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ARTICLE IV.

RECENT WORKS BEARING ON THE RELATION OF SCIENCE TO RELIGION.

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NO. II. — THE DIVINE METHOD OF PRODUCING LIVING SPECIES.

IN preparing our remarks on the subject named above, we have consulted the following works. We specify the editions to which we have particularly referred. We do not pretend that we include in our list all the works which have been published on the subject, but mention those only which we have examined.

Agassiz. 1. Principles of Zoölogy; touching the Structure, Development, Distribution, and Natural Arrangement of the Races of Animals, Living and Extinct. By Louis Agassiz and A. A. Gould. Revised edition. pp. 248. Boston. 1855.

2. Contributions to the Natural History of the United States of America [Essay on Classification]. Vol. i. pp. 232. Boston. 1857. Reviewed by Dana in American Journal of Science for March 1858. pp. 202–216; April, pp. 321–341.

3. Methods of Study in Natural History. pp. 318. Boston. 1871.

Argyll. 1. The Reign of Law. By the Duke of Argyll. First American from fifth London edition. pp. 462, xxvii. New York. 1868.

2. Primeval Man. An Examination of some Recent Speculations. pp. 200. New York. 1869.

3. Article in Contemporary Review, Vol. xxvi. pp. 352–376.

Chadbourne. Final Cause of Varieties. By P. A. Chadbourne, Professor in [now President] Williams College. Bib. Sac., Vol. xxi. pp. 348–362.

Chapman. Evolution of Life. Philadelphia. 1873.

Cope. Transactions of the American Philosophical Society, Vol. xiii. (1869). The Hypothesis of Evolution in Lippincott's Magazine. See also University Series, No. 4.

Dana. 1. Manual of Geology: Treating of the Principles of the Science; with special reference to American Geological History. By James D. Dana. Silliman Professor of Geology and Mineralogy in Yale College. 2d ed. pp. 828. New York. 1875.

2. Articles in Bibliotheca Sacra, Vol. xiii. pp. 80, 631; Vol. xiv. pp. 388, 461, 854. New Englander, Vol. xxii. pp. 283, 495. American Journal of Science for March 1858, pp. 202–216; April, pp. 321–341.

Darwin. On the Origin of Species by Means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life. By Charles Darwin, M.A., F.R.S., etc. 6th ed. pp. xxi, 458. London. 1873.

2. The Variation of Animals and Plants under Domestication. 2 Vols. pp. 494, 568. New York: Orange Judd and Co.

3. The Descent of Man, and Selection in Relation to Sex. New edition, revised and augmented. Complete in one volume. pp. 688. New York. 1875.

4. The Expressions of the Emotions in Man and Animals. pp. 374. London. 1872.

Dawson. 1. The Story of the Earth and Man. By J. W. Dawson, LL.D. pp. 498. New York. 1874.

2. Nature and the Bible. pp. 257. New York. 1875.

Foster, Rev. Randolph S., D.D.,LL.D., President of the Drew Theological Seminary, Madison, N. J. The Ingham Lectures. pp. 1–106. Cleveland, O. 1873.

Gray. 1. Natural Selection not inconsistent with Natural Theology. A Free Examination of Darwin's Treatise on the Origin of Species, and of its American Reviewers. By Asa Gray, M.D., Fisher Professor of Natural History in Harvard University. Reprinted from the Atlantic Monthly for July, August, and October, 1860. pp. 55. London. 1861.

2. Articles in the American Journal of Science and Arts for March 1860, pp. 153–184; Sept. 1860, pp. 226–239.

3. Articles in The Nation (New York), Vol. xviii. pp. 44–46 and 348–351.

4. An Address of Professor Asa Gray, President of the American Association for the Advancement of Science, Delivered at the Meeting held at Dubuque, Iowa, Aug. 1872.

5. Memoirs of American Academy of Arts and Sciences. Vol. vi. pp. 377–452. Boston. 1859.

Haeckel. 1. Generelle Morphologie der Organismen. Allgemeine Grundzüge der organischen Formen-Wissenschaft, mechanisch begründet durch die von Charles Darwin, reformirte Descendenz-Theorie, von Dr. Ernst Haeckel, Professor an der Universität Jena. Tzwei Bände, pp. 574, 462. Berlin. 1866.

2. Natürliche Schöpfungsgeschichte, etc. pp. 568. Berlin. 1868. A translation of this work has been published in two volumes by Appleton and Co.

Henslow. The Theory of Evolution of Living Things, and the Application of the Principles of Evolution to Religion, considered as Illustrative of the Wisdom and Beneficence of the Almighty. By the Rev. George Henslow, M.A., F.L.S., F.G.S. pp. 220. London. 1873.

Hodge. 1. Systematic Theology. By Charles Hodge, D.D., Professor in the Theological Seminary, Princeton, N. J. 3 Vols. pp. 648, 732, 880. New York. 1872, 1873.

2. What is Darwinism? pp. 178. New York. 1874.

Huxley. 1. On the Origin of Species; or, The Causes of the Phenomena of Organic Nature. A Course of Six Lectures to Working Men. By Thomas H. Huxley, F.R.S., F.L.S. pp. 150. New York. 1872.

2. Lay Sermons, Addresses, and Reviews, etc. pp. 344. London. 1872.

3. Critiques and Addresses. pp. 350. London. 1873.

Hooker. Flora of Tasmania. Introductory Essay, American Journal of Science (1860), Vol. xxix. pp. 1 ff., and 305 ff.

Hyatt (Professor Alpheus). Memoirs of the Boston Society of Natural History, Vol. i., part 2d (1867); American Naturalist, Vol. iv. pp. 230–277 (June 1870).

Jevons. The Principles of Science: a Treatise on Logic and Scientific Method. By W. Stanley Jevons, M.A., F.R.S. 2 Vols. pp. 463, 480. New York. 1874.

Le Conte. Religion and Science. By Joseph Le Conte, Professor of Geology and Natural History in the University of California. pp. 324. London. 1874.

Lyell. 1. Principles of Geology; or the Modern Changes of the Earth and its Inhabitants, considered as illustrative of Geology. By Sir Charles Lyell, Bart., M.A., F.R.S. Eleventh and entirely revised ed. 2 vols. pp. 671, 652. New York: D. Appleton and Co. 1873.

2. The Student's Elements of Geology. pp. 624. London. 1871.

3. Geological Evidences of the Antiquity of Man. Fourth ed., revised. pp. 572 and xix. London. 1873.

McCosh. Religious Aspects of the Doctrine of Development. By the Rev. James McCosh, D.D., LL.D., Princeton, N. J., President of the College of New Jersey. In Proceedings of the Evangelical Alliance, 1873, pp. 264–271.

Mill. A System of Logic, Ratiocinative and Inductive. Being a connected View of the Principles of Evidence and the Methods of Scientific Investigation. By John Stuart Mill. 8vo. pp. 600. New York. 1867.

Miller. The Footprints of the Creator. By Hugh Miller. pp. 337. Boston. 1854.

Mivart. 1. On the Genesis of Species. By St. George Mivart, F.R.S. pp. 296. London. 1871.

2. Contemporary Review, Nov. 1875. pp. 936–957.

Müller Max. Chips from a German Work-Shop. Vol. iv.

Murphy. Habit and Intelligence, in their Connection with the Laws of Matter and Force. A Series of Scientific Essays. By Joseph John Murphy. 2 vols. pp. 349, 240. London: Macmillan and Co. 1869.

Owen. 1. Palaeontology; or a Systematic Summary of Extinct Animals and their Geological Relations. By Richard Owen, F.R.S., Superintendent of the Natural History Department in the British Museum, etc. 2d ed. pp. 463. Edinburgh. 1861.

2. The Anatomy of the Vertebrates. 3d vol. pp. 915. London. 1868. The last chapter of Vol. iii. was republished in Silliman's Journal of Science, for January, 1869.

Peabody. 1. Christianity and Science. A Series of Lectures by Rev. A. P. Peabody, D.D., of Harvard College. pp. 287. NewYork. 1875.

2. Bearing of Modern Scientific Theories on the Fundamental Truths of Religion. Bib. Sac., Vol. xxi. pp. 710–724.

Parsons. On the Origin of Species. By Theophilus Parsons, Dane Professor of Law in Harvard University, Cambridge, Mass. American Journal of Science and Arts, July 1860. pp. 1–13.

Pfaff (Friederich, Professor der Geologie zu Erlangen), Die neuesten Forschungen und Theorieen auf dem Gebiete der Schöpfungsgeschichte. Frankfort. 1868.

Porter. 1. Science and Revelation; their Distinctive Provinces, etc. An Address by J. L. Porter, D.D., LL.D., Prof. of Biblical Criticism, Assembly's College, Belfast. pp. 38. Belfast. 1874.

2. Theological Colleges, etc. Opening Lecture, with special Reference to the Evil Tendencies of Recent Scientific Theories. pp. 24. Belfast. 1874.

Reusch. Bibel und Natur. Vorlesungen über die mosaische Urgeschichte und ihr Verhältniss zu den Ergebnissen der Naturforschung. Von Dr. F. Heinrich Reusch, Professor der Theologie an der Universität zu Bonn. Dritte, umgearbeitete Auflage. pp. 524. Freiburg. 1870.

Seelye. A Criticism of the Development Hypothesis. By Rev. Julius H. Seelye, D.D. 4to. pp. 16. Appendix to Vol. ii. of Johnson's Natural History. New York. 1874. See also Johnson's New Universal Cyclopaedia, under Darwinism.

Schmidt. The Doctrine of Descent and Darwinism. By Oscar Schmidt, Professor in the University of Strasburg. pp. 334. London. 1875.

Spencer. The Principles of Biology. By Herbert Spencer. 2 vols. pp. 492, 569. New York. 1871.

St. Clair. Darwinism and Design; or Creation by Evolution. By George St. Clair, F.G.S., M.A.I., etc. pp. 359. London. 1873.

Wallace. 1. Contributions to the Theory of Natural Selection. By A. R. Wallace. 2d ed. pp. 384. New York. 1871.

2. The Malay Archipelago, etc. pp. 638. New York. 1869.

Whewell. 1. History of the Inductive Sciences from the Earliest to the Present Time. 3d ed., with additions. 2 vols. pp. 566, 648. New York. 1870. First edition published in 1837; third and enlarged edition in 1857.

2. The Philosophy of the Inductive Sciences. By the Rev. William Whewell, B.D. 2 vols. pp. 586, 523. London. 1840.

Whitney (Professor W. D.) Darwinism and Language. Article in North American Review. Vol. cxix. pp. 61–88.

Winchell. The Doctrine of Evolution: Its Data, its Principles, its Speculations, and its Theistic Bearings. By Alexander Winchell, LL.D., Chancellor of Syracuse University, Author of Sketches of Creation, Geological Chart, etc., etc. pp. 148. New York. 1874.

Youmans. An Exposition of the Development Hypothesis. By Prof. E. L. Youmans, M.D., etc. 4to. pp. 35. Appendix to Vol. i. of Johnson's Natural History. New York. 1874. See also Johnson's New Universal Cyclopaedia, under Darwinism.

PERIODICAL LITERATURE BEARING ON THE SUBJECT.

American Theological Review. Vol. II. pp. 326–344, by Pres. D. R. Goodwin, D.D. Vol. II. pp. 496–518; Vol. IV. pp. 680–687; Vol. V. pp. 394–405, all by Prof C. Dewey.

American Presbyterian Review. Vol. III. (1871) pp. 347–379, by Prof. John Bascom.

Bibliotheca Sacra. Vol. XX. pp. 256–278, by Rev. J. M. Manning, D.D. Vol. XX. pp. 489–561, by Prof. Edward Hitchcock, D.D. Vol. XXIV. pp. 363–388, 429–481, by Prof. C. H. Hitchcock. Vol. XXVIII. pp. 654–685, by Prof. J. Bascom (on Instinct). Vol. XXIX. pp. 240–289, by Prof. F. Gardiner, D.D. See also in Catalogue of Authors, Dana, Chadbourne.

Baptist Quarterly. Vol. II. pp. 257–274, by Prof. Heman Lincoln. Vol. VI. pp. 1–29, by Charles E. Hamlin. pp. 129–146, by Samson Talbot. Vol. VII. pp. 69–87, 204–227, both by E. Nesbit, D.D. Vol. VIII. pp. 250–269; Vol. IX. pp. 48–74, 281–305, all three by Prof. L. E. Hicks, pp. 149–164, by S. H. Carpenter, LL.D.

Christian Examiner (for May 1860). pp. 449–464. One of the most spirited of the early protests.

Methodist Quarterly. Vol. XLIII. pp. 605–628, by Prof. W. C. Wilson. Vol. XLV. pp. 29–55, by Charles Martins, translated from the "Revue des Deux Mondes," pp. 175–179, editorial, pp. 181–204, by Henry M. Harmon, Esq. Vol. XLVII. pp. 29–49, 186–207, both from the "Revue des Deux Mondes," pp. 207–230, by Prof. Tayler Lewis, pp. 378–400, by John Johnston, LL.D. Vol. XLVIII. pp. 187–206, from the German of Dr. O. Föchler.

New Englander. Vol. XXVI. pp. 603–636, by Prof. W. N. Rice. Vol. XXX. pp. 464–471, by Rev. James B. Tyler. pp. 601–616, by Rev. G. F. Wright. Vol. XXXI. pp. 447–468, by Rev. Borden P. Bowne.

North American Review. Vol. XC. pp. 474–506, Vol. XCI. pp. 528–536. Vol. CVII. pp. 465–500, by H. B. Adams. Vol. CX. pp. 284–299, by

Rev. C. L. Brace. Vol. CXI. 282–311, Vol. CXIII. pp. 63–103, Vol. CXV. pp. 1–31, Vol. CXVI. pp. 245–310. These last four were by Chauncey Wright, of Cambridge, Mass. They are a defense of Darwinism against the attacks of Mivart; and were so much valued by Mr. Darwin that the first of the series was republished by him in pamphlet form.

North British Review. Vol. XXXII. pp. 455–487, Vol. XLVI. (June 1867) pp. 277–318. This last is anonymous, but is one of the ablest arguments against Darwinism that has appeared.

Princeton Review. Vol. XXXII. pp. 577–608, Vol. XXXIV. pp. 435–464, Vol. XLI. pp. 5–33, Vol. XLII. pp. 55–86.

It is neither necessary nor desirable for the understanding of the subject to peruse all the works here mentioned. A word of advice will doubtless be acceptable to those who have not unlimited time to spend upon the literature of the subject. The following books are indispensable to a just appreciation of the state of progress in Evolutionary Theories: Darwin's Origin of Species, 6th ed.; Descent of Man, 2d ed.; Animals and Plants under Domestication; Lyell's Principles of Geology, 10th or 11th ed.; Dana's Manual of Geology, 2d ed.; Agassiz on Classification, or Methods of Study in Natural History; Owen's Palaeontology, and chap. 40 in Anatomy of the Vertebrates; Wallace on Natural Selection; Whewell, Mill, and Jevons on Inductive Logic.

Of the shorter treatises the articles of Prof. Gray, in the order named, should have the first place. They are marked equally by scientific accuracy, philosophical insight, metaphysical discrimination, and religious reverence. It is greatly to be regretted that they are not collected and published in a single volume. Huxley, Henslow, Schmidt, St. Clair, and Winchell give tolerably complete summaries of the arguments for the Darwinian Theory. Schmidt and Haeckel are too ready to reason upon the subject from *a priori* principles, and are offensively dogmatic. The weightiest objections to Darwinism are found best stated, first, in his own works, then in those of Agassiz, Argyll, Dawson, Mivart, Owen, and Wallace. Cope, Gray, Henslow, Hyatt, Mivart, Owen, St. Clair, Wallace, and Winchell are Evolutionists, without being altogether Darwinians. Hodge has so many misrepresentations that he furnishes much ground for the little esteem with which theological criticisms of scientific subjects are regarded by scientific men.[1]

[1] In confirmation of this assertion, which is not made recklessly, the reader is referred to the Bibliotheca Sacra, Vol. xxxi. pp. 788, 789, for one glaring instance of misapprehension. For a second, let the reader compare what Huxley really said with what Dr. Hodge, on page 16 of the 2d Vol. of his Theology makes him say. Huxley is made to say that he from the first regarded Darwin's "Origin of Species" as "the death-blow of teleology, i.e. of the doctrine of design and purpose in nature." We have no fondness for Professor Huxley,

Twenty-five years ago naturalists and theologians were in a heated discussion over the "Unity of the Human Race." The doctrine of the immutability of species was pushed by some to such an extreme, that they declared it incredible that the different races of men should have descended from a single pair. Professor Agassiz was an advocate of this view; and his name was, on that account, a terror to orthodox interpreters of the Bible. Even in 1872 Dr. Hodge makes the assertion that the unity of the human race is denied by "a large and increasing class of scientific men."[1] It would gratify a good deal of curiosity if the learned doctor had informed us from what ranks this "large class of scientific men," who disbelieve in the unity of the human race, is receiving so many recruits. For it seems to appear on the face of almost all recent works scientifically treating the subject of vegetable or animal life, that the question of the day is not whether the human races are of common origin, but

and should despair of success in any attempt to reconcile with one another, all of his crude and heated utterances; but even he should have his due. Professor Huxley did indeed write that "teleology, *as commonly understood*, had received its death-blow at Mr. Darwin's hands." Dr. Hodge, when he quotes Huxley on page eighty of his book on Darwinism, inserts the omitted phrase which we have italicized, but does not seem to see that it in any degree removes the curse from Professor Huxley, nor does he appear to have noticed the following significant sentences which occur in the very paragraph from which his quotation is drawn. "We [Huxley] should say that, apart from his [Darwin's] merits as a naturalist, he has rendered a most remarkable service to philosophical thought by enabling the student of nature to recognize, to their fullest extent, those adaptations to purpose which are so striking in the organic world, and which teleology has done good service in keeping before our minds, without being false to the fundamental principles of a scientific conception of the universe. The apparently diverging teachings of the teleologist and the morphologist are reconciled by the Darwinian hypothesis." — Lay Sermons (4th ed.), pp. 303, 304. London, 1872. Compare further, Dr. Hodge's quotation from, and comments upon, Professor Huxley's Article in the Academy (1869), with the full statement of Professor Huxley (republished in Critiques and Addresses, pp. 305–308), in which he says, p. 307, "The teleological and the mechanical views of nature are not, necessarily, mutually exclusive. On the contrary, the more purely a mechanist the speculator is, ... the more completely is he thereby at the mercy of the teleologist, who can always defy him to disprove that this primordial molecular arrangement was not intended to evolve the phenomena of the universe."

[1] Systematic Theology, Vol. ii. p. 77.

whether the whole animal kingdom may not have descended in unbroken chain from one progenitor.

I. Outline.[1]

This question we propose to discuss in the following order:

(1) We will present, as fully as our limits will allow, the argument in favor of the evolutionary origin of species.

(2) Give a summary of the objections to which these arguments are open, together with the rejoinders of those who advocate the origin of species through evolution.

(3) Treat of the analogies between Calvinism and the modern bent of scientific men.

(4) Make a provisional adjustment of evolutionary theories to the true doctrine of final cause or design in nature.

(5) Discuss more particularly the attitude of the Bible toward scientific discovery.

The present paper will be devoted to a statement of the argument in favor of the Origin of Species by Evolution.

II. Reasons for entering this Field of Discussion.

There is constant danger that misunderstanding should

[1] We beg leave to emphasize in the outset every term in the title of this Article. For we never mean to lose sight of these two postulates, both of which we shall defend at a later stage of the discussion. 1st. That scientific men deal only with the method that appears in the sequences of secondary causes. Even when treating of the origin of species, they do not, if they speak as scientific men, refer to the first and true causal origin. This is a problem of theology. But in scientific treatises reference is had solely to the order under which actual forces are seen or inferred to operate. 2d. Whatever the method may be, God is the author of it. God both makes the machine and operates it. The writer begs still farther leave to warn his readers that he must not be held to personal responsibility for the theories here discussed, and the arguments presented. This, and the succeeding paper in the series, are summaries of the arguments of others. It is best also here to emphasize the fact that if the theory of natural selection should be established in its general conclusions, it would not necessarily comprehend the essential characteristics of man in the scope of its operations. And on the other hand, the miraculous creation of man might no more disprove the general theory of natural selection than an ordinary miracle of Christ would disprove the general reign of natural law. The exception may even prove the rule. There would be no miracle if uniformity did not ordinarily prevail. There is, doubtless, miraculous interference with uniformities of nature when there is sufficient reason for it, and only then.

arise between the students of nature and the interpreters of the Bible. They who should dwell together in peace are too often at war with one another. It is our purpose to mediate between these parties, to show how asperities may be avoided, to reveal the body of truth which both hold in common, and more definitely to mark out the provinces in which each may have undisputed sway.

Dr. Whewell,[1] in his chapter on the "Relation of Tradition to Palaetiology," has with great wisdom and candor discussed the relations that ought to subsist between theologians and men of science. He shows, in the first place, how the promulgators of religious truth are compelled to avoid reference to the more recondite matters of science, for fear of calling attention away from the weightier matters of the spiritual life that more personally concern men. He points out that the flexibility of the scriptures in adapting their teaching to scientific discoveries arises chiefly from this excellence, that their language is "adapted to the common state of man's intellectual development, in which he is supposed not to be possessed of science."[2] But from these facts there must arise trials of faith.

"The moral and providential relations of man's condition are so much more important to him than mere natural relations, that at first we may well suppose he will accept the sacred narrative, as not only unquestionable in its true import, but also as a guide in his views even of mere natural relations. He will try to modify the conceptions which he entertains of objects and their properties, so that the sacred narrative of the supernatural condition shall retain the first meaning which he had put upon it in virtue of his own habits in the usage of language."[3]

In the same chapter it is very well remarked that physical science can tell us nothing of the origin of things.

"The thread of induction respecting the natural course of the world snaps in our fingers when we try to ascertain where its beginning is. Since, then, science can teach us nothing positive respecting the beginning of things, she can neither contradict nor confirm what is taught by scripture on that subject.... The providential history of the world has its own beginning and its own evidence."[4]

[1] The Philosophy of the Inductive Sciences, Vol. ii. pp. 137–157.
[2] Ibid. p. 143. [3] Ibid. pp. 141, 142. [4] Ibid. p. 145.

Another fact of great interest is noticed by the same author.

"Scientific views, when familiar, do not disturb the authority of scripture. ... When the language of scripture, invested with its new meaning, has become familiar to men, it is found that the ideas which it calls up are quite as reconcilable as the former ones were with the most entire acceptance of the providential dispensation. And when this has been found to be the case, all cultivated persons look back with surprise at the mistake of those who thought that the essence of the revelation was involved in their own arbitrary version of some collateral circumstance in the revealed narrative. At the present day we can hardly conceive how reasonable men could ever have imagined that religious reflections on the stability of the earth, and the beauty and use of the luminaries which revolve around it, would be interfered with by an acknowledgment that this rest and motion are apparent only. And thus the authority of revelation is not shaken by any changes introduced by the progress of science in the mode of interpreting expressions which describe physical objects and occurrences; provided the new interpretation is admitted at a proper season, and in a proper spirit; so as to soften, as much as possible, both the public controversies and the private scruples which almost inevitably accompany such an alteration."[1]

The question is then raised as to the proper time and spirit in which the "religious and enlightened commentator" is to make such changes in the current interpretation of sacred scripture as shall adjust it to new scientific theories. We may sum up his views in two or three easily remembered sentences. (1) Do not make scientific difficulties for the sake of adjusting scripture to them. The conservatism of religious feeling is of so much value that it is a crime to disturb it wantonly, or before there is a tolerably clear case of necessity. (2) Face the difficulties manfully when they appear, and show the same candor in your treatment of scientific men that you ask them to exhibit to you. Both theologians and men of science should remember, as Kepler says, that "it is for their common advantage to conciliate the finger and the tongue of God—his works and his word."[2] There is great loss in unreasonably delaying the concessions

[1] The Philosophy of the Inductive Sciences, Vol. ii. pp. 146, 147. See also, History of Inductive Science, Vol. i. p. 286.

[2] Quoted by Whewell, Philosophy of the Inductive Sciences, Vol. ii. p. 153.

which biblical interpreters must from time to time make to science.

In endeavoring to state and measure the scientific argument with which our discussion has to do, it may seem unfortunate that this is not a scientific periodical, and that the writer is not recognized as authority on any scientific subject. This, however, has its advantages. Unless a scientific theory is of such a nature, and is so far developed and established, that its leading points can be both apprehended and stated by the average religious teacher, the time has not arrived for religious teachers to pay much attention to it. Furthermore, we who make a special study of historical records and monuments can pass intelligent judgment on the credibility of witnesses who report scientific observations, and upon the bearing of their established facts upon a theory of causation. For scientific observers do not pretend to see the bond of secondary causation which unites similar things together. The existence of such a bond is, in any case, an inference. It is visible only to thought, and is discoverable only by the exercise of reason.

We must remember also, that the discussions upon which we are entering belong to the inductive sciences, in which it is unfair to demand demonstration. In this realm we must be satisfied with the highest attainable degree of probability. We must not overlook the distinction between a *theory* and a *theorem*. The first is of induction; the second of deduction. One is provisional; the other is absolute.

As religious teachers, dealing with the proofs of an external revelation, we are to be classed with inductive philosophers. The providential dispensation known as Christianity, is established by a rigorous application of the principles of induction. We are confident that the present bent of the scientific mind is favorable to that style of reasoning by which the credibility and authority of the Bible have been established. In the present endeavor to account for the origin of species, science is taking a higher aim than has heretofore been seriously entertained by any large number

of her votaries. Scientific men aim now to do far more than observe and classify. They are seeking the deeper meaning of the facts which they observe. They are endeavoring to trace out the bond of order which all believe to reign supreme in nature. This kind of intellectual endeavor is congenial to the theological mind. Because this work is both important and appropriate for us, we make bold to enter the arena.

III. Definition of Species.

It is necessary at the outset to ask the question, What is a species? Indeed our whole discussion will have regard to the true meaning of that word. With the limited space at our command, it would not be best to plunge into the deep mysteries of nominalism and realism. These mysteries, however, are more closely related to our subject than might at first be supposed. The definition of species given by Prof. Dana is sufficiently realistic.[1] "A species among living things, then, as well as inorganic, is based on *a specific amount or condition of concentrated force defined in the act or law of creation*," i.e. a species is a real unfolding of a real force, and by whatever act or law of creation defined, is the realization of a well-defined divine idea. But even this definition, distinct as it is in recognizing the creative act which is the initiatory cause of the species, does not determine the mode through which the creative impulse reaches its realization in natural forms. For anything given in this definition, we may suppose that the forces which became at last concentrated in the conditions of specific forms of life, may have run in devious and independent channels during all the time preceding their intersection and consequent production of what we call the species.

A prominent question involved in the study of natural history is, What part does inheritance play in giving to individuals that degree of likeness which constitutes them one species? The ordinary answer has been that the points of

[1] See Bibliotheca Sacra, Vol. xiv. p. 861.

likeness which characterize a species are the result of the law of inheritance; while the variations which constitute varieties and sub-varieties, are the result of the action of the diverse conditions of existence.

According to Linnæus,[1] "Species tot sunt, quot diversas formas ab initio produxit Infinitum Ens; quae formae, secundum generationis inditas leges, produxere plures, at sibi semper similes." In the words of Professor Oliver, "All individual plants which resemble each other so nearly that it is consistent with experience to suppose that they may all have sprung from one parent stock, are regarded as belonging to the same species."[2] Agassiz insists that to bring in descent from one parent stock, as an element in the definition of species, is an entire begging of the question, and only serves to add perplexity to the subject;[3] for no one has ever preserved the genealogy of plant or animal. If the individuals of a species have a common pedigree, how is that to be proved? It is evident that aside from inferential proof, there is none. "*Individual plants* [or animals] *which resemble each other so nearly that it is consistent with experience to suppose that they may all have sprung from one parent stock*," are inferred to have a common ancestry. And for this reason; that inheritance is, in the case of plants and animals, a known cause of resemblance in operation around us on the most extended scale; and furthermore, it is the only known cause of such resemblance. It is by no false analogy that inheritance is brought in as the bond of unity in the constitution of a species. The bond, however, is usually inferential; and naturalists experience a vast amount of perplexity in determining how great a degree of unlikeness is compatible with descent from a common ancestry. The practical difficulty encountered in limiting species may be seen in a statement of Dr. Gray.

[1] Philosophia Botanica (1770), §157, p. 99. Quoted in Jevon's Principles of Science, Vol. ii. p. 415.

[2] Lessons in Elementary Botany. By David Oliver, F.R.S., F.L.S., etc. (3d ed., London, 1870), p. 122.

[3] See Essay on Classification, p. 163 ff.

"In a flora so small as the British, one hundred and eighty-two plants generally reckoned as varieties have been ranked by some botanists as species. Selecting the British genera which include the most polymorphous forms, it appears that Babington's Flora gives them two hundred and fifty-one species, Bentham's only one hundred and twelve; a difference of one hundred and thirty-nine doubtful forms. ... Illustrations of this kind may be multiplied to a great extent."[1]

Commenting upon these facts, the distinguished botanist from whom we quote farther remarks:

"They make it plain that whether species in nature are aboriginal and definite or not, our practical conclusions about them, as embodied in systematic works, are not *facts* but *judgments*, and largely fallible judgments. ... We are constrained by our experience to admit the strong likelihood, in botany, that varieties, on the one hand, and what are called closely-related species, on the other, do not differ except in degree. Whenever the wider difference separating the latter can be spanned by intermediate forms, as it sometimes is, no botanist long resists the inevitable conclusion. ... Whether we should continue to regard the forms in question as distinct species, depends upon what meaning we shall finally attach to that term; and that depends upon how far the doctrine of derivation can be carried back, and how well it can be supported."

But this question runs insensibly into others of a kindred nature. The foregoing and the two following sections are one problem in three forms of statement.

IV. Importance and Difficulty of Classification.

It is not optional with the scientific man whether he classify the facts of nature. He must classify or retire from the field. Unless he group things according to their prominent resemblances, disregarding, meanwhile, their minor differences, the man of science will be put to utter confusion by the interminable number of objects that come to his attention. Even as it is, the progress of science in enumerating so-called species is rapidly outstripping the power of retention which a single finite mind may possess. For example, botanists enumerate more than one hundred thousand species of phaenogamous plants; zoölogists, more than three hundred and fifty thousand species of animals. There are three hundred thousand species of the class articulata, and

[1] Silliman's Journal of Science, March, 1860, p. 168 f.

twenty-one thousand of vertebrata.[1] The elder De Candolle spent a long life on a descriptive catalogue of phaenogamous plants. His son took up the work, but has recently abandoned it in despair. It is estimated that nearly four hundred years would be required for one man to arrange and systematically describe them.[2] Between four and five hundred closely-printed octavo pages are required for their enumeration of the species of the Leguminous family,[3] and between sixteen and seventeen hundred for those of the great family of Compositae. Were it not for the fact that there is method in the relation of this vast multitude of species to one another, naturalists might well cease from the work of classification, and limit themselves to the contemplation of the individuals. But species do not have a hap-hazard existtence; they fall into a hierarchy of orders.

"It is a truly wonderful fact, the wonder of which we are apt to overlook from familiarity, that all animals and all plants throughout all time and space, should be related to each other in natural groups, subordinate to groups, in the manner which we everywhere behold, namely, varieties of the same species most closely related together; species of the same genus less closely and unequally related together, forming sections and sub-genera; species of distinct genera much less closely related; and genera related in different degrees, forming sub-families, families, orders, sub-classes, and classes. The several subordinate groups in any class cannot be ranked in a single file, but seem rather to be clustered round points, and these round other points, and so on in almost endless cycles."[4]

"According to the laws of botanical nomenclature adopted by the International Botanical Congress, held at Paris, August, 1867, no less than twenty-one names of classes[i.e. grades of relationship], are recognized, viz. Kingdom, Division, Sub-division, Class, Sub-class, Cohort, Sub-cohort, Order, Sub-order, Tribe, Sub-tribe, Genus, Sub-genus, Section, Sub-section, Species, Sub-species, Variety, Sub-variety, Variation, Sub-variation."[5]

V. Does a Species have more than one Centre of Dispersion?

It will be well at this point to consider more attentively

[1] See Dana's Manual of Geology (1st ed.), p. 575.
[2] See Popular Science Monthly, April, 1874. Also, Nation, Vol. xviii. p. 42.
[3] Lindley's Ladies' Botany, Vol. i. p. 122.
[4] Darwin's Origin of Species, pp. 135, 136.
[5] Jevon's Principles of Science, Vol. i. p. 417.

how a scientific man undertakes to solve the problem of an abnormal distribution of a species. When, for example, the same, or apparently the same species of animal or plant is found distributed over both England and the Continent, the question at once arises, how was this distribution effected? There are few intellectual operations more interesting than to observe the method of a naturalist as he attacks some of the more difficult of these problems concerning the distribution of the members of a single species. The law of parsimony, or of the continuity of nature, is of the highest importance in the inductive sciences. Hugh Miller thus emphasizes the necessity of insisting that members of the same species must have originated in the same centre.

"If members of the same species may exist through *de novo* production, without hereditary relationship, so thoroughly, in consequence, does the fabric of geological reasoning fall to the ground, that we find ourselves incapacitated from regarding even the bed of common cockle or mussel shells, which we find lying a few feet from the surface on our raised beaches, as of the existing creation at all. Nay, even the human remains of our moors may have belonged, if our principle of relationship in each species be not a true one, to some former creation, cut off from that to which we ourselves belong, by a wide period of death. All palaeontological reasoning is at an end forever, if identical species can originate in independent centres, widely separated from each other by periods of time; and if they fail to originate in periods separated by time, how or why in centres separated by space?"[1]

Thus also Dr. Gray.

"The ordinary and generally-received view assumes the independent, specific creation of each kind of plant and animal in a primitive stock, which reproduces its like from generation to generation, and so continues the species. ... Whenever two reputed species are found to blend in nature, through a series of intermediate forms, community of origin is inferred, and all the forms, however diverse, are held to belong to one species. ... The orthodox conception of species is that of lineal descent: all the descendants of a common parent, and no other, constitute a species; they have a certain identity, because of their descent, by which they are supposed to be recognizable. So naturalists had a distinct idea of what they meant by the term species, and a practical rule, which was hardly the less useful because difficult to apply in many cases, and because its application was indirect, that is, the community of origin had to be inferred

[1] Footprints of the Creator, p. 255.

from the likeness; that degree of similarity, and that only, being held to be conspecific which could be shown or reasonably inferred to be compatible with a common origin."[1]

In accounting for the distribution of a species over both England and the Continent, it is readily seen to be no violent supposition that the island was formerly a part of the continent. But the following problem, to which Prof. Asa Gray[2] applied himself a few years ago, is far more intricate; yet it is extremely difficult, not to say impossible, for one to follow the steps of the reasoning and not assent to the conclusion. The facts are these: there is a remarkable degree of identity between the species of animals and plants in Japan and those of the Atlantic basin of the United States, though climatic and oceanic barriers now absolutely forbid migration. And still further, the flora of the Eastern United States much more nearly resembles that in Japan than either of those resembles the flora of Oregon and California. A threefold combination is required in the key that unlocks the problem; and this he produces. First comes the geological evidence of the existence of a warm climate, and of these species, or their representatives, in the lands that during the tertiary period clustered about the north pole. Secondly, there is the evidence of a succeeding glacial period which drove before it southward these inhabitants and their temperate climate, till at length all occupied corresponding lower latitudes on both sides of the Pacific Ocean. Thus we have the distribution and the similarity accounted for. Thirdly, there is the wide sweep of forces which produces similarity of climate on the eastern sides of the continents and a contrast between that of the eastern shores and that of the western. In these forces we have the sieve which sorts the species, and preserves similar species in Japan and on the Atlantic coast, while allowing a different class to maintain its foothold upon the Pacific slope of America.

It should be noted, however, that Professor Agassiz, as

[1] American Journal of Science, March, 1860, pp. 155, 157.

[2] See Memoirs of American Academy (1859), Vol. vi. pp. 377–452. Also, Dubuque Address.

Dr. Gray observes,[1] diverges from the ordinary views respecting species in exactly the opposite direction from Darwin.

"Agassiz discards the idea of a common descent as the real bond of union among the individuals of a species, and also the idea of a local origin; supposing, instead, that each species originated simultaneously, generally speaking, over the whole geographical area it now occupies or has occupied, and in, perhaps, as many individuals as it numbered at any subsequent period. Mr. Darwin, on the other hand, holds the orthodox view of the descent of all the individuals of a species, not only from a local birth-place, but from a single ancestor or pair; and that each species has extended and established itself, through natural agencies, whenever it could; so that the actual geographical distribution of any species is by no means a primordial arrangement, but a natural result. He goes farther, and this volume [Origin of Species] is a protracted argument intended to prove that the species we recognize have not been independently created, as such, but have descended, like varieties, from other species. Varieties, on this view, are incipient or possible species. Species are varieties of a larger growth and a wider and earlier divergence from the parent stock; the difference is one of degree, not of kind. ... The theory of Agassiz, referring as it does the phenomena both of origin and distribution directly to the divine will, ... may be said to be theistic to excess."

In pursuing the direct line of our argument, we take for granted, that there is an organic connection between members of the same species, however widely they may be separated either by time or space.[2] Until recently a specific

[1] Silliman's Journal of Science (March, 1860), pp. 155, 156.

[2] Agassiz, however, writes (Cont. to Nat. History, etc., Vol. i. pp. 39, 40). See also pp. 165, 166. "It was a great progress in our science, when the more extensive and precise knowledge of the geographical distribution of organized beings forced upon its cultivators the conviction, that neither animals nor plants could have originated upon one and the same spot upon the surface of the earth, and hence have spread more and more widely until the whole globe became inhabited. ..... All animals and plants have occupied, from the beginning, those natural boundaries within which they stand to one another in such harmonious relations. Pines have originated in forests, heaths in heathers, grasses in prairies, bees in hives, herrings in schools, buffaloes in herds, men in nations! I see a striking proof that this must have been the case in the circumstance that representative species, which as distinct species, must have had from the beginning a different and distinct geographical range, frequently occupy sections of areas, which are simultaneously inhabited by the representatives of other species which are perfectly identical over the whole area. ..... Facts lead, step by step, to the inference that such birds as the Mallard and the Scaup originated simultaneously and separately in Europe and in America; and that all animals

difference was regarded by scientific men as necessitating separate original creation; the species of a genus being always regarded as of independent origin. The genus, and all higher orders, were supposed to be altogether ideal, with no connecting bond of physical causation between their subordinate members.

We come now to the facts which seem to force upon us the higher problem of accounting, by natural means, for the origin and dispersion of allied species and genera.

VI. Distribution of Species in Space.

In studying the distribution of living animals and plants, we are impressed with the existence of natural barriers which prevent the present intermingling of species. The rule is, that in proportion as the barriers which separate provinces are impassable, the contrasts are greater throughout the whole range of organic life. For example, the larger part of the dry land of the globe lies in the northern hemisphere, and is nearly contiguous in the arctic zone. Furthermore, geological evidence is abundant, that during the tertiary period a warm climate extended far up towards the pole. Fossil animals and plants are found in Greenland and adjacent lands like those which now cannot endure anything colder than a warm temperate climate. Thus it is plain that during a recent geological period the insuperable barriers which now prevent the migration of plants and animals from Europe and temperate Asia to America were not in existence.

originated in vast numbers; indeed, in the average number characteristic of their species, over the whole of their geographical area, whether its surface be continuous or disconnected by sea, lakes, or rivers, or by differences of level above the sea, etc. The details of the geographical distribution of animals exhibit, indeed, too much discrimination to admit for a moment that it could be the result of accident, that is, the result of the accidental migrations of the animals or of the accidental dispersion of the seeds of plants. The greater the uniformity of structure of these widely distributed organized beings, the less probable does their accidental distribution appear. I confess that nothing has ever surprised me so much as to see the perfect identity of the most delicate microscopic structures of animals and plants from the remotest parts of the world."

This fact is significant when viewed in connection with the close similarity of the faunas throughout the temperate regions of the northern hemisphere.

"The fauna of Europe is very closely related to that of the United States proper.... Notwithstanding the immense extent of country embraced, the same stamp [of animal life] is everywhere exhibited. Generally the same families, frequently the same genera, represented by different species are found."[1]

On the other hand, as we proceed on either continent through the torrid and south temperate zones, where the oceanic and climatic barriers are, and doubtless for a long time have been, vastly greater;

"Instead of that general resemblance, that family likeness which we have noticed between all the faunas of the temperate zone of the northern hemisphere, we find here the most complete contrasts. Each of the three continental peninsulas which jut out southerly into the ocean represents, in some sense a separate world. The animals of South America, beyond the tropic of Capricorn, are in all respects different from those of the southern extremity of Africa."[2]

But this dissimilarity of native animals and plants does not arise solely from dissimilarity in the physical conditions in those regions; for foreign plants when introduced have often flourished in a remarkable degree. For example, in New Zealand the Norwegian rat has extirpated the native rat, and is to be found everywhere. The progeny of the pigs which Captain Cook and other navigators left with the natives run wild in such a way that it is impossible to destroy them. There are large tracts of country where they reign supreme. In South America the horse has with equal facility increased in a wild state. Among plants we may mention the Scotch thistle, briar, rose, plantains, and docks, which have all become noxious weeds in South Africa and Australia.[3]

Lyell pertinently remarks, that if we reject the generally received doctrine of specific centres of creation and natural barriers to distribution,

[1] Principles of Zoölogy, by Agassiz and Gould, pp. 200, 203.

[2] Buffon, quoted in Lyell's Principles of Geology, Vol. ii. pp. 329, 332.

[3] See Hooker, in Popular Science Review (London), Vol. vi. p. 131 ff. Republished in The Eclectic Magazine (New York), for July, 1867.

"The fact that not a single native quadruped is common to Australia, the Cape of Good Hope, and South America, can in no way be explained by adverting to the wide extent of ocean, or to the sterile deserts, or the great heat or cold of the climates, through which each species must have passed, before it could migrate from one of those distant regions to another. It might fairly be asked of one who talked of impassable barriers, why the same kangaroos, rhinoceroses, or llamas should not have been created simultaneously in Australia, Africa, and South America? The horse, the ox, and the dog, although foreign to these countries until introduced by man, are now able to support themselves there in a wild state; and we can scarcely doubt that many of the quadrupeds at present peculiar to Australia, Africa, and South America might have continued in like manner to inhabit all the three continents, had they been indigenous in each, or could they once have got a footing there as new colonists."[1]

VII. Species arranged in Clusters.

Notwitstanding the great dissimilarity between the products of life on the southern extremities of the three continents, there is a striking similarity between the species inhabiting these several peninsulas and those found upon the islands adjacent to each. The islands are, in their forms of life, the satellites of the nearest continents. One of the most striking illustrations of this principle is found in the relation of the fauna and flora of the Galapagos Archipelago to those of South America. These islands lie nearly on the equator, five hundred miles west of the main land. They are of volcanic origin, and in their soil, elevation, and climate differ greatly from the neighboring coast. In these natural respects they very much resemble the Cape de Verde Islands, which are situated in the same latitude, and about the same distance to the west of Africa that the Galapagos are west of South America. The environment, or the conditions of life, are very much alike on the Galapagos and on the Cape de Verde Archipelago; while the conditions of life on each of these Archipelagos are in great contrast to those which surround the faunas and floras of their adjacent continents. The species of birds, reptiles, and plants found on the Galapagos are, for the most part, such as exist nowhere else in the

[1] Lyell, Principles of Geology, Vol. ii. p. 333.

world. On the ordinary view, naturalists would say they must have been created there. But according to Mr. Darwin,[1] — and it was this fact which turned his mind into the channel of speculation which has made him so justly famous, —

"Nearly all [these species] bore an American stamp. In the song of the mocking-thrush, in the harsh cry of the carrion-hawk, in the great candlestick-like opuntias, I clearly perceived the neighborhood of America, though the islands were separated by so many miles of ocean from the main land, and differed much from it in their geological constitution and climate. Still more surprising was the fact that most of the inhabitants of each separate island in this small Archipelago were specifically different, though most closely related to each other."

The animals and plants on the Cape de Verde Islands have a corresponding affinity to those of Africa. The problem is to find, if possible, the bond of secondary causation which shall join together these complex phenomena. It must account for the similarity under diverse conditions, and the diversity under similar conditions. Mr. Darwin believes that it is idle for us to search here for a "final cause." So far as there is truth in his remark it is, in our opinion, partially owing to the inadequate views now current regarding the doctrine of final causes. Mr. Darwin supposes he has found a natural mode of accounting for the similarities and the difference of representative species, in the effect of diversity of condition acting on the descendants of a common ancestry. According to him, the facts delineated with regard to the relationship between the forms of life on the islands and those on the adjoining continental areas, point to community of descent in comparatively recent time. No one can deny that there is great plausibility in this explanation.

In further illustration similar facts may be adduced regarding the island of Madagascar, where all the species of animals but one, and nearly all the genera, are different from those on the continent of Africa.[2] Yet these genera

[1] "Animals and Plants under Domestication," Vol. i. p. 21. See also "Origin of Species," pp. 353–356.

[2] Lyell's Principles of Geology, Vol. ii. p. 347.

and species resemble those in Africa more than they do those of any other province.

The direction and character of the boundary line between the fauna of Australia and that of Asia is still more impressive. The Philippine Islands, with Sumatra, Java, and Borneo, are in a sea that is nowhere more than six hundred feet deep. So that with an elevation of the Malay Archipelago to that amount, the continent of Asia would extend as far southeast as the island of Java, or twelve degrees of latitude beyond the Malay peninsula. Beyond a line drawn from the southeast end of Java, to the southernmost of the Philippine Islands, the depth of the ocean is more than six hundred feet. According to Mr. Wallace,[1] the line of soundings of six hundred feet, marking the termination of shallow seas, between the Indo-Malayan and the Austro-Malayan regions, is also the boundary between Australian and Asiatic genera of plants and animals, though in one instance the islands of these different zoölogical provinces are within sight of each other. The animals and plants of Asia are supposed to have migrated to the farthest islands in the shallow seas of the Malay Archipelago when they were continuously connected by land now moderately submerged; while the Marsupials of Australia maintained their ground on the islands that are now, and probably have been from a very remote period, surrounded by deep water. The principle is pretty well established that, with little regard to natural conditions, the fauna of islands is more nearly allied to that of the nearest continent than to that of any other region, and that the deeper the sea between them the more diverse is the fauna.

This class of facts receiyes explanation on the supposition that the Creator has given to the life-principle a power co-ordinate with that of the conditions of existence. The changes in the forms of life follow a long way behind the changes in the physical conditions. The islands surrounded

[1] See "The Malay Archipelago," pp. 20–31. Also Lyell's Principles of Geology, Vol. ii. pp. 349, 350.

by deep water are supposed to have retained the earlier forms of life because they have been longer isolated, and the conditions have there been more uniform, and there has been less room for competition between varieties.

Darwin[1] makes good use also of the fact that there are "no [native] Batrachians and terrestrial Mammals on oceanic islands."[2] There are only bats, whose presence can be accounted for by their power of flight. But the absence of frogs and Mammals is not due to lack of adaptations to the conditions; for often, when introduced, they thrive in a remarkable manner. Frogs have become a nuisance in Madeira and the Azores.[3] The full bearing of these facts cannot be seen till they are joined with two or three other coordinate series of phenomena. We proceed, therefore, to speak

VIII. Of the Distribution of Species in Time.

As long ago as 1844, Professor Owen enunciated the law "that with extinct as with existing Mammalia, particular forms were assigned to particular provinces, and that the same forms were restricted to the same provinces at a former geological period as they are at the present day."[4] In 1861, he adds:

"That period was the more recent Tertiary one. In carrying back the retrospective comparison of existing and extinct Mammals to those of the Eocene and Oölitic strata, in relation to their local distribution, we obtain indications of extensive changes in the relative position of sea and land during these epochs, in the degree of incongruity between the generic forms of the Mammalia which then existed in Europe and any that actually exist on the great natural continent of which Europe now forms part. It would seem, indeed, that the further we penetrate into time for the recovery of extinct Mammalia, the further we must go [from Europe] into space to find their existing analogies. To match the Eocene Palaeo-

[1] Origin of Species, p. 351.

[2] Origin of Species, p. 350. See also Lyell's Principles of Geology, Vol. ii. pp. 406–436.

[3] Ibid. p. 416.

[4] Quoted from Transactions of the British Association, 1844, in Owen's Palaeontology, p. 433.

theres and Lophiodons we fetch Tapirs from Sumatra or South America, and we must travel to the antipodes for Myrmecobians, the nearest living analogues to the Amphitheres of our Oölite strata."

The law of the distribution of species in time and space has been stated by Professor Dana thus :[1]

"The Orient has always been the continent of progress. From the close of the Palaeozoic its species of animal life have been three times as numerous as those of North America, and more varied in genera. In the early Tertiary its flora in the European portion had an Australian type, and there were Marsupials and Edentates there. In the middle and later Tertiary it represented recent North America in its flora. But from this condition it emerged to a higher grade. In the Post-tertiary it became the land of the Carnivores, while North America was the continent as distinctly of Herbivores — an inferior type; South America of Edentates — still lower; Australia of the lowest of quadrupeds — the Marsupials. In the closing creations Australia remained Marsupial, though with dwindled forms; South America was still the land of Edentates, but of smaller species, and with inferior Carnivores and the inferior type of monkeys, or Quadrumana; North America of Herbivores, also small compared with the Post-tertiary; while the Orient, besides its new Carnivores, received the highest of Quadrumana. Thus the Orient has successively passed through the Australian and American stages, and, leaving the other continents behind, it stood in the forefront of progress."[2]

Dawson emphasizes the same point :

"It thus appears that the Miocene flora of Europe resembles that of America at present, while the Eocene flora of Europe resembles that of Australia, and the Eocene [Pliocene?] flora of America, as well as the modern, resembles the Miocene of Europe. In other words, the changes of the flora have been more rapid in Europe than in America, and probably slowest of all in Australia. The eastern continent has taken the lead in rapidity of change in the tertiary period, and it has done so in animals as well as in plants."[3]

IX. Connecting Links between Species.

The argument in favor of the affinity of species cannot be adequately set forth, until attention has been called to the general unities of anatomical structure which pervade the species, genera, and orders of each of the four departments

[1] Manual of Geology (1st ed., Philadelphia, 1863), p. 585.
[2] See also Principles of Zoölogy, by Agassiz and Gould, p. 235.
[3] Story of the Earth and Man, pp. 259, 260.

of the animal kingdom, and which serve as the basis upon which they are grouped together in classes. We will attend to these deeper unities a little later; restricting ourselves in this section to what may more properly be called intermediate links between species that are now reckoned as distinct.

It is a fact, commented on at length by Dana and Agassiz, that the species which appear earlier in the history of the globe are of a more comprehensive type than those which appear later. The earlier forms are not so specialized in their structure as the later. The earlier types are spoken of as prophetic. Their structure contains intimations of what the peculiarities of future species are to be. All palaeontologists admit that as the present is approached there is progress in the geological record of life. The grade of life indicated in a geological formation is, in a general way, intermediate between that of the formation above and that below. Numerous transitional forms are found between the various classes and genera of vertebrate animals. Reptiles are anatomically intermediate between fishes and birds. The passage from the water-breathing class of Vertebrates to an air-breathing class, is "by close transitional steps."[1] The affinities of reptiles while they are close, in vertebral structure, with the ganoid fishes, are equally close with birds and mammals. The archaeopteryx was half reptile and half bird. It had the vertebrate tail of the reptile, which was, at the same time, supplied with the true feathers of the bird. Its foot had no characteristics that would distinguish the class to which it would belong. Professor Marsh[2] has found in the Cretaceous strata of Nebraska birds possessing teeth. In the Dinosauria the reptile class is allied more closely to the mammals. The Marsupials are midway between the oviparous Vertebrates and the placental Mammalia. Between the mastodon and the elephant there are many transitional species.[3]

[1] See Owen, Palaeontology, p. 320.

[2] See American Journal of Science for October, 1872, and January, 1873; also American Naturalist for October, 1875.

[3] Owen's Palaeontology, p. 376.

There are numerous intermediate forms joining together the rhinoceros and the horse, the bear and the wolf, the hyena and the civet, and even forms so diverse as the hog and the camel.[1]

Professor Owen remarks[2] that when the transmutation theories of the early part of the century were under discussion by Cuvier, with whom he was then studying, in opposition to these theories reliance was chiefly placed on the absence of intermediate species, especially the lack of intermediate forms between the Palaeotherium of the early Eocene and the hoofed quadrupeds of the present age. But adds:

"The progress of Palaeontology since 1830 has brought to light many missing links unknown to the founder of the science.... The discovery of the remains of the *Hipparion* supplied one of the links, required by Cuvier, between the Palaeotherium and the horse of the present day; and it is still more significant of the fact of filiation of species that the remains of such three-toed horses are found only in deposits of that Tertiary period which intervene between the older palaeotherian one and the newer strata in which the modern horse first appears to have lost its lateral hooflets. ... Other missing links of this series of species have been supplied; as, e.g. by the Paloplotherium of the newer Eocene of Hordwell, Hants; by the *Palaeotherium aurelianense* from the 'molasse marine' of Orleans, and by the *Palaeotherium hippoïdes* of the lacustrine calcareous beds of Sansan, all which deposits are Miocene, or are transitional between Eocene and Miocene." In the two last examples, "the whole foot is longer and more slender, with a longer and thicker middle toe, than in the older Eocene type-genus, whence the generic name *Anchitherium*, applied to them by von Meyer."

Prof. Marsh has since found a very complete gradation of fossil horses in America, some with three hoofs on each foot, others with a main hoof and two hooflets, and others in which the fingers are all rudimental, except the middle one which bears the hoof.[3] The general law, that intermediate geological formations contain intermediate species, was thus announced by Prof. Agassiz:

"Each formation contains remains peculiar to itself, which do not extend into the neighboring deposits above or below it. Still there is a

[1] See Wallace, Con. Theory. Nat. Selec., pp. 299, 300.

[2] Anatomy of the Vertebrates, Vol. iii. pp. 789–792. See also Dana, Manual of Geology (2d edition), pp. 503–520.

[3] American Journal of Science (March, 1874), pp. 247–258. See also Dana, Manual of Geology, p. 505.

connection between the different formations more strong in proportion to their proximity to each other. Thus the animal remains of the Chalk, while they differ from those of all other formations, are, nevertheless, much more nearly related to those of the Oölitic formation, which immediately precedes, than to those of the Carboniferous formation, which is much more ancient; and, in the same manner, the fossils of the Carboniferous group approach more nearly to those of the Silurian formation than to those of the Tertiary."[1]

Thus it must be admitted that the broken lines of life upon which we stumble in the geological record are not parallel; but they lie in directions radiating from a well-defined centre. There is more interlacing of these lines than we have been accustomed to admit. Life is a web.

X. Homologous and Rudimental Structures.

Vertebrate animals are all variations of one type of structure. A significant unity pervades the whole department. Even generic distinctions are founded upon "minor peculiarities of anatomical structure, such as the number, disposition, or proportions of the teeth, claws, fins, etc. ... Thus the lion, tiger, leopard, and cat are put into the same genus because they agree in the structure of their feet, claws, and teeth;" while the dog, fox, jackal, and wolf have another and different peculiarity of these parts of their bodies.[2] The species is formed upon less important distinctions, such as color, size, proportions, sculpture, etc.

The persistent and fundamental unity of structure throughout the vertebrata is extremely remarkable. For example, in the class of mammals the cervical vertebrae are constant in their number throughout all genera. The long neck of the giraffe has the same number of vertebrae with the short neck of the whale or the elephant. For all practical purposes the whale or elephant might as well have but one bone each in their necks; but each has seven, so small, and crowded so closely together, that they are in effect but one.

Limbs that are used for very different purposes have

[1] Principles of Zoölogy, p. 221.

[2] See Principles of Zoölogy, by Agassiz and Gould, p. 18.

frequently a structure that is anatomically the same. The bones of the human arm and hand have their homologues in the legs and feet of all quadrupeds, in the wings of all birds, and in the pectoral fin of the fish, and the flipper of the seal. The hoof of the horse is on his middle finger; the other phalanges are rudimental, though all present. The carpal and metacarpal bones are also partially represented in the legs of the horse; so also is the radius, though these bones are now rudimentary and useless.

Among other rudimentary structures may be mentioned the foetal teeth of whales and of the front part of the jaw of ruminant quadrupeds.

"These foetal structures are minute in size, and never cut the gum; but are reabsorbed without ever coming into use, while no other teeth succeed them or represent them in the adult condition of those animals. The mammary glands of all male beasts constitute another example, as also does the wing of the apteryx, — a New Zealand bird utterly incapable of flight, and with the wing in a quite rudimentary condition (whence the name of the animal). Yet this rudimentary wing contains bones which are miniature representatives of the ordinary wing-bones of birds of flight."[1]

Is there in all this any meaning which the human mind can interpret? Do these facts have any natural correlation to those innate tendencies of the mind on which beliefs are based? Is their glimmer of light in any degree trustworthy, and if so, to what degree? Or are they altogether like Will-o'the Wisps going before us but to deceive? Mr. Darwin's comparison has the merit of being clear, if not cogent.

"Rudimentary organs may be compared with the letters in a word, still retained in the spelling, but become useless in the pronunciation, but which serve as a clue for its derivation. On the view of descent with modification, we may conclude that the existence of organs in a rudimentary, imperfect, and useless condition, or quite aborted, far from presenting a strange difficulty, as they avowedly do on the old doctrine of creation, might even have been anticipated in accordance with the views here explained."[2]

[1] See Mivart, Genesis of Species, pp. 7, 155–187.
[2] Origin of Species, p. 402.

XI. Embryology.

Another class of facts presenting peculiar difficulties to the ordinary hypothesis of special creation, relates to the process of development through which the young animal passes in its embryonic condition. We quote again from the elementary work on Zoölogy by Professor Agassiz.

"As a general result of the observations which have been made up to this time [1855] on the embryology of the various classes of the animal kingdom, especially of the Vertebrates, it may be said, that the organs of the body are successively formed in the order of their organic importance, the most essential being always the earliest to appear. In accordance with this law, the organs of vegetative life, the intestines and their appurtenances, make their appearance subsequently to those of animal life, such as the nervous system, the skeleton, etc.; and these, in turn, are preceded by the more general phenomena belonging to the animal as such. .. Hence the embryos of different animals resemble each other more strongly when examined in the earlier stages of their growth. We have already stated that, during almost the whole period of embryonic life, the young fish and the young frog scarcely differ at all; so it is also with the young snake compared with the embryo bird." [1]

"This similarity of members of the same great class, in their embryonic condition, — the embryo, for instance, of a mammal, bird, reptile, and fish being barely distinguishable," is pronounced by Darwin "the most wonderful fact in the whole round of natural history." [2] That the embryos of the higher vertebrates should in their development pass through all the stages of the lower orders of their class, taking upon them at successive stages the peculiarities that characterize the order, the family, the genus, the species, and the individual; that this order coincides with the distribution of species in time; and that rudimentary organs are often developed at particular stages of the growth, and then partially or wholly re-absorbed, are certainly coincidences which it is hard to accept as accidental or meaningless. But on the theory of a common descent with modifications, all these facts come in harmoniously, this element of descent

[1] Principles of Zoölogy, p. 153.

[2] Animals and Plants under Domestication, Vol. i. p. 24.

being the hidden bond of connection which naturalists, in their efforts at classification, have been seeking, under the term of the natural system.[1]

XII. Analogous Variation.

An argument is also drawn from the facts of analogous variation. For instance, distinct breeds, like those of the domestic pigeon, which are now very unlike, tend to vary in a similar manner, resembling one wild species from which they are supposed to have descended. The slaty-blue color and the black bars across the wings of the original rock pigeon are occasionally assumed by individuals of all the varieties, though when kept pure they usually breed true and have no trace of those colors. When, however, different breeds are crossed, the tendency of these black bars and this blue color to appear is greatly increased, and the peculiarities of the crossed birds disappear.

Similar facts afford proof of the affinity of the horse and the ass to the zebra. By a wide induction, Darwin has shown that the appearance of the stripes which characterize the zebra are sometimes seen on every variety both of the horse and of the ass. And furthermore, that the mule, which is a cross between the horse and the ass, is much more likely than either to display those characteristic stripes, especially when young. Upon this Darwin remarks:[2]

"He who believes that each equine species was independently created, will, I presume, assert that each species has been created with a tendency to vary, both under nature and under domestication, in this particular manner, so as often to become striped like other species of the genus; and that each has been created with a strong tendency, when crossed with species inhabiting distant quarters of the world, to produce hybrids resembling in their stripes, not their own parents, but other species of the genus. To admit this view is, as it seems to me, to reject a real for an unreal, or at least for an unknown, cause. It makes the works of God a mere mockery and deception. I would almost as soon believe with the old and ignorant cosmologists that fossil shells had never lived, but had been created in stone, so as to mock the shells living on the sea-shore."

[1] See Origin of Species, pp. 381, 396 and 403. [2] Origin of Species, p. 130.

XIII. Summary of Facts.

Before proceeding to an explanation of these phenomena, we will briefly recapitulate. If in the animal kingdom we take one of the departments, Vertebrata, for instance, we find that all the individuals are characterized by certain fundamental likenesses, and are distinguished by varying degrees of unlikeness. Upon the bond of the similarity characterizing the grand division, the differences are superimposed which designate the more specific stages of our advancement in classification. There is a natural order of classification, so that starting along certain lines of divergence, and passing through more and more restricted clusters of likenesses, we reach a system of species and varieties and individuals, branching off from a common point, in which there is no intermingling and little ground for confusion.

Theories of evolution have in their favor the analogies of the known mode of the production of individuals. So far as we know, individuals are born and developed; not produced by a direct act of creation, or by spontaneous generation. "Every life is from an egg." So constant is this law that the supposed production of a living thing without a cell for its origin is strong proof either of the incompetence of the observer's method or of the imperfection of his instruments.

The natural system of classification corresponds in general with the embryonic development of each individual. The more generic characters of the animal appear first in the developing embryo. The specific characters are superinduced from time to time, as the period of birth approaches, or, indeed, long afterwards, in the post-natal development.

In the distribution of animals in time the same order of development is observable. The earlier forms of life that are studied in fossil remains are, as a rule, more generalized in their structure than the later forms. Classes of animals, like birds, reptiles, and fishes, were not so clearly distinguishable in the early Tertiary and in the Maesozoic times as now.

Again, in space animals and plants are separated by natural

barriers. The farther you recede from the continental hemisphere of the earth the more diverse the existing forms of life are from each other, and the nearer they resemble the more generalized forms of past time. Also the forms of life on islands are, as a rule, conformed not so much to the existing conditions of soil and climate as to the type of animal life on the nearest continental area.

XIV. Proper to Speculate upon the Problem.

The foregoing are the more important of the facts that press upon us for an explanation. It is not in accordance with what we specially value in the modern habits of thought to cut the Gordian knot with the assertion, "so God has made it," and set that up as the Ultima Thule of our investigation. Such a course would be suicidal to all scientific thought, and would endanger the rational foundation upon which our proof even of revelation rests. It is superstition, and not reverence, that leads us to avoid the questions concerning the order and mode of divine operations.

It is a principle never to be forgotten in any department of study that we are to press known secondary causes as far as they will go in explanation of facts. We are not to resort to an unknown cause for explanation of phenomena till the power of known causes has been exhausted. If we cease to observe this rule there is an end to all science and all sound sense.

In viewing the complicated movements of the heavenly bodies, it would relieve us from much labor, if we should simply register the phenomena, and attribute them directly to the divine activity. Newton, however, was not satisfied till he had interpreted the laws under which these movements proceed. He believed that in the peculiarities of planetary movements God permitted us to read the method of his operations. By a most successful application of the law of parsimony all that variety of movement in cycle and epicycle was traced to the effects of two forces, centripetal and centrifugal; the one constant, the other varying as the square of the distance between the attracting objects.

Through a generalization of this nature Mr. Darwin has, with greater success than any previous naturalist, approached the exceedingly complex phenomena exhibited in the organization of living forms. As Newton left the nature of the centrifugal and centripetal forces with the mysteries of the creation, so Darwin can leave where they belong the forces that have moved and directed the development of life upon the earth. Human pride may not boast too confidently of having sounded any of the deep things of God. The genuine man of science does not use the word 'explanation' with reference to the final solution of the problems of nature. In this respect Mr. Darwin is much more cautious than some of his followers. In the main he contents himself with viewing the unknown in the light of the known, and refrains from speculating upon the nature of the ultimate facts of observation. It should be remembered that, in the highest sense, it is no adequate explanation of the movements of the moon to show that it is to be classed with those of an apple as it falls from a tree. To any thoughtful mind the absolute mystery is rather increased than explained by such classification. And it may well be said that scientific explanation, such as it is, intensifies rather than diminishes our admiration of divine power. If the undevout astronomer be mad, it would in still greater degree be true that the irreverent disciple of Darwin is mad.

XV. Darwin's Method of Solution.

Darwin starts with two or three principles derived from our observation of living individuals and varieties of species, and tries to see how far there are indications that these principles have had sway in past times. The lamp by which he guides his feet among the scattered fragments of the creation is the fundamental axiom of all science, that similarity of effect indicates similarity of cause.

It is a matter of common observation that while it is true, in a loose sense, that "like begets like," — that plant and animal beget after their kind, — this law is co-ordinated by

another, just as centrifugal is co-ordinated with centripetal force. The progeny is never just like the parent. There is no dead level of uniformity in organic beings. Not even two peas are exactly alike. The law of heredity in animals and plants is a resultant of two tendencies; the one to likeness, the other to variation. The tendency to variation revolves around the tendency to uniformity. One force is centripetal, the other centrifugal. This is a general truth about which there is no dispute. It remains for the more accurate and extended observation of scientific men to determine the orbit of this revolution and the limits of this oscillation.

Is there such degree of plasticity in species that the orbit of one may break into that of another? This question we cannot hope to settle by direct observation. But we are permitted to determine very few things by direct observation. We never see the curve of the orbit of a star. We see it at different points of its orbit, and supply the rest of the curve on the ground of our confidence in intuitive principles. We go beyond observation whenever we try to prove anything. We believe that Biela's comet was drawn out of its orbit by the force of the attraction of the planet Jupiter. The proof of it is an exercise of mind far nobler than that of watching a vaporous disk in the glass of a telescope. The conformity of certain facts to principles established by broader observation and more intricate calculations may involve the veracity of God as absolutely as the agreement of a signature with a business man's known hand-writing may connect the two together, and prove the genuineness of the document. In this light let us try to answer the question, Are species transmuted into other species?

XVI. Elasticity of Species.

That species are in some degree plastic is evident to all, in the fact that varieties exist and that individuals are distinguishable from one another. Under the guidance of man, both animals and plants vary to a remarkable extent. Such

variations are produced in the vegetable world, that botanists are much averse to pronouncing upon the species of a domestic plant. Plants may be made to vary in almost any part of their structure.

There are several hundred varieties of our American grapes, with fruit ranging from the small acrid berry that grows wild on our river banks, to the luscious Catawba that would not ripen in Northern New England out of a conservatory. Yet they all range under three or four species.[1]

The strawberry was confined a hundred years ago to a very small number of varieties. While now, principally through the skill of gardeners within the last sixty years, the varieties are innumerable.[2] Potatoes, cabbages, apples, roses, and numerous other cultivated plants, are synonymes for variability in different parts of their organism.

In the animal creation too, every one is familiar with facts indicating a great amount of variability in domestic breeds. Indeed, the word breed indicates the fact. Horses have probably all descended from what would be called one species. Yet what a contrast between a dray-horse and an English race-horse! Or between Black-hawk and a Canadian pony! Whatever might be said about the original diversity of the wild varieties of the cow and the sheep, which have been domesticated, there is no doubt that the skill of breeders has produced additional and most important changes.

It is almost demonstrable that domestic pigeons are descended from one parent species, — the rock-pigeon. But now they have been transformed by fanciers to the strange forms of the pouter, fantail, carrier, barb, tumbler, and a hundred other varieties that breed true and have been named. These are made to differ in various points of anatomical structure more than is often required to establish a difference of species, or even of genus.[3]

The changes in domestic animals and plants take place under the directing agency of man. Man does not produce

[1] See Darwin, Animals and Plants under Domestication, Vol. i. p. 400 f., which, however, chiefly relates to European varieties.

[2] Ibid. p. 423.

[3] Ibid. p. 194.

the variation. He only uses it when for some unknown reason it appears. The tendency to variation has its origin in a cause that is mysterious; though change of circumstances increases the tendency. The agency of man is confined to accumulating by selection the variations that appear in a certain line. Without his interference, the tendencies to vary in opposite directions would, where communication was unrestricted between individuals, counteract each other, and keep the species uniform. Hence, it might occur that when a skilful breeder passed away, the breed would pass away with him, from lack of his skill in selecting the animals from which to propagate the variety. How far this process of variation may proceed in a particular line is still undetermined. Indeed, that is the question under consideration. With pigeons it has gone so far that the varieties if found in a wild state would be called species. The difficulties of classification are evidence of a great plasticity in species. It repeatedly occurs that what have been classed as distinct species are, by the subsequent discovery of intermediate forms grouped together as varieties of a single species. In such cases the divergence of the varieties from the type of the species measures the known degree of the elasticity of the species.

The changes which man secures in animals and plants by systematically selecting for propagation the individuals that possess qualities subservient to human want or caprice, are in one sense superficial, since they are made blindly. A variety is chosen for propagation because of peculiarities that can be seen, in ignorance of their correlated relation to profounder anatomical or physiological changes that simultaneously occur. Still farther, man protects his animals from the effect of deficient food or shelter, and so may preserve a peculiarity of structure which would be fatal to the existence of the animal if in a natural state.

If we go beyond the reach of the directing agency of man it would seem that there could be no analogous force able to enlarge indefinitely the orbit of individual variability.

XVII. Natural Selection.

But Mr. Darwin must have the credit of presenting in a new light, if not of discovering, a natural power of selection which is marvellous in its possibilities and probabilities. In the first place, the physical agencies that produce the succession of the seasons and the distribution of heat and moisture, and which so powerfully influence the animal and vegetable world, are in a state of unstable equilibrium. The seasons vary in periods that are of unequal duration, and that are dependent on far-reaching causes. If we extend our observation through the long ages of geologic record, we have brought to view alternations from temperate to frigid, and from frigid to torrid, climates, that are as extensive as the globe. In the alternate contraction and expansion of the continental areas, through the elevation and depression of the land, there are brought to light other important changes in the conditions to which animal and vegetable life have been subjected. At one time Europe is an archipelago of scattered islands. At another time England is joined to Ireland and to the continent by a continuous belt of land. During these periods of contraction, and at those times when drouth or winter was creeping over the world, there must have been a struggle for existence between the various individuals that were living at the time, in which the weakest would die first. At one time the survival would depend on the nature of the instinct, at another on the fleetness or size, at another on the ability to withstand extremes of heat and cold. In some of these conditions increase of size would be an advantage to the individual, in others it would be a disadvantage. In time of scarcity of food increase of size would make more food necessary, and perhaps bring more food within reach.

It is evident that these extraordinary trials would sift out those least fitted to the conditions, and leave behind those best fitted. "Animals, like men, are tried in the fire of affliction. The hay, wood, and stubble are burned, and the gold is left." In Darwin's system, however, "gold" does not mean necessarily a higher organism, but those peculiarities of the

organism that protect one from present physical evils, whether it be peculiarities that indicate progression or retrogression. Indeed, the very opposite qualities might secure immunity from destruction. A large dog might jump over a fence where a small one would go through, and only the medium sized be kept in by it. A nervous animal might live where a stupid one would die, and vice versa.

XVIII. The Struggle for Life.

In enumerating these changes in external nature, we have brought before us only one of the known agencies which serve as a crucible in which to test the tenacity of the life of any organic form. Whatever may be the ultimate explanation of it, it is a fact that the "whole creation groaneth and travaileth together in pain until now." There is a constant state of warfare in the organic world. The grub is trying to kill the tree, and the woodpecker is seeking, with exquisite instruments, to take the life of the grub; the parasite is worrying the life of the woodpecker, and so on through the whole story of the house that Jack built.

The Malthusian law of the tendency of all living things to increase through reproduction in geometrical ratio, while the stores from which they feed and the houses in which they live are limited by definite measurements, becomes in Darwin's hands a mighty power. If slow breeding man were not limited by many unavoidable evils from increasing and multiplying according to his natural instincts, there would in a few thousand years be so many people in the world that standing-room could not be found for them. If a plant should produce two seedlings a year, and its two produce each two more, and so on, there would in twenty years be a million plants. Mr. Darwin says:[1] "The elephant is reckoned to be the slowest breeder of all known animals, and I have taken some pains to calculate its probable minimum rate of natural increase; it will be under the mark to assume that it breeds when thirty years old, and goes on breeding till ninety years

[1] Origin of Species (5th ed.), p. 51.

old, bringing forth three pairs of young in this interval; if this be so, at the end of the fifth century there would be alive fifteen million elephants, descended from the first pair." When now we come to consider the rapidity with which innumerable other organisms tend to increase, we shall have before us a faint idea of the power that is here brought into the equation. We may safely assume that plants produce every year a million times as many seeds fitted for growth, as ever come to perfection. So that the ground of a forest is year by year literally covered with seedlings that are destined to die from lack of room and want of access to the elements necessary to their growth. Of the smaller plants we know that the ground is full of their seeds. Turn up the ground where you will, and it will be found that there are germs of life in it, or that they will lodge on it, and cover it very speedily with a rank vegetation. A few rank weeds, like the burdock or the thistle, delight to lord it over their weaker brethren. Infanticide and oppression are, in a figure, practised to an alarming extent throughout the vegetable kingdom. "Plants do not grow where they like best, but where other plants will let them."

Animals have feeling, which plants have not. But of compassion the animal kingdom is utterly devoid. The equilibrium of the animal world is maintained not merely by preparation for war, but by actual and unceasing conflict. Almost every species of animal is pressing beyond the limits of its means of subsistence. There are low forms of animals that produce millions of young every season. Yet the number of progeny which survive may not be at all in proportion to that which comes into existence. The mishaps that befall a young trout are far more numerous than those to which a whale is liable. "The condor lays a couple of eggs, and the ostrich a score; and yet in the same country the condor may be the more numerous of the two. The fulmar petrel lays but one egg, yet it is believed to be the most numerous bird in the world." It is plain that the number of individuals of a species that are found in existence is not at all

in proportion to their natural tendency to increase, but is rather dependent on their ability to contend against forces, both organic and inorganic, which oppose them after they are brought into existence. The great difficulty to be overcome in the continual existence of a species is that of adjusting itself to the other forms of life that crowd in upon it.

There is a constant oscillation in the comparative numbers of different classes of animals. As the food of herbivorous animals for any cause increases, the law of geometrical increase soon fills the enlarged possibility of subsistence, and individuals of this order are in competition again with each other. But the increase of Herbivora is soon followed by that of the Carnivora who feed upon them till these two orders are again in sharp competition, and the Carnivora contend with a diminishing relative supply of food.

When the animals are superabundant upon which the Carnivora feed, the weakest and most clumsy of that order could supply himself with food, and it would be the most helpless of the Herbivora that would be devoured. But when the balance was restored and the competition commenced again, the fleetest or strongest of the Herbivora, or those that had some other advantage, would be preserved; only the more favored of the Carnivora could then take or overcome them. The unfortunate of both orders would perish, and the more favored ones of both survive. Somewhat thus must be the internal contest among the animals which are food one for the other. When the struggle is in the same family with lessening amount of food, either absolute or relative, or with changing climate, analogous results must follow. In both cases, those variations from the type of the species that occur in every individual are the centrifugal force tending to divergence, counteracted, when nothing else interferes to augment it, by the law of inheritance and by the inter-crossing of individuals with opposite variations.

The external power in nature which supplies the place of man's agency as seen in domesticating animals, is the varying conditions of life which arise from changes in climate,

in temperature, in the extent of territory open for the range of the species, together with the encroachment of other species upon their domain. In this complicated environment we have a power which Darwin personifies as "Natural Selection." He speaks, we suppose, of power in the secondary sense, as when we use similar language regarding the force of gravity. He proceeds to trace the action of this secondary cause with reference to the production of species, as geologists would try to account for the features of a river valley by the erosive action of flowing water; or as the mathematician verifies the law of gravitation by the solutions it affords to the complicated observations of the astronomer. Or yet again, the problem is similar to that of the historian who sits in judgment on the documents before him, and pronounces them true or false according as they conform or not, to the known action of the human mind under the stress of given motives.

It should be remembered in this connection that the limits which we have set to the liberty of variation inherent in species is altogether arbitrary. It is perfectly proper for any person to proceed according to the law of parsimony from what is actually known of the variability of species and of the power of "Natural Selection," and see how far these factors will account for all the changes that are apparent. To the theologian the question regards the mode of the divine operations in nature. Darwin's law of "Natural Selection" only furnishes a natural bond for what Agassiz calls the ideas of God that were realized in innumerable special creations, and during countless periods of past time.

The theologian stands in no more need of miracles for the production of species than he does for that of the planets and their movements. Direct providential interposition is not for the irrational creation, but for the rational. So we may divest ourselves of theological prepossessions of any kind in reference to the material machinery by which the diversity of animal and vegetable life has been produced. But of these points we will speak farther on.

XIX. Time as a Factor in the Equation.

The rate at which changes may proceed through "natural selection" is an indeterminate quantity. If natural selection be the secondary cause that has determined the development of species, then its speed must have been inversely as the time in which it has operated. If time has been short, natural selection must either have been incompetent for the results, or have worked the faster. We do not know that any clue has been given as to the rapidity with which, in favorable circumstances, changes may proceed in species. Mr. Darwin insists, too strenuously perhaps, upon a very slow rate of variation. By a singular misnomer the school in geology led by Lyell, and of which Darwin's is the complement in natural history, was called uniformitarian, whereas both these distinguished authors emphasize not so much the uniformity of the past as the instability of the present. Time can easily be eliminated when cause and effect are brought into line. It must be admitted that geological measures of time are very indefinite and unsatisfactory.

Without dispute, however, geology opens up an expanse of time through which plants and animals have lived that is ample enough for almost any purpose. The geological succession of the earth's strata extends the present order of things back to a point that is far out of sight. Darwin may with confidence claim one hundred million years, and without much fear of contradiction, five times that period, as a field in which his law may have operated. As near as we can ascertain, we are in the middle of duration, and God has been no more pressed for time in which to do his work in the past than he is to be for the future. God is as prodigal of time as of space, and to appearance has shown himself as little concerned about the fate of the mere forms of life that have in succession inhabited the world, as about the quantity of dirt it has required to make the world; though doubtless, before divine omniscience, every hair of each minutest insect has its place in the general scheme of organic development, and every grain of sand on the surface has been weighed.

As a single illustration of the demands which geology makes upon us for time, it is enough to refer to the great gorge of the Colorado.[1] "This Cañon is three hundred miles long, and has walls of rock three thousand to six thousand feet high. The walls are sections of nearly horizontal strata, ranging for the principal part of their extent from the granite to the top of the carboniferous, and higher up the stream to the top of the cretaceous; and the whole bears undoubted evidence, according to Newberry, that it was made by running water. The granite has been excavated in some places to a depth of nearly one thousand feet; above this there are two thousand to two thousand five hundred feet of Palaeozoic sandstones, shales, and limestones, one thousand feet of probably subcarboniferous limestone, and one thousand two hundred feet of Carboniferous sandstones and limestones." This enormous gorge must have been principally worn out since the beginning of the Tertiary period, for very little progress could have been made before the elevation of the mountains of that region which bear upon their shoulders the Cretaceous formation. If we suppose the erosion to have proceeded at the rate of one inch a year, it would place the beginning of the Tertiary period more than twenty million years ago. That is, this period would have elapsed since there are known to have existed a number of species of animals (Palaeothere, Lophiodon) closely allied to the horse and the hog (Hieracothere, Chaeropotamus), also those that partook of characteristics between the Pachyderms and the stag among Ruminants (as the Anoplothere and Dichobune). "There were also monkeys, bats, deer, and opossums in England and France, although in the present age there are no opossums out of America, and monkeys are confined to the tropical zones." It is evident that the rate of change required to pass during such a period from the Palaeotherium to the horse and from Chaeropotamus to the hog might be very slow. Reflection on the vastness of these pre-historic ages does much to smooth the way for the acceptance of such a

[1] Dana's Manual of Geology (1st ed.), p. 569. The account is not materially different in the 2d edition.

theory as that of Darwin. Time is one factor; change is another. To produce a given result each would vary inversely as the other. As we pass into the period preceding the Tertiary the vistas of time recede in increasing ratio to the beginning of organic existence. During this period positive evidence concerning the plasticity of the existing species diminishes, while there is a corresponding increase of the unknown element of time and physical change. The more cautious scientific men pause before venturing far into the mazes of primordial time.

XX. Conspectus.

Setting out from that period when the Creator first breathed life into one, or, more probably, four or five, distinct forms, Mr. Darwin supposes the development to have been something as follows:

A vast, extremely complicated, and inscrutable environment of physical forces has furnished both material and limits to the development of organic life. The generic thread of life has been continuous from its introduction to the present day. Species in every part of their organism were endowed with an indefinite and imperfectly understood power of variability. Those variations which were best fitted to the changing conditions of their existence have of course survived. The conditions favoring the existence of a divergence from the type may continue so long that new species shall result. The qualities required to give a new variety the advantage in the struggle for life are as varied as the whole range of organic functions, of animal impulse, and of social instinct. "Utility" has as broad a meaning in Darwin's law of natural selection as "desire" has in systems of ethics or political economy. Desire ranges from the brutal instincts of the savage to the loftiest aspiration of the philosopher or the Christian martyr. The conclusions of the science of political economy are as indefinite as its basis of desire is broad. In like manner the superstructure of Darwin's evolutionary hypothesis must be as indeterminate as its base of utility is comprehensive. The preservation of a divergent

variety may depend on its own absolute completeness for the struggle, or on the comparative weakness of its competitors. It may depend on gigantic stature or diminutive littleness, on endurance or alertness, on boldness or timidity, on acuteness or stupidity. The range of social and sexual instinct is also exceedingly wide. We give the logical chain according to Wallace,[1] Organisms tend to a rapid increase, while the total number of individuals is stationary: this induces a struggle for existence, which combined with "heredity and variation," results in the "survival of the fittest"; this, combined with "unceasing change of external conditions," secures changes of organic forms, of such degree and permanency that they are called specific; thus *Species* may originate.

On the supposition of a preponderance of land during an early period in the Southern hemisphere, analogous to that which now exists in the Northern, many of the anomalous facts of the distribution of species, and the retention of old forms of life in the isolated centres of the South, will approach solution.

Through the discovery of connecting links, and fresh investigation of the facts bearing upon the distribution, gradation, and variability of species, much presumptive proof of the evolution of species has accumulated. What was required, and what "natural selection" has to some extent supplied, was not so much additional positive arguments, as the production of a theory which should not in its mode of operation do violence to the facts pointing so strongly in an opposite direction. A secondary cause, known to operate within certain limits, and which may have operated through the whole extent of organic life, and bound all species of an order into a united whole is brought to light. It is endeavored thus to put the advocates of the independent creation of species on the defence, and to throw the burden of proof upon those who deny the organic unity of the animal and vegetable creation. Of the defences put forth for the old-time view of the manner of the production of species we will speak in a succeeding Article.

[1] Con. Theory Nat. Selec., p. 302.