliged to yield to it. The growing brain fashions the vertebræ which enclose it. The skull is composed of these enlarged and greatly modified vertebræ, rounded into its beautiful form by the brain, which it encloses.

483. In an anatomical examination of the brain, this osseous envelope first meets our eye after removing the integument, or scalp. It is composed of two

tables, or plates of bone, between which a cellular framework is placed. In front, over the eyes, these tables spread apart, leaving a large cavity filled with the same. The object of this is to protect the brain from injury, as a blow that would crush the skull if formed of one plate, would only break the outer table, leaving the inner unharmed. The wide separation in front has the same object in view, as the forehead is much more liable to injury than any other portion of the head.

484. In the skull of the embryo, in the cartilage which first envelops the jelly-like brain, opaque points are observed, sending out rays like frostwork on a window pane. This ossification commences near the centre of each of the bones of the skull, and enlarging in all directions, meets along the lines called sutures. The irregular edges, closing together, produce the angular appearance, dovetailing the pieces together. This arrangement is another safe-guard to the enclosed brain, as an injury which cracks only one part of the skull cannot extend farther than one of these sutures.

485. If we now carefully remove the skull, a dense, white, glistening membrane is brought to view enveloping the brain. This is the dura mater. It consists of two layers united by cellular tissue; the external is formed from the internal periosteum of the skull.

486. If the dura mater be now removed, the brain will be brought to view, with its convolutions and hemispheres. The cerebrum is divided, along the median line of the head, into two equal halves, or hemispheres, the office of which is precisely alike. Between these the dura mater throws down a partition, to prevent them from pressing against each other.

487. The brain is covered with a delicate membrane, — pia mater, — which dips between the convolutions, and is designed to give support to the delicate network of vessels which supply the great nervous centre with blood.

These membranes are admirably adapted for the office they are designed to fill. The external layer of the dura forms a dense tissue around the brain; the internal is smoothly polished, to prevent friction. The pia mater, though sufficiently dense to support its blood-vessels, is not sufficiently so to interfere with the pulsations of the brain. It will be seen that the brain, with its investments, does not fill the cavity of the skull, nor does the spinal cord fill the channel of the spine. In old people especially, when the tissues shrink, the bones remaining nearly permanent, a large space is left unoccupied. If this was not obviated by some peculiar contrivance, the brain would be thrown from side to side, and be ever in danger of paralyzing concussions. The dura not only envelops the brain, but is prolonged down the spine, and from its inner surface pours out the cerebro-spinal fluid, like the synovial membrane of the joints, which always keeps the cavity full. If the brain enlarges, a portion of the fluid is absorbed; if it diminishes, a fresh fluid is poured out; so that the pressure is always the same, and the cavity always full. In this fluid the nerves float as a prepared brain floats in a jar of alcohol. They are surrounded by a liquid cushion, which prevents all jars or concussions. The spinal cord, after passing through a perforation in the base of the skull, becomes very much enlarged, from the deposition of cellular neurine, and is called the medulla oblongata.

488. We now come to the brain, resting at the

summit of the nervous system, the great centre in which the ganglia are all represented, which wills and controls the entire body. It is the human brain we are investigating, and are at once impressed by the enormous development of the cerebral ganglia, and the compression and consolidation we observe. The brain is composed of six pair of ganglia, but these are so concentrated within the skull that it is with difficulty that they can be distinguished; and only by tracing them downward, where they separate in the loosely aggregated brain of the lower vertebrata, can their independent existence be clearly proved. As in them we find optic and auditory thalami and olfactory ganglia, in which the nerve-fibres of sight, hearing, and smell terminate in cellular neurine, by which their effects are manifested. Reposing on the medulla is the cerebellum, almost concealed by the backward folding of the cerebrum. It is much smaller in man, proportionally, than in most animals, in which it crowds the cerebrum forwards, being much the largest. When cut in section, it presents the curious appearance called the *arbor vitæ*, representing the branches of a tree, from the peculiar distribution of its nerve-fibres and the cellular neurine, by which the muscles are united and reduced to harmony.

489. Reposing on these, and almost entirely enveloping them, is the cerebrum, the acknowledged organ of thought; and hence the most interesting portion of the system. The brain is not the homogeneous, pulpy mass which it appears to be to the casual observer, but it is the finest organized and most finished structure in the animal organism. The finest machine, the delicate diamond-pivoted watch, is a rude effort to its delicate fibres, some of which do not exceed the

40,000th of an inch in diameter. The course and functions of these is interesting to the student of cerebral anatomy, and prepares the way for subsequent conclusions. There are fibres uniting the opposite sides of the brain. It will be recollected that there are two cerebral organs for each function. As there are two hands, two feet, two lungs, two eyes, &c., so there are two organs in the brain of precisely the same character. On each side of the median line, organs exactly alike are situated, so that there are two brains in the skull, one on each side of this line. But if there was no tie of union between these two portions of brain, diverse manifestations would be produced, and the body would become an awkward instrument. To obviate this, the two are tied together by fibres. In the optic nerves this is accomplished by a crossing of fibres, so that the right optic nerve communicates with the left side of the brain, and the left optic with the right. But in the cerebrum, fibres from the exterior of every portion of one hemisphere cross in the corpus callosum, and terminate in every portion of the other hemisphere, beginning and ending in the cellular neurine which coats their exteriors. By this arrangement the brain becomes unitized, and impressions made on one region are immediately transmitted to every other. Another set of fibres collect from every portion of the cerebrum, and terminate in every portion of the cerebellum, by which their action is unitized.

490. From every portion of the cerebrum go out the fibres of volition, and after visiting the minutest fibrillæ of the body, return along the pathway of their going out as fibres of sensation, terminating in the same place where they began.

491. If the cerebellum exercises such an important

function on the muscles, it must be closely connected with them; and we find that from its entire surface fibres collect, pass down the spine, and after visiting every part of the organism, return, terminating in the same locality from whence they set out.

492. This will be better understood by reference to the engraving, which is an ideal representation of the manner in which the fibres are distributed. It represents a section of one hemisphere. *g* represents the corpus callosum; *c c*, the fibres uniting the cerebrum and cerebellum; *a*, the fibres of volition, returning on the anterior of the spinal cord, as nerves of sensation; *d*, the volitional, or motor nerves of the cerebellum; U, its excitor, or sensational fibres. The lines X X illustrate the manner in which all the fibres radiate to the surface of the hemispheres; V V cellular neurine, by which the fibres receive their nervous power.

Ideal Section of the Brain.

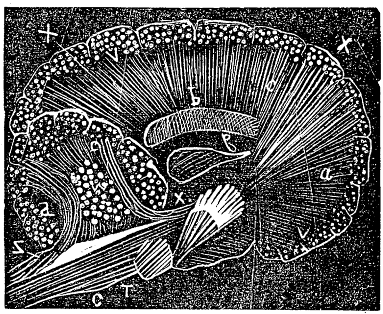

Fig. 18.

493. When the fibres which pass down into the spinal cord are traced out, it is found that this unitizing is still further increased by a crossing of all the fibres from one side over to the opposite side of the cord, as is proved by injuries on one side of the brain affecting the opposite side of the body, instead of the same side, as it must necessarily, if there was no intersection of the nerves.

A similar union exists between the ganglia of the spine. They are arranged in pairs, and might act independently of each other, unless brought into constant sympathy. (See Fig. 19.) M O shows the manner in which they are united by crossing fibres.

494. By what a perfect system is every portion of the body brought and kept in sympathy! Not the minutest cell secreting bile or mucus, not a fibrilla of muscle, not a gland, but is visited, and has open communication with the great central office. Its wants are all sent directly and instantaneously there, and the supplies are forwarded. The least disturbance in one portion of the organism is felt by the whole frame, and any cause prostrating one organ pulls the others after it. Physicists speak of the influence the blow of a hammer would produce on the earth, repeating itself on the space-ether until it vibrated on the remotest star in space: more perfect is the sympathy which exists in the vital organism. The beatings of the heart are reciprocated by the brain, and it pulsates in measured time with the former. If the heart cease its labor for a moment, the blood stops circulating through its channels, and the brain no longer performs its function; its adjustments are useless, its machinery stops, it dies. If the liver purifies not the blood, the base of the brain becomes inflamed, and animal ferocity and brutality are manifested. So of other functions; all are represented in the brain, which is first to speak of impurities in the circulating fluid. How soon do the lungs reciprocate the affection of the liver, and how completely does a disease of the stomach prostrate the entire system! The stomach is the laborer, preparing food for all the other organs; and if its work is not well done, they feel its neglect. The brain receives one

fifth of the entire circulating fluid, and in consequence is first to be influenced by its qualities. The thoughts and emotions it manifests have an intimate relation to the quantity and quality of the blood, and these depend on the food.

495. Having briefly described the prominent features in the structure of brain and nerves, we now turn to the functions they perform in the animal economy, and to the manner in which they produce their peculiar phenomena.

496. Physiologists have endeavored by various methods to arrive at the true functions of the nerves and brain, and have usually studied the subject in the same manner that they would the office of any other physical organ. The old method of vivisection has been discarded as cruel, and leading to unimportant results; yet, so far as it can be applied, it has contributed very much to the positive knowledge of the cerebral functions. The study of their comparative development in the lower animals has contributed largely to our stock of knowledge, and is one of the prominent methods in use at present. In connection with pathological facts, comparative anatomy is the main source of external research.

The impressibility of the mind — a recent discovery, and still more recently applied — would seem, by the vast amount of light it has in so short a period poured on the mysteries of mental science, to be the key by which its most secret chambers can be unfolded. While the other methods are mere external in their observations, this enters the innermost recesses of the soul, and reveals the wonderful operations which go on within the congeries of the nerves unseen, and unknown by the external observer.

497. The spinal cord of man is composed of a series of ganglia homologous and perfectly analogous to the spinal cord of insects.

The number of ganglia determines the number of vertebræ, being thirty-two in man. Each ganglion has its particular function to perform, and it never departs from the office assigned it. The auditory, olfactory, optic, and phrenic ganglia give rise to the auditory, olfactory, optic, and phrenic nerves, which convey to them respectively the sensations of hearing, smell, sight; and from the phrenic the impulse is constantly conveyed to the diaphragm, which keeps it in perpetual motion, causing respiration. The functions of each are determinate, and never change.

498. It will be inferred that as there are thirty-two vertebræ, there are thirty-two ganglia, and the same number of pairs of nerves. These nerves are wholly composed of continuous fibres, and, in their minutest capillary ramifications, are composed of four distinct sets of fibres, designed for appropriate offices. This is true of every nerve thrown off from a ganglionic centre, although the relative number of fibres in these four classes greatly vary in different nerves, as in the nerves which go to the internal viscera, send few fibres to the cerebrum, while the optic nerve sends a very great number. In the one case the object is to convey the impression of external objects to the whole mind at once, in the other to supply, simply, nervous force; and as this can be done without the aid of the cerebrum, few fibres are sent by the visceral nerves to it, and hence we feel not the disturbances which may exist in the internal organs as acutely as we otherwise should — a circumstance extremely benevolent in its effects, as it contributes largely to human happiness

The nerves are divided into four sets; the excito-motors and the sensatory and volitional.

499. The excito-motor system is that of insects, and the others are added in proportion as we ascend the scale — the volitionary preponderating in man. When the junction of a nerve with the spinal cord is examined, this system becomes plainly perceptible and distinct from the others. The annexed figure represents a longitudinal section of a spinal ganglion, the fibres extremely magnified. L represents the motor nerves; the lighter lines, the nerves which convey the impressions from the appropriate organs to the

Ideal Section of a Vertebral Ganglion.

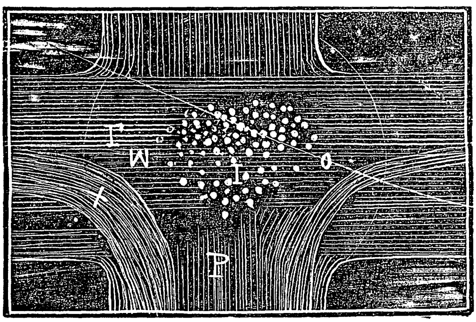

Fig. 19.

ganglion; the darker lines are the nerves which convey motion in obedience to the dictates of the received impression. O represents nerve fibres connecting opposite organs, passing through the ganglion. The fibres represented by X X go to the brain, and come in contact with every portion of its surface, both of the cerebrum and cerebellum, and return in parallel courses to the points from whence they originate.

500. The excito-motor system is not necessarily

connected with consciousness; on the contrary its functions terminate with automatic actions. Where it exists alone, and there is no concentrated cerebral mass, though the animal may manifest motion governed, apparently, by will, yet its motions are not conscious or volitional, more than those of the sensitive plant. As we ascend the scale, a greater number of fibres are sent to the cerebral mass, which augments in size, and the two systems become blended. Even in man they can be separated, and his instructive actions referred to those nerves which manifest them in the insect.

501. The spinal cord, medulla oblongata, and sensory ganglia represent the nervous system of insects and fishes. From these all nervous power is derived, and the influence of the cerebrum over the organic functions is extremely limited, if it may be said to have any influence at all. Impressions conveyed to appropriate ganglia are reflected by the motor nerves, independent of volition. That this theory is correct is supported by the strongest facts of physiology. It is certain that all the functions of life can be carried on independently of the cerebrum or cerebellum. Infants have been born destitute of these, yet lived apparently healthy for a considerable time.

Animals and birds have been known to live for months after the removal of both the cerebrum and cerebellum. The amphioxus has scarcely a vestige of either, yet manifests the instincts necessary for its existence.

502. A mammal will live for a considerable length of time after its nervous system has been reduced to the condition of that of the mollusk, by dissecting away all except the medulla, and cutting off the cord

below the respiratory ganglia. If the cord is cut above this ganglia, respiration ceases, and of course death results.

503. When the cerebrum and cerebellum are removed from the living animal, all consciousness, sensation, and will must cease, and whatever movements the animal may exhibit cannot be referred to them.

504. These movements are never spontaneous, but are always excited by an irritant. Even the respiratory movement is excited by the presence of venous blood in the lungs. It is thus certain that the nervous power which controls the involuntary motions does not reside either in the cerebellum or cerebrum, but in some portion of the cord; that the impression conveyed by an excitor nerve goes no farther than its ganglion, and is from thence reflected through the required motor fibres to the muscles, causing them to contract, independent of the will.

505. When the spinal cord is severed into several pieces, similar movements occur. If the spine of the frog be cut in the middle and behind the head, its limbs become completely paralyzed to the will, yet they move if touched, and with almost intelligent actions avoid a heated body; but its four limbs do not act in concert, as they do when the intervening spinal cord is not severed.

The spinal axis is nearly the whole nervous system of insects, and experiments in this direction succeed in a remarkable manner with them. When the mantis religinosa, or walking-stick, is approached, it assumes a defiant posture, elevating its head and the front portion of its body, and raising its long, sharp claws. If while in this position it be suddenly cut in two immediately in front of its middle pair of legs, the posterior portion will remain balanced as before, resisting every effort to overthrow it, and regaining its position when overthrown, and when irritated running from the irritating body, moving its wings in the same manner that the unmutilated insect previously had done. These movements are independent of volition, as the volitional ganglia have been severed. Still further in illustration, if the head be severed from the previously severed thorax, the ganglia which this section of the body contain will set in motion the long arms, and fix their claws in the finger that disturbs them.

506. If the head of the centipede be suddenly cut off, when the insect is in motion, it will continue to move; or if cut into several pieces, each piece will continue to move, for each piece has a motor nervous centre. If any pair of its limbs are selected, and their nervous centre dissected out, then all the others continue to move, but they remain paralyzed. There is no consciousness in these movements, for when it reaches an impassable obstacle, it turns neither to the right nor the left, but the stump is forced against the object, the limbs continuing to move.

507. The same phenomenon is seen in reptiles. If the head of the turtle is cut off, of course the movements of its body cannot be referred to volition; yet it loses not its power of motion or of avoiding obstacles. If its limbs are touched, they withdraw; if molested, it runs away; if a burning body is brought near it, it turns aside. These movements are the result of the excito-motor system, independent of the will.

508. By this system, the lower animals become almost automatons, and it is as easy to account for the nervous influence as for the circulation of the blood. Even in man it exists in his involuntary

movements. This peculiarity in the structure of the articulata guides them to the attainment of certain determinate ends. In the most remarkable families, a mixture of the automatic and intellectual is observable. The bees, wasps, &c., are the most instructive of the articulata; yet in them there is a fixed regularity in the actions of all individuals, and they never depart from narrow limits. These insects have a great concentration of ganglia in their heads, and there is evidence of the presence of a cerebrum, by which manifestations not strictly automatic are produced. They can adapt themselves to different circumstances; they do not build an hexagonal cell over the worm which has stolen into their hive; the form and position of the comb they adapt to the cavity in which it is built. The certainty of their actions depends on the uniformity of their organization, making them all to will alike, as well as to produce automatic impulses. Bees have a memory, as they have been known to return in the spring to places where they obtained honey in the fall. That species of wasp which feeds its young on spiders, when it catches a spider too large for it to carry, will bite off its limbs one by one, until it is able to rise with it. This wasp makes a cell of mud, in which it deposits a spider and an egg. If, on trial, the spider is too large to be forced into the small orifice, the wasp reduces it in size, by biting off its superfluous portions, till it can enter. Such instances might be multiplied to volumes; but this represents the class, and is sufficient to prove the existence of a high order of conscious faculties.

509. Such are the facts from which the reflex action of the spinal cord is inferred; and it becomes a fact in science that the entire motions of the lower

animals, and the involuntary in man, originate independently of the will, in the spinal ganglia, by impressions conveyed by one set of fibres reflected to appropriate muscles by another set — the excito-motor system.

510. The medulla oblongata is simply the cranial prolongation of the cord, and contains the ganglia in which the respiratory and stomato-gastric nerves terminate. The act of swallowing and that of respiration are consequently purely automatic. Mastication and the prehension of food by the lips, though partially controlled by the will in adults, in infants are purely automatic. There is a class of secondary automatic motions, which at first appear to be controlled by the will, but are at length performed without its agency; as the musician can play a familiar air while engaged in conversation; and we often walk a long distance on a familiar road without bestowing a single thought on the movements of our limbs. The will at first induces the movement in the motor nerves, and does so until there becomes such an intimate relation between the impulse of the will and the object on which the motors are exerted, that they continue to act under the stimulus of the object alone after the will is withdrawn. This has been a vexed question to the metaphysician; but when he leaves the dusty path of his wonted verbiage, the solution is readily effected.

511. The enormous development of the cerebrum in man endows him with intellect; yet it is remarkable how many of his actions are automatic, or instinctive. While many of the lower animals have astonishing intelligence, and even moral and sympathetic natures, in constructing their habitations, in the care of their young, and treatment of their companions, man par-

takes largely of their instinctive faculties. What he gains in volitional or mental power, he loses in instinctive.

512. It is not necessary that the will understand the structure of the organs on which it operates, but it requires practice to harmonize the muscles and the will, as the child only gains control over its limbs by long practice; and equally arduous is the penman's task to gain the necessary control over the muscles of the hand, and the musician to govern his vocal organs. Thus is the distinction drawn between it and instinct, one being referable to the spinal axis, the other to the brain.

513. The office of the brain can be studied by the light of comparative anatomy. The first observation which we make in regard to the cerebellum, when we glance over the dissected brain of the vertebrata, is, that it is small in animals of weak muscular power, while it is large in those frequently called on to display great and energetic movements. While the motor system gives force to the muscles, an organ is necessary to systematize their actions and regulate their movements in accordance with one design. Gregarious fishes, and other aquatic animals with small muscular power, immersed as they always are in a dense fluid, have a small cerebellum; while in the fierce shark, capable of rapid motion, and endowed with prodigious muscular power, and birds of strong wing and remarkable balancing powers, as the eagle and birds of prey, it is large. It is large in the monkey, larger in the ape, still larger in the orang, and largest in man, who, by his upright position, brings in requisition the greatest amount of muscular action, and who, by cultivation, performs the most complicated and various movements.

514. That such is its function is proved by dissecting it out from the brain of the living animal. When this is done, they lose not the power of motion, but the power of combining the several muscles is totally lost, and the animal is unable to stand, or move its feet, harmoniously. The power to move them by the will is unimpaired, and only the unitizing influence lost. It is not the severity of the operation which produces this effect, for the cerebrum can be removed without any such result. The cerebellum is also closely connected with the passions, imparting strength and energy to their manifestations.

515. It has been previously remarked that on dissecting away the cerebrum from the brain of the living animal, it immediately lost all consciousness, perception, and will. This fact plainly indicates the office of that portion of the brain — that it originates will and all the mental manifestations. It is very small in unintelligent animals and in idiots, and larger in proportion to the intelligence displayed, its size, if of the same quality or fineness holding an exact proportion to the degree of intelligence.

516. The spinal axis has been shown to be the seat of involuntary motion; the office of the cerebellum to be the unitizing of muscular action, and to give energy to the passions; while the cerebrum is the organ of thought, of volition, and spiritual energy. Previous to the time of Gall, although this function was assigned to it, yet it was regarded as a single organ; but instead of analyzing it in a positive manner, the field was deserted by all, save the metaphysician, who, fully persuaded that words were adequate to the solution of mystery, heaped up great volumes of verbiage, till lost in his own wanderings.

Nature is our guide, and positive science will only satisfy the questioning mind. Mind is never brought to view by the scalpel of the demonstrator. The cerebrum presents to him but an inert mass of fibres and cells. Even the microscope detects not the difference between the fibres of different organs. But if different regions of the cerebrum perform different functions, we know there must be a difference between their component fibres, or their manifestation would be the same.

517. The manifestations of mind are divisible into determinate classes. The emotions are distinct from the intellect; the passions from morality. It would be extremely unphilosophical to refer these diverse manifestations to the same organ, if that organ be regarded as a whole; but if they are referred to the activity of different regions, appropriated to their production, then mental science becomes reduced to the greatest simplicity. Mind is divided into five classes—passions, perception, will, intellect, and morality. Each of these must have its own region of brain, by which it is manifested. Starting with this proposition, comparative anatomy lends important aid in ascertaining the locality of these regions. Animals with a large development along the base of the cerebrum possess fierce, reckless passions, sexual impulses, and love of offspring, and are deficient in docility, intelligence, and all the higher qualities. If, while only the base of the cerebrum is developed, such propensities are displayed, then it is a legitimate deduction, that the base of the brain is devoted to the passions. This is the predominant portion in all animals, and of many races of men. A thick neck indicates a large development of the base of the brain, and is proverbial for

great strength of the animal passions. The lion and tiger are broad across the base of the skull, and how truly does the fact speak their fierce dispositions! The passions *should* be thus situated. There they quickly feel the stimulus and wants of the body. They can satisfy corporeal wants and become to the intellect what fire is to the furnace and steam to the engine. They connect intellect with the body.

518. Animals with a large development of the frontal portion of the base of the brain have an intuitive perception of natural phenomena. This space, then, is devoted to the perceptions. If a line be drawn from the upper portion of the ear backward, with a slight elevation, it will form the upper boundary of the region of the passions. If this line is continued forward to the centre of the forehead, all that portion lying beneath it, in front of the extreme angle of the eyebrows, is the organ of the perceptions, devoted to the observation of transpiring phenomena.

519. Most animals manifest another class of faculties. The peacock is proud, the ass is stubborn, the horse and dog show a remarkable friendship to their masters; nearly all have a love of power, and desire for mastery, and energy of character. This group may be called the will, and it is located on the posterior coronal region of the brain. If a line be drawn perpendicularly upward from the cavity of the ear, the space included behind and between it and the previous line is the region of the will.

520. In animals the frontal portion of the cerebrum is extremely low, and never overhangs the eyes; but in man it juts far over the eyes, and rises up square and broad, and with its growth in this direction, and in exact proportion with it, is the manifested intelligence.

A high, broad, jutting forehead, is proverbial of wisdom. Men in all ages have ascribed such heads to their gods, their heroes, and their sages. This, then, is the region of intellect.

521. The enormous growth of man's cerebrum carries him far beyond the animal in mental development. Not only is the coronal and frontal portion enlarged, but between and reposing on these lies an entirely new growth, or at least its convolutions are not perceptible in the animal. With it there is a manifestation of a moral nature, which is displayed in exact proportion to its size. This, then, is the moral region, removed farthest from the influence of the body, and connecting it with spirit. There enthroned, it acts the sovereign over the propensities with love and kindness, and smiles at the approach of death, which lifts the curtain that conceals from mortal vision the ennobling futurity which awaits the immortal spirit.

CHAPTER XX

THE SOURCE OF THOUGHT STUDIED FROM A PHILOSOPHICAL STAND-POINT.

522. To the cerebrum, nerve fibres from every portion of the body concentrate. The nerves of sensation from the fine capillary ramifications in the heart of organs, and over the surface of the viscera and skin, send up their fibres to transmit intelligence with the central office, and, side by side returning in an opposite

direction, send out the nerves of volition, along which circulate the messages to appropriate muscles to contract or expand, according to the nature of the information received. The nerve fibres are hollow tubes, and from the point of their origin to their termination they are continuous throughout, never uniting with other fibres, so that the minutest capillary is in direct connection with the brain, forming a continuous tube. In the minute division of their extremities, the capillaries of volition unite with those of sensation, and form a circuit from and to the brain. In a similar manner are the excito-motor fibres related with each other; but the circuit formed by them terminates in a spinal ganglion. If a motor fibre be traced from its termination to its source, it will be found to end in a ganglion, while a volitional fibre can be traced directly to the brain.

523. Throughout their whole extent the smooth and parallel fibres remain identically the same. They cannot generate nervous influence; their office is simply to transmit the generated power. This is proved by severing a nerve. When the nerve of a limb is severed, all volition and sensation is lost, and even the galvanic efforts of the excito-motors are stopped, as the nerve no longer communicates with a ganglion. Sensation and volition, then, do not reside in the nerves themselves, but at their origins, whether brain or ganglion. This is the first step towards the determination of their nature and functions. We have now, by the simple process of intersecting a nerve, proved that the nervous influence is confined to the ganglionic centres. These are composed of the terminating nerve fibres, and of a gray, nervous matter, differing entirely from the nerve material. This gray neurine is only found

at the surface of the cerebrum, where the fibres terminate, spreading around their extremities. To one or the other must be assigned the source of nervous influence; and physiologists, by the most careful and close observation, have assigned this function to the gray neurine, while the fibres are simply conductors. The next question asked is, How is the nervous power generated? Physiology is silent; it records the facts, and asks the first question — From whence is it derived? But how, it knows not. Anatomy throws a feeble light on this important question.

524. The professor, over the dead brain, dissects fibre from fibre, and gives each a high-sounding name; but his real knowledge goes no farther than this exercise of his memory, and the mere externals of mechanics. The life which vivified the organ has gone; all its pulsating centres are still; the blood is stagnant in its vessels; it throbs not, it thinks not, nor gives a clew to the process by which, in the flush of life, it manifested divine thought or the gush of emotions. But thought has been produced by that brain, and brains just like it are producing thought. How? Look at the gray neurine which coats the surface of the cerebrum. It is entirely made up of cells, globular bodies, filled with a peculiar limpid fluid. On the exterior surface they appear recently formed or immature; but as they approach the extremities of the fibres, they become matured and disappear. What is their office? They are certainly not useless, nor are their continual growth and decay unattended by useful results.

525. The brain receives one fifth of the entire amount of blood in the system. It flows into it as pure arterial blood, and comes away loaded with refuse matter — a dark, sluggish, venous fluid. It has been at work,

and has produced great changes in that organ. We find that it has principally circulated through the gray neurine, which, from the innumerable capillaries which circulate through it, is a complete mesh of blood vessels. There, then, has it performed its mission, whatever it may be. As the amount of blood an organ receives is in proportion to the exercise to which it is subjected, and as the fibres of the nerves only transmit nervous influence, it would not be expected that they would require any great amount of blood, but in that region where the power is generated a great quantity would be required.

526. The fact that the cells of which the gray neurine is composed are immature on the external surface, shows that there they are formed, while their maturity, as they approach the extremities of the fibres, shows that they are forced inward by the birth of new cells on the outside. Their formation uses up the great quantity of blood thrown to the brain, but the brain becomes no larger by their constant production, and the amount of gray neurine remains the same. We must conclude, then, that the cells must be used up in the process by which thought is manifested. They are crowded inward, and when brought in contact with the conducting fibres they disappear. The cells thus formed by the secreting organs dissolve when they have performed their mission, and so do these gray cells. Do they pour their contents back into the blood? No; for that could subserve no possible purpose; then they must pour it into the nerve tubes, or fibres, as they furnish the only possible means of absorption.

527. This process will be better understood by referring to the engraving, where V represents the gray neurine. A cell forms at the surface, and is crowded

inwards, until it reaches the extremities of the fibres V, into which it pours its contents.

528. The analogy between the brain and the secreting organs is remarkable, and has been frequently mentioned. In fact its office includes that of secretion, and hence the analogy.

529. Nervous matter contains a greater quantity of phosphorus than any other tissue in the body, if the bones are excepted. That intense thought necessitates the waste of nerve tissue is proved by the remarkable increase of phosphorus in the secretions of the kidneys after intense thought. That waste is not of the fibrous substance, but necessarily of the gray neurine. To manifest thought, the cells pour their contents into the tubular fibres; and this fluid, after performing its mission, must enter the blood, and affect its properties, before secreted by the kidneys as waste and effete matter.

530. We here have a reason for the greater flow of blood to the brain while intensely thinking. As every thought necessitates a waste of cells, a greater quantity of blood must circulate to repair the damage. The activity of one organ, or part of the system, predisposes a greater flow of blood to itself from the same cause. So fast as the cells are used up, so fast must their place be supplied; and if the mind is constantly excited, the circulating vessels enlarge, and the brain itself increases in size.

531. Again, why can we not constantly think in one channel? The mind tires; there are bounds which it cannot pass, and if driven beyond that point, it falls prostrated, and a complete lassitude ensues. Why is this? The present theory beautifully explains this fact. A peculiar train of thought calls into activity

certain regions of the brain. The intensity of thought determines the rapidity of the destruction of the cellular neurine. This predisposes the flow of blood to those regions: soon they become inflamed; they cannot answer the demand; and then the mind in that direction is prostrated; while in other channels, where new regions of brain are brought into action, it may be perfectly healthy and strong.

532. The cerebellum cannot exercise its functions of unitizing the actions of the muscles without means whereby to create the nervous influence it employs; hence it has its own mass of cellular neurine by which its office is fulfilled.

533. The ganglia, to which the thirty-two pair of nerves centre, if they administer to the involuntary muscles to create action independently of the brain, if the theory here advanced be true, must have a mass of cellular neurine by which their functions are performed; and we find that the various enlargements of the spinal axis are not produced by the addition of new fibres, but by the interposition of cellular matter.

534. Wherever the cellular neurine is formed, we observe the accompanying nervous action; and all the recorded facts are in harmony with the proposition that the nervous power resides in the cellular neurine. That the manifestation of nervous power depends on the destruction of these cells, is shown by the increase of phosphorus in the blood after mental exertion. The only channel for it to escape is through the tubular fibres. Observe the harmony. These tubes originate in this neurine, and go out into every portion of the body as nerves of volition; returning, they come back as nerves of sensation, terminating in the same

place where they originated. Around their extremities lies the source of their power, the cellular matter. Impressions acting on the surface of the body are transmitted to it by appropriate fibres, and there produce sensation, causing the destruction of cellular material in transmitting the return message.

535. The influence of the nerves is widely felt in the secreting and elaborating processes of the body. Every movement in the organism is ultimately referable to them. The secreting organs are largely supplied with nerves, and the nature of their secretion on them entirely depends. Thus, if the mind is agitated with intense grief or anger, the lacteal and salivary secretions become bitter and poisonous, showing that the nature of the secretion depends on the kind of influence conveyed by the nerves. Whether that influence is exerted to keep the diaphragm in perpetual activity, to secrete bile in the liver, gastric fluid in the stomach, milk in the breasts, the law remains the same. It is worthy of remark that all these and similar processes go on independently of the will, and are as well executed after its paralysis as before, because their functions depend on the spinal axis. The nerves which go out to perform all these functions, originate in ganglia of their own, from which they receive the stimulus appropriate to their functions.

536. It is evident that the nervous influence employs some form of electricity to contract and expand the muscles. A muscle at rest is in an entirely negative state, but one in motion is positive. The expanded muscle is positive to the relaxed muscle. From such facts it is apparent that by inducing positive and negative relations in the muscles, the brain controls the body.

537. We would not be understood as maintaining that mind is originated by and dependent on the body; but that its manifestation is thus produced, is an undeniable fact. The condition of the physical frame determines the kind and degree of thought that is manifested. The greatest thinker of the age, by one hour's attack of disease, often loses all his mental powers, and when old age steals on him, he becomes a second child, as prattling and foolish as he was at first. Reason wanes with the decay of the body, and when the latter dies, with a few faint flickerings, like a lamp without oil, seems to expire with it. We are simply endeavoring to show the method by which mind exerts its influence on the nerves, and by the nerves on the body. The method is one of the most simple in man's physical economy. The cells of the vascular neurine are the agents it employs, while the fibres are the channels through which it transmits its messages, and is made cognizant of external impressions.

CHAPTER XXI.

RETROSPECT OF THE THEORY OF DEVELOPMENT, AS HEREIN ADVANCED.—CONCLUSIONS.—FACTS FOLLOWED FROM THEIR SOURCE TO THEIR LEGITIMATE RESULTS.

538. MATTER is eternal. Its existence depends on fixed and determinate attributes. It has weight, form, extension, divisibility; and without these it could not exist. On these the universe rests, so that the principles of nature can be philosophically referred to the constitution of matter itself.

539. If chaotic matter is left free to obey these inherent principles, it will evolve the order of creation we behold around us. So long as matter has its present attributes, it will act as it has done, and produce the effects we now see it produce.

540. The attributes on which its existence depends are fully sufficient to account for every effect, either in the external world or the world of mind.

They exhibit life, and there are human beings.

They exhibit intelligence, and there are intelligent beings.

When we have a sufficient cause, shall we seek for a higher one, and thus render philosophy as cumbersome as the crystalline spheres of Ptolemy? But here is the objection: this view sweeps away the existence of God. Yes, it sweeps away Brahma, Buddha, Jupiter, and Jehovah; but it leaves the great principles of intelligence and love, on which these were all founded. It sweeps away all the gods of mythology and conjecture, and reveals the Great Unknown enthroned in the universe! It makes the unknown God known to his creatures, and proves every part of nature pervaded by the Omnipotent Presence. He works not by miracle, but by law. His will is the principles of matter; and in infinite intelligence he always wills aright. He is a progressive being; is one with nature, and the existence of the two depend on each other.

541. The external world is nature, the internal is God. The two make a perfect unity of materials and principles.

542. But this is not the God of theology. Granted; but it is the God of nature. It is not a Unitarian God, or a Trinitarian God, but the laws and principles of nature personified.

543. All the mythological conceptions of Deity are vague and dim shadowings of these great principles, which become personified in the human mind from its difficulty of grasping abstract principles.

544. The universe was not created as man constructs a house. There is adaptation of cause and effect; for matter, having determinate attributes, moves in fixed channels, and seeks an equilibrium, and that equilibrium is obtained when the elements sustain a certain relation to each other. That relation we call cause and effect; and it is the intelligence which shadows forth in the mind of man the necessity for the existence of a Supreme Being.

545. But these attributes cannot be passed by, as they furnish a sufficient cause for all the phenomena of nature. They must be God, or the will of God.

It has been proved, or rather it is self-evident, that matter is eternal. This is an admitted proposition. Its existence depends on its inherent properties. But if these properties exist by the will of God, then there could not have been any matter previous to the time he willed these into existence, and he must have created matter — an inference which cannot be supported, as it presupposes the self-existence of a being so vastly transcending matter that he can speak it into existence; whereas it is far more reasonable to suppose the eternity of matter.

546. These properties of matter act in determinate channels. If they are the will of God, he is bound and circumscribed by them, and cannot will otherwise than as they dictate. He can will what he pleases, but he must will in accordance with these principles, because these principles are perfect. If he could be supposed to will a world to be oblong or square,

gravity, one of his own principles, would pay no heed to it, but would round it just as it would a dew-drop. We cannot suppose God to annul, alter, or destroy his own perfect attributes.

God is thus shadowed forth in nature. His highest personification on earth is the human spirit.

547. The beginning was a chaos. Perhaps universe after universe had matured and passed away; nature had toiled on in perpetual and untiring activity, long before the last great revolution of all systems had returned back again to chaos. However that may be, we find at the beginning of the present order a chaotic, gaseous ocean filling the immensity of space. In that ocean, matter, true to its instincts and its innate principles, rounds itself into suns, sending off rotating worlds, all balanced in perfect equilibrium; for the contending elements battled until the equilibrium was gained, or until all the causes and effects in creation balanced each other. This stupendous result was accomplished by the same law that rounds the dew-drop, and makes the stone fall to the earth.

548. When the earth became prepared, by the formation of a crust and the condensation of water, for the reception of life, it came.

549. Life is a principle of matter. Living beings are the individualization of that life. Deep down in the transition rocks we found the primordial cellular forms, and observed the dawn of an infinite progress. Its individualization was the result of conditions such as are now occurring in the depths of the sea, producing the lowest forms of life; so that should the world be divested of life, it could begin a new series of advancement, differing only from that recorded in the rocks by the superiority of the present conditions of the earth to those of the original chaos.

550. Life began as a simple cell. This is proved by the convergence of all living forms at that point, by embryonic growth, and its history as revealed by the strata beneath our feet.

551. The intelligence manifested by living beings is the individualization of the intelligence of nature.

552. Thus originating, living forms progressed through the vast epochs recorded by geology, each era surrounding it by better conditions.

553. The individualization of life depends on conditions, and it adapts itself to them, is formed by and maintained by their influence.

554. Hence, as each age became more perfect, physically, life moved onward in the same ratio.

555. When the earth became sufficiently perfected, man came. At first not superior to the orang. Then he became a savage, then half civilized. His intellect was but developed instinct; his desires and aspirations, at first, scarcely above the animal. He was, however, subject to the mighty law of progress, which impelled him onward. The savage became civilized, the civilized man enlightened.

556. The latent germ of a spiritual nature in the animal, in man became awakened, and developed a spiritual life, glorious and immortal.

557. This is a brief view of the theory advanced and endeavored to be supported in the preceding pages. It proves nature to be an harmonious whole, without jar or contention, and leaving the external world, it carries the same principles into the domain of mind, and shows that as fixed and determinate laws rule its erratic manifestations as in the physical nature.

The universe is bound together with the same sympathetic relations as the human body. Not an atom moves, but it affects the farthest star. Not a breeze blows, not a wave beats on the shore, but it affects all the worlds of space.

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558. We have now drawn to its close the imperfect outline of the plan of creation, which we proposed for the first volume. The grand forces which we have discussed have had an ultimate end to accomplish. Through ill defined and through devious paths we have endeavored to trace their progress, in the mighty flow of matter upwards towards its ultimate. That ultimate — the sublime aim and end of all the restless activity of nature — we have found to be man. For him the inferior world exists, and by it he was created. With the *material* relations of his mind, its dependence on the highest form of physical organization, brain, the plan of this volume closes; but a vast field yet remains to be explored. It is a field yet unknown, and positive science has failed to grasp its facts and phenomena. The incomprehensible spirit realm, shrouded in mystery and fable, comprising the major portion of nature, invites our attention. Having constructed a firm basis in the physical world, we shall endeavor to extend the same course of positive reasoning into that higher world which is but its reflection and ultimation. The origin, method of existence, and laws of spirit and the spirit world, will be the important themes the second volume will discuss, showing crude matter's progress to perfection in the infinite spheres of spirit progress.

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