Theistic evolution catholic answers

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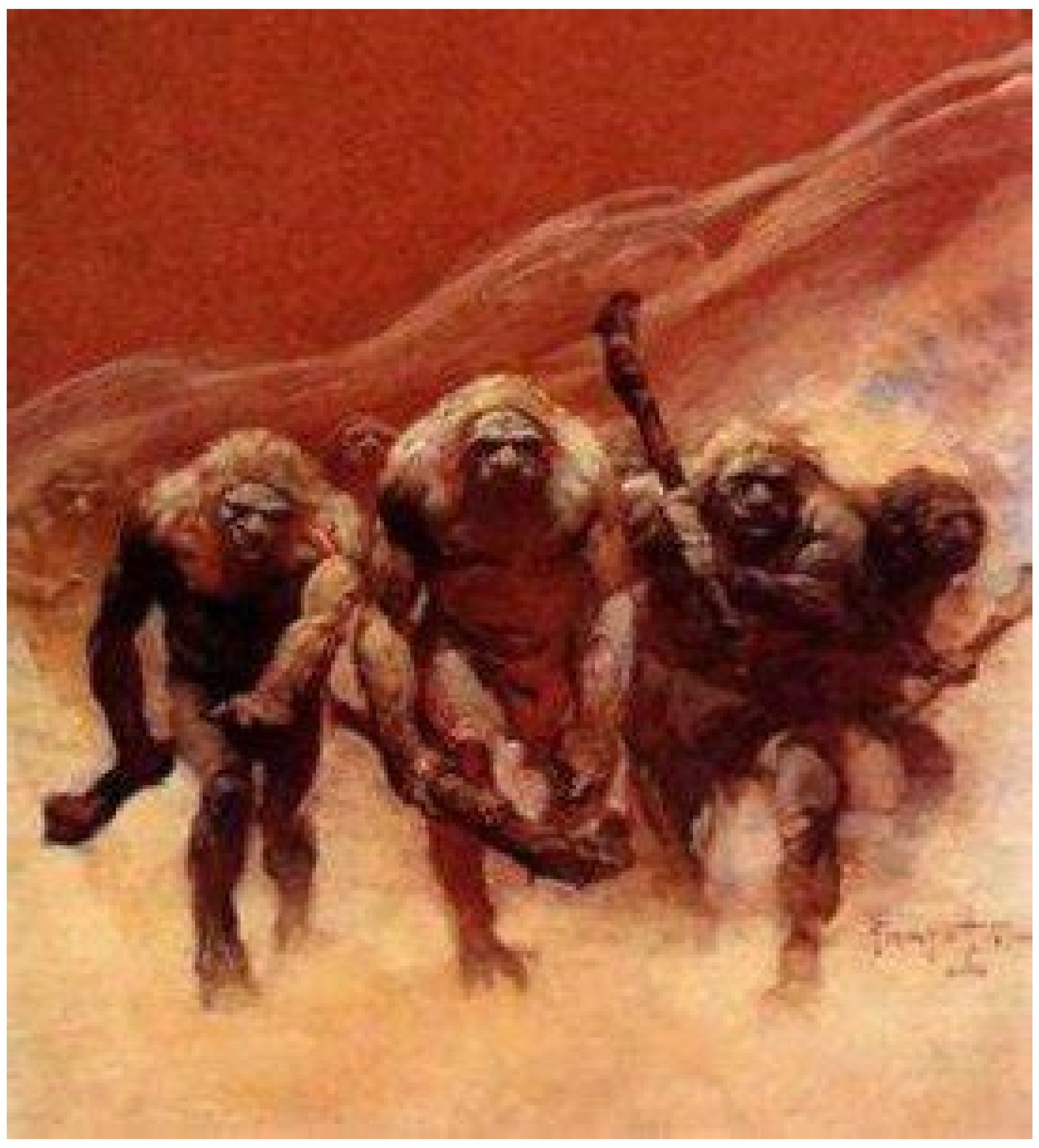

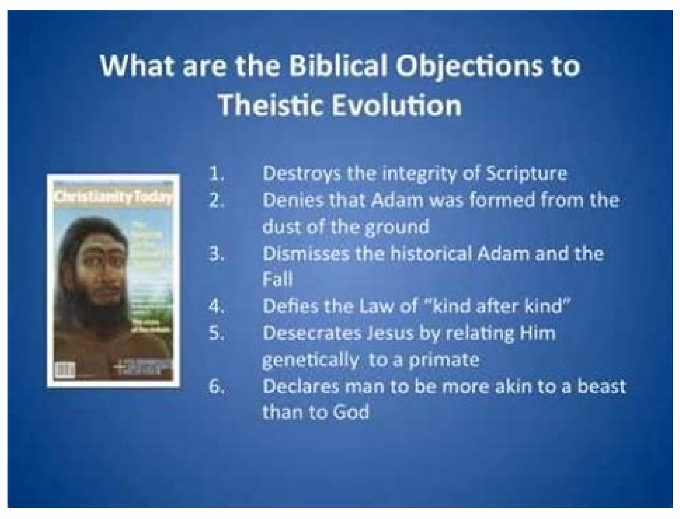

Theistic evolution catholic. Catholic answers theory of evolution. Catholic answers evolution.

How far is the theory of evolution based on observed facts? It is understood to be still only an hypothesis. The formation of new species is directly observed in but a few cases, and only with reference to such forms as are closely related to each other; for instance, the systematic species of the plant-genus Oenothera, and of the beetle-genus Dinarda. It is, however, not difficult to furnish an indirect proof of great probability for the genetic relation of many systematic species to each other and to fossil forms, as in the genetic development of the horse (Equidae), of ammonites, and of many insects, especially of those that dwell as "guests" with ants and termites, and have adapted themselves in many ways to their hosts. Upon comparing the scientific proofs for the probability of the theory of evolution, we find that they grow the more numerous and weighty, the smaller the circle of forms under consideration, but become weaker and weaker, if we include a greater number of forms, such as are comprised in a class or in a sub-kingdom. There is, in fact, no evidence whatever for the common genetic descent of all plants and animals from a single primitive organism. Hence the greater number of botanists and zoologists regard a polygenetic (poly-phyletic) evolution as much more acceptable than a monogenetic (monophyletic). At present, however, it is impossible to decide how many independent genetic series must be assumed in the animal and vegetable kingdoms. This is the gist of the theory of evolution as a scientific hypothesis. It is in perfect agreement with the Christian conception of the universe; for Scripture does not tell us in what form the present species of plants and of animals were originally created by God. As early as 1877 Knabenbauer stated "that there is no objection, so far as faith is concerned, to assuming the descent of all plant and animal species from a few types" (Stimmen aus Maria Laach, XIII, p. 72). Passing now to the theory of evolution as a philosophical speculation, the history of the plant and animal kingdoms upon our globe is but a small part of the history of the entire earth. Similarly, the geological development of our earth constitutes but a small part of the history of the solar system and of the universe. The theory of evolution as a philosophical conception considers the entire history of the cosmos as an harmonious development, brought about by natural laws. This conception is in agreement with the Christian view of the universe. God is the Creator of heaven and earth. If God produced the universe by a single creative act of His will, then its natural development by laws implanted in it by the Creator is to the greater glory of His Divine power and wisdom. St. Thomas says: "The potency of a cause is the greater, the more remote the effects to which it extends" (Summa c. Gent., III, c. lxxvii); and Suarez: "God does not interfere directly with the natural order, where secondary causes suffice to produce the intended effect" (De opere sex dierum, II, c. x, n. 13). In the light of this principle of the Christian interpretation of nature, the history of the animal and vegetable kingdoms on our planet is, as it were, a versicle in a volume of a million pages in which the natural development of the cosmos is described, and upon whose title-page is written: "In the beginning God created heaven and earth." (2) The theory of evolution just stated rests on a theistic foundation. In contradistinction to this is another theory resting on a materialistic and atheistic basis, the first principle of which is the denial of a personal Creator. This atheistic theory of evolution is ineffectual to account for the first beginning of the cosmos or for the law of its evolution, since it acknowledges neither creator nor lawgiver. Natural science, moreover, has proved that spontaneous generation—i.e. the independent genesis of a living being from non-living matter—contradicts the facts of observation. For this reason the theistic theory of evolution postulates an intervention on the part of the Creator in the production of the first organisms. When and how the first seeds of life were implanted in matter, we, indeed, do not know. The Christian theory of evolution also demands a creative act for the origin of the human soul, since the soul cannot have its origin in matter. The atheistic theory of evolution, on the contrary, rejects the assumption of a soul separate from matter, and thereby sinks into blank materialism. (3) Darwinism and the theory of evolution are by no means equivalent conceptions. The theory of evolution was propounded before Charles Darwin's time, by Lamarck (1809) and Geoffroy de Saint-Hilaire. Darwin, in 1859, gave it a new form by endeavoring to explain the origin of species by means of natural selection. According to this theory the breeding of new species depends on the survival of the fittest in the struggle for existence. The Darwinian theory of selection is Darwinism—adhering to the narrower, and accurate, sense of the word. As a theory, it is scientifically inadequate, since it does not account for the origin of attributes fitted to the purpose, which must be referred back to the interior, original causes of evolution. Haeckel, with other materialists, has enlarged this selection theory of Darwin's into a philosophical world-idea, by attempting to account for the whole evolution of the cosmos by means of the chance survival of the fittest. This theory is Darwinism in the secondary, and wider, sense of the word. It is that atheistical form of the theory of evolution which was shown above—under (2)—to be untenable. The third signification of the term Darwinism arose from the application of the theory of selection to man, which is likewise impossible of acceptance. In the fourth place, Darwinism frequently stands, in popular usage, for the theory of evolution in general. This use of the word rests on an evident confusion of ideas, and must therefore be set aside. To what extent is the theory of evolution applicable to man?—That God should have made use of natural, evolutionary, original causes in the production of man's body, is per se not improbable, and was propounded by St. Augustine (see St. Augustine of Hippo. under V. Augustinism in History). The actual proofs of the descent of man's body from animals is, however, inadequate, especially in respect to palaeontology. And the human soul could not have been derived through natural evolution from that of the brute, since it is of a spiritual nature; for which reason we must refer its origin to a creative act on the part of God. E. WASMAN. B. HISTORY AND SCIENTIFIC FOUNDATIONS.—The world of organisms comprises a great system of individual forms generally classified according to structural resemblances into kingdoms, classes, orders, families, genera, species. The species is considered as the unit of the system. It is designated by a double name, the first of which indicates the genus, e.g. canis familiaris, the dog, and canis lupus, the wolf. Comparing the species of the present day with their fossil representatives in the geological layers, we find that they differ from one another the more the farther we retrace the geological record. To explain this remarkable fact two theories have been proposed, the one maintaining the stability and special creation of species, the other the instability and evolution, or genetic relation, of species. As is plain from the preceding section of this article, the principal difference between the two theories consists in this: that the theory of evolution derives the species of today by a progressive development from one or more primitive types, whilst the theory of constancy insists upon the special creation of each true species. It is generally admitted that the determination of specific forms depends largely on the subjective views and experience of the naturalist. We shall here confine our attention to the history and scientific foundations of the biological theory of evolution, leaving all purely philosophical and theological discussions to others. The entire subject will here be divided into the following parts: I. HISTORY OF THE SCIENTIFIC THEORIES OF EVOLUTION; II. DEFINITION OF SPECIES; III. VARIABILITY AND EXPERIMENTAL FACTS RELATING TO THE EVOLUTION OF SPECIES; IV. THE PALIEONTOLOGICAL ARGUMENT; V. THE MORPHOLOGICAL ARGUMENT; VI. THE ONTOGENETIC ARGUMENT; VII. THE BIOGEOGRAPHICAL ARGUMENT. Before we begin, we wish to remind the reader of the important distinction brought out in the preceding essay, that the general theory referring to the mere fact of evolution must be well distinguished from all special theories which attempt to explain the assumed fact by ascribing it to certain causes, such as natural selection, the influence of environment, and the like. In other words, an evolutionist—that is, a defender of the general scientific theory of evolution—is not eo ipso a Darwinian, or a Lamarckian, or an adherent of any special evolutionary system. No less important are the other definitions and distinctions emphasized above under A. I. HISTORY OF THE SCIENTIFIC THEORIES OF EVOLUTION.—The historical development of the scientific theories of evolution may be divided into three periods. The main figure of the first period is Lamarck. The period ends with an almost complete victory of the theory of constancy (1830). The second period commences with Darwin's "Origin of Species" (1859). The idea of evolution, and in particular Darwin's theory of natural selection, enters into every department of the biological sciences and to a great extent transforms them. The third period is a time of critical reaction. Natural selection is generally considered as insufficient to explain the origin of new characters, while the ideas of Lamarck and G. Saint-Hilaire become prevalent. Besides, the theory of evolution is tested experimentally. Typical representatives of the period are Bateson, Hugo de Vries, Morgan. First Period.—Linnaeus based his important "Systema naturae" on the principle of the constancy and special creation of every species—"Species tot numeramus quot diversae formae in principio sunt creatae" ("Philosophia botanica", Stockholm, 1751, p. 99). For, "contemplating the works of God, it is plain to every one that organisms produce offspring perfectly similar to the parents" ("Systema", Leipzig, 1748, p. 21). Linnaeus had a vast influence upon the naturalists of his time. Thus his principle of the constancy of species was universally acknowledged, and this all the more because it seemed to be connected with the first chapter of the Bible. Georges Louis Leclerc Buffon (1707-88), the "suggestive" author of the "Histoire naturelle generale et particuhere", was the first to dispute the Linnaean dogma on scientific grounds. Till 1761 he had defended the theory of constancy, but he then became an extreme evolutionist, and finally held that through the direct influence of environment species could undergo manifold modifications of structure. Similar views were expressed by the German Gottfried Reinhold Treviranus in his work "Biologie oder Philosophie der lebenden Natur" (1802), and by "the poet of evolution", J. W. Goethe (1749-1832). However, none of these men worked out the details of a definite theory. The same must be said of the grandfather of Charles Darwin, Erasmus Darwin (1731-1802), physician, poet, and naturalist, the first who seems to have anticipated Lamarck's main views. "All animals undergo transformations which are in part produced by their own exertions in response to pleasures and pains, and many of these acquired forms and propensities are transmitted to their posterity" (Zoonomia, 1794). Jean-Baptiste de Lamarck (b. 1744) was the scientific founder of the modern theory of evolution and its special form, known as Lamarckism. At the age of forty-nine Lamarck was elected professor of invertebrate zoology at the Jardin des Plantes (Paris). In 1819 he became completely blind, and died ten years later in great poverty and neglected by his contemporaries, socially and scientifically. The main ideas of his theory are contained in his "Philosophie zoologique" (1809) and his "Histoire des animaux sans vertebres" (1816-22). Lamarck disputes the immutability of specific characters, and denies that there is any objective criterion for determining, with any degree of accuracy, which forms ought to be considered as true species. Consequently, according to him, the name species has only a relative value. It refers to a collection of similar individuals "que la generation perpetue dans le meme etat tant que les circonstances de leur situation ne changent pas assez pour fair varier leurs habitudes, leur caractere et leur forme" (Phil. zool., I, p. 75). But how are species transformed into new species? As to plants, Lamarck believes that all changes of structure and function are due to the direct influence of environment. In animals the changed conditions of the environment first call forth new wants and new activities. New habits and instincts will be produced, and through use and disuse organs may be strengthened or weakened, newly adapted to the requirements of new functions, or made to disappear. The acquired changes are handed down to the offspring by the strong principle of inheritance. Thus the web in the feet of water birds was acquired through use, while the so-called rudimentary organs, e.g. the teeth of the baleen whale, the small eyes of the mole, were reduced to their imperfect condition through disuse. Lamarck did not include the origin of man in his system. He expressed his belief in abiogenesis, but he maintained at the same time that "rien n'existe que par la volonte du sublime Auteur de toutes choses" (Phil. zool., I, p. 56). Lamarck's theory was not sufficiently supported by facts. Besides, it offered no satisfactory explanation of the origin and development of new organs, though he did not ascribe the effect to a mere wish of the animal. Finally, he offered no proof whatever for his position that acquired characters are inherited. Lamarck had very little influence upon his own time. Shortly after his death the famous discussion took place between Geoffroy Saint-Hilaire and Cuvier. As professor of vertebrate zoology Saint-Hilaire (1772-1844) had long been the colleague of Lamarck. Saint-Hilaire held the mutability of species, but ascribed the main influence in its evolution to the monde ambiant". Besides, in order to account for the discontinuity of species, he imagined that the environment could produce sudden changes in the specific characters of the embryo (Philosophie anatomique, 1818). In 1830 G. Saint-Hilaire presented to the French Academy of Sciences his doctrine of the universal unity of plan and composition in the animal kingdom. Cuvier opposed it with his celebrated theory of the four "embranchements", and showed that his adversary had mistaken resemblance for unity. Cuvier brought convincing facts in support of his attitude; Saint-Hilaire did not. That settled the issue. The theory of evolution was officially abandoned. Naturalists left speculation and returned for a few decades to an almost exclusive study of positive facts. A single writer of some celebrity, Bory de Saint-Vincent (1780-1846), took up Lamarck's doctrines, but not without modifying them by insisting upon the final constancy of specific characters through heredity. Isidore Saint-Hilaire (1805-61), who shared the views of his father concerning environment and heredity, defended a very moderate theory of evolution. He assumed a limited variability of species according to the variability of the environment. Second Period.—Charles Robert Darwin's book, on the "Origin of Species by means of natural selection or the preservation of favored races in the struggle for life", published November 24, 1859, marks a new epoch in the history of the evolution idea. Though the principal factors of Darwin's theory, namely "struggle, variation, selection", had been enunciated by others, it was mainly Darwin who first combined them into a system which he tried to support by an extensive empirical foundation. Assisted by a number of influential friends, he succeeded in obtaining an almost universal acknowledgment for the general theory of evolution, though his special theory of natural selection gradually lost much of the significance attached to it, especially by Darwin's extreme followers. Charles Robert Darwin was born at Shrewsbury, February 12, 1809. From 1831-36 he accompanied as naturalist an English scientific expedition to South America. In 1842 he retired to his villa at Down in Kent, where he wrote his numerous works. He died on April 19, 1882, and was buried in Westminster Abbey a few feet from the grave of Newton. Biogeographical observations on his voyage to South America led Darwin to abandon the theory of special creation. "I had been deeply impressed", he says in his Autobiography, "by discovering in the Pampean formation great fossil animals covered with armor like that on the existing armadillos; secondly by the manner in which closely allied animals replace one another in proceeding southward over the continent; and thirdly by the South American character of most of the productions of the Galapagos archipelago and more especially by the manner in which they differ slightly on each island of the group... It was evident that such facts could only be explained on the supposition that species gradually became modified." In order to account for the transformation, Darwin began with a systematic study of numerous facts referring to domesticated animals and cultivated plants. This was in July, 1837. He soon perceived that selection was the keystone of man's success in making useful races, namely, by breeding only from useful variations. But it remained a mystery to him how selections could be applied to organisms living in nature. In October, 1838, Darwin read Malthus's "Essay on Population" and understood at once that in the struggle for existence described by Malthus "favorable variations would tend to be preserved and unfavorable ones to be destroyed, and that the result of this selection or survival would be the formation of new species". The struggle itself appeared to him as a necessary consequence of the high rate at which organic beings tend to increase. The result of the selection—that is the survival of the fittest variations—was supposed to be transmitted and accumulated through the principle of inheritance. In this manner Darwin defined and tried to establish the theory of natural selection. Long after he had come to Down he added an important complement to it. The formation of new species implies that organic beings tend to diverge in character as they become modified. But how could this be explained? Darwin answered: Because the modified offspring of all dominant and increasing forms tend to become adapted to many and highly diversified places in the economy of nature. In short, according to Darwin, species are continuously transformed "by the preservation of such variations as arise and are beneficial to the being under its conditions of life", that is, by the survival of the fittest, which is to be considered "not the exclusive", but the "most important means of modification". As his studies and observations progressed, Darwin lost his almost exclusive belief in his own theory, as he held it in 1859, and gradually adopted, at least as secondary causes in the origin of species, the Lamarck factor of the inheritance of the effects of use and disuse and the Buffon factor of the direct action of the environment, especially in case of the geographical isolation of species. As to the human species, Darwin was, as early as 1837 or 1838, of the opinion that it was likewise no special creation, but a product of evolutionary processes. The numerous facts which, according to Darwin, might be adapted to substantiate his views are contained in his work, "The Descent of Man" (1871). As a supplementary work to "The Origin of Species", Darwin published, in 1868, "The Variation of Animals and Plants under Domestication", which contains many valuable facts and theoretical discussions concerning variation and heredity. The principle of natural selection is certainly a very useful factor in removing variations not well adapted to their surroundings, but the action is merely negative. The main point (that is the origin and teleological development of useful variations) is left untouched by the theory, as Darwin himself has indicated. Moreover, no proof is brought forward that variations must accumulate in the same direction and that the result must be a higher form of organization. On the contrary, as we shall point out below, the experimental evidence of the post-Darwinian period has failed to substantiate Darwin's claim. It is however well to note that Darwin did not wish to ascribe the origin and survival of useful variations to chance. That word, he declares, is a wholly incorrect expression which merely serves to acknowledge plainly our ignorance of the cause of each particular variation. Later on, it is true, he seems to have abandoned the idea of design. "The old argument", he says in his "Autobiography" (1876)..."fails, now that the law of natural selection has been discovered." Similarly, his belief in the existence of God, which was strong in him when he wrote the "Origin", seems to have vanished from his mind in the course of years. In 1874 he confessed: "I for one must be content to remain Agnostic". Of the numerous friends of Darwin who contributed so much to the development and spread of his theories, we mention in the first place Alfred Russel Wallace, whose essay on natural selection was read before the Linnaean Society, in London, July 1, 1858, together with Darwin's first essay on the subject. The main work of Wallace, "Darwinism, an Exposition of the Theory of Natural Selection with Some of its Applications" (1889), "treats the problem of the origin of species on the same general lines as were adopted by Darwin; but from the standpoint reached after nearly 30 years of discussion." In fact the book is a defense of pure Darwinism. Wallace, too, assumed the animal origin of man's bodily structure, but, contrary to Darwin, he ascribed the origin of man's "intellectual and moral faculties to the unseen Universe of spirit" (Darwinism). Thomas H. Huxley (1825-1895) was one of the most strenuous defenders of Darwin's views; his book on "Man's Place in Nature" (1863) is a defense of man's "Oneness with the brutes in structure and in substance". Besides Wallace and Huxley, there were the geologist Sir Charles Lyell, the zoologist Sir John Lubbock, and the botanists Asa Gray and J. D. Hooker, who supported Darwin's theory almost from the beginning. Quatrefages and Dana accepted it in part, but declared that there were no arguments in favor of the animal origin of man. Spencer's views are not very much different from those of Darwin's later years. Natural selection is more aptly called by him "the survival of the fittest" ("Principles of Biology", 1898, I, p. 530). Trying to harmonize the Lamarckian and Darwinian factors of evolution, he was among the first to defend the so-called neo-Lamarckian theory, which insists upon the direct influence of the environment and the inheritance of newly acquired characters. Before we enter upon the last phase in the development of the evolution idea, it is necessary to devote some space to the extreme defenders of Darwinism in Germany. Ernst Haeckel, of Jena, is in some sense the founder of the science of phylogeny, which seeks at least by way of hypothesis, to determine the genetic relation of past and present species. In 1868 Darwin wrote to Haeckel: "Your boldness makes me sometimes tremble". This refers especially to the phylogeny, which is in fact an aprioristic structure often contradicted, and at almost no point supported, by experiment and observation. The tetrahedral carbon atom is, according to Haeckel, the external fountain head of all organic life. Through abiogenesis certain most primitive organisms are said to have been formed, such as "moners", which Haeckel described as unicellular beings without structure and without any nuclear differentiation. During ages of unknown duration these simple masses of protoplasm have been evolved into higher plants and animals, man included. As one of his main arguments, Haeckel refers to the so-called "biogenetic law of development". The supposed law maintains that ontogeny is a short and rapid repetition of phylogeny, that is, the stages in the individual development of an organism correspond more or less to the stages which the species passed through in their evolution. The causes of development are, according to Haeckel, the same as were proposed by Darwin and by Lamarck; but Haeckel denies the existence of God and rejects the idea of teleology. Our leading scientists do not care to support the unfounded generalities of Haeckel's doctrines. They have even, most severely, but justly, censured Haeckel's scientific methods, mainly his frauds, his want of distinction between fact and hypothesis, his neglect to correct wrong statements, his disregard of facts not agreeing with his aprioristic conceptions and his unacquaintance with history, physics, and even modern biology. They have also pointed out that the biogenetic law of development is by no means a trustworthy guide in retracing the phylogenetic succession of species, and that many other theories suggested by Haeckel are without foundation. But above all we must reject Haeckel's popular writings because they contain numerous errors of every kind, and ridicule in a shameful manner the most sacred convictions and moral principles of Christianity. It is a sad fact, that especially through the influence of "Die Welträtsel" great harm was done to religion and morality, especially in Germany and in the English-speaking countries. The present leader of extreme Darwinism is August Weismann of Freiburg (Vorträge über Descendenztheorie, 2d ed., 1904), the energetic opponent of Lamarck's idea that acquired characters are inherited. According to Weismann, every individual and specific character which may be transmitted by heredity is preformed and prearranged in the architecture of certain ultra-microscopical particles composing the chromatin of the germ-cells. On account of qualitative differences the various groups of these ultimate particles or "biophores" have a different power of assimilation. Besides, they are present in different numbers. In consequence thereof an intracellular struggle for existence will arise, especially after the germ-cells are united in fertilization. The outcome of the struggle will be that the weaker particles always or at times succumb. Thus the principle of the survival of the fittest is transferred to the germ-cells. Weismann, moreover, admits an indirect influence of the environment upon the germ-cells. In order to account for the facts of regeneration and reorganization established by Driesch, Morgan, and others, Weismann appeals at times to unknown forces of vital affinities, without, however, dismissing his thoroughly materialistic and antiteleological suppositions. It will be superfluous to add that Weismann's theory is a mere hypothesis whose foundation can probably never be controlled by observation and experiment. But it must be acknowledged that Weismann was among the first to point out the intrinsic connection between the evolution of species and the science of the cell. As extreme scientific opponents of Darwinism and evolution we mention above all the botanist Albert Wiegand and the zoologist and palaeontologist Louis Agassiz, the well-known adversary of Asa Gray. These men produced many an excellent argument against the extreme defenders of pure Darwinism, but, probably by attending too much to the exceedingly weak foundations of the current theory of the general development by small changes, they rejected evolution almost entirely. The most recent representative of such extreme views is the zoologist Albert Fleischmann, who has become a complete scientific agnostic. Third Period.—The third period in the history of the biological evolution theory has only in recent years assumed the form which marks it as a new epoch. Its path was prepared by the fact that two classes of naturalists had in course of time been drawing nearer to one another. On the one hand were those whose work was merely critical, by discriminating clearly between Darwinism and evolution, and on the other hand those who gave their undivided attention to the work of experimental investigation. Only in recent years have the two classes joined hands and, in men like de Vries, Bateson, Morgan, have gained very efficient assistance. At the present time the greatest importance is laid on the explanation of the gaps in species, on the adaptation of organisms to environment, and on the inheritance of characters thus acquired, and above all on the idea of the segregation and the independence of biological characters, as was pointed out almost fifty years ago by Gregor Johann Mendel. As far back as 1865, K. von Nägeli decided in favor of the general theory of evolution and against Darwinism. According to him progressive evolution required intrinsic laws of development, which, however, as he added, were to be sought for in molecular forces. Natural selection alone could only eliminate, that is to say, could only explain the survival of the more useful, but not its origin. Like Spencer, Nägeli was a determined precursor of neo-Lamarckism. This theory, which is now defended by many evolutionists, attempts to reconcile Lamarck's principle of the use and disuse of organs with Saint-Hilaire's theory of the influence of external circumstances. There are many evolutionists, such as Th. Eimer, Packard, Cunningham, Cope, who defend this view. However, the experimental evidence for the foundation of neo-Lamarckism—namely, the inheritance of acquired characters—is still wanting, or at least strongly debated. Nägeli's most important work, "Mechamsch-physiologische Theorie der Abstammungslehre", appeared in 1884. The embryologist K. E. von Baer, who did not share the antiteleological views of Nägeli, opposed no less energetically Darwin's theory of natural selection, because, as he argued, that theory does not explain teleology and correlation, and is at the same time in contradiction to the persistence of species and varieties. He also vigorously controverted Haeckel's system, especially his biogenetic law of development. But he maintained the transformation of species within certain limits through the agency of gradual and sudden changes. This leads us to the theory of saltatory evolution which is today most strongly defended by Bateson, de Vries and others. Some of the first scientific expositors of this view were R. von Kolliker and St. George Mivart. In his work "On the Genesis of Species" (1871) Mivart proposed a number of convincing arguments against the opinion of the power of natural selection as a prevailing factor. According to him species are suddenly born and originate by some innate force, which works orderly and with design. Mivart concedes that external conditions play an important part in stimulating, evoking, and in some way determining evolutionary processes. But the transformation of species will mainly, if not exclusively, be produced by some constitutional affection of the generative system of the parental forms, an hypothesis which Mivart would extend also to the first genesis of the body of man. Hugo de Vries (Die Mutationstheorie, 1901-03) is, with Bateson, Reinke, and Morgan, a typical representative of the exponents of the modern theory of saltatory evolution. He first endeavored to show experimentally that new species cannot arise by selection. Then he attempted to demonstrate the origin of new forms by saltatory evolution. The principal illustration to establish his theory of "mutation" was the large flower, evening primrose (Enothera Lamarckiana). Th. H. Morgan ("Evolution and Adaptation", 1903) summarizes this view as follow "If we suppose that new mutations and ‚Äòdefinitely inherited variations suddenly appear, some of which will find an environment to which they are more or less well fitted, we can see how evolution may have gone on without assuming new species to have been formed through a process of competition. Nature's supreme test is survival. She makes new forms to bring them to this test through mutation and does not remodel old forms through a process of individual selection." We shall see that de Vries overrated the importance of his experiments. Still it is not to be denied that he has become through his method a master for the experimental investigation of the problems of evolution. Of especial value is his analysis of the concept of species, though probably his greatest service is the rediscovery of Mendel's laws and their introduction into the realm of biological investigations. The earliest forerunners of Mendel were the first scientific hybridists J. G. Köhlreuter (1733-1806) and T. A. Knight (1758-1838). Köhlreuter's results are of special interest because, through the repeated crossing of a hybrid with the pollen or ovules of one of the parents, forms appeared which more and more reverted to the characteristics of the respective parent. K. F. von Gärtner (1772-1850) was the most prolific writer on hybridism of his time, though he did not surpass Köhlreuter as to the positive results of his experimental research. C. Naudin's essay on the hybridity in plants (1862) represented a considerable advance. The author pointed out that the facts of the reversion of the hybrids to the specific forms of their parents, when repeatedly crossed with the latter, are naturally explained by the hypothesis of the segregation of the two specific essences in the pollen grains and ovules of the hybrids (Leek). This formed in after years no small part of Mendel's discovery, which is indeed one of the most brilliant results of experimental investigation. Gregor Mendel was born July 22, 1822, at Heinzendorf near Odrau (Austrian Silesia). After finishing his studies he entered, in 1843, the Augustinian monastery at Brünn. Having been for fourteen years professor of the natural sciences, he was elected abbot of the monastery in 1868, and died in January, 1884. Mendel's celebrated memoir, "Versuche über Pflanzenhybriden", appeared in 1865, but attracted little attention, and remained unknown and forgotten till 1900. It was based on experiments that had been carried out during the course of eight years on more than 10,000 plants. The principal result of these experiments was the recognition that the peculiarities of organisms produced entities independent of one another, so that they can be joined and separated in a regular way. As we have said above, H. de Vries was the first to recognize the value of Mendel's paper. Other investigators who have taken up the same line of work are Correns, Tschermak, Morgan, and, most of all, Bateson, the principal founder of "Mendelism", or the science of genetics. II. DEFINITION OF SPECIES.—Before Linnaeus's time genera were considered to be the units of the plant and animal kingdoms, and it was assumed these had been created by God, while the species were descended from them. By the nomen specificum was understood the more or less short description by which Tournefort and his contemporaries distinguished the various species of genera. Linnaeus introduced the binomial system establishing the species as the unit of the organic world. There are as many species as there were different forms created in the beginning. The same theoretical norm had already been adopted before Linnaeus by the English physician John Ray (died 1678). The practical criterion for determining genera and species was taken from characteristic morphological features. For instance, the essential generic characteristic of the quadrupeds was derived from the teeth; that of birds from the bill. The species was designated in a similar manner "by retaining the primary characteristic among the various differences which separated two individuals of the same species." The establishment therefore of a genus or of a species depended ultimately, then as now, on the knowledge and subjective views of the systematizer. The whole system was an artificial one precisely because it took note of one single feature alone, leaving the rest out of consideration; for instance, in the vegetable kingdom the character of the flower alone was taken into consideration. Later on Linnaeus entertained the idea that originally God created only one species of each genus, and that the rest had been derived from these original species by crossbreeding. Linnaeus's conception of species was strengthened by Georges Cuvier, who defended the unchangeableness of the categories beginning with the species up to the four types (embranchement). He was supported in this, as was later L. Agassiz, by the absolute dearth of intermediate forms in geological strata. Hence arose his Theory of Catastrophes, which in turn gave way to his Migration Theory. Cuvier came victorious out of the controversy with Etienne Geoffroy Saint-Hilaire, who maintained the unity of the plan of animal structure and the continuous transition of forms in the animal kingdom. The views prevailing under Linnaeus and Cuvier were then divided into two main branches. (I) The more moderate Transmutationists held that genera were the originally created units, and that from these all species and varieties were derived. (2) The followers of Linnaeus, on the other hand, affirmed that the Linnaean species were the created units, and the subdivisions of these were the derived ones. Then followed the Jordan schools, which asserted that within the Linnaean species were what they called "small species", individually variable, but specifically immutable (not connected by intermediate forms), and, as such, to be considered the true units or "elementary species". Linnaeus's Draba verna, for instance, comprehends about 200 "elementary species". The norm or criterion of the elementary species is the experimentally proved constancy of the features (it is quite immaterial how small they may be) during a series of generations. How are we to regard these opinions? Before answering this question we must strongly emphasize the fact that the biological idea of species has nothing whatever in common with the Scriptural conception or with that of Scholastic philosophy. The Mosaic story of Creation signifies nothing more than this, that ultimately all organisms owe their existence to the Creator of the world. The concrete how has nothing to do with the proposition of faith regarding creation. The enumeration of certain popular groups of organisms, such as fruit trees, draft-animals, and the like, could have no other design than to manifest to the simplest as well as to the most cultivated mind the action of the Creator of all things; at least, there can be no question of a scientific conception of genera and species. The biological concept of species is likewise removed from the philosophical concept which designates either the metaphysical or the physical species. The former is identical with the integra essentia (Urraburú)—"integral essence"—of a being; the latter is founded on the essence (fundatur in essentia—T. Pesch), and is to be recognized by some attribute (gradus alicujus perfections) which remains constant and unchangeable in every individual of every generation and so appears to be necessarily connected with the most intimate essence of the organism (necessario cum rei naturae connecti—Haan). The concept, therefore, of species according to Holy Scripture, Philosophy, and Science, is by no means a synonymous one for the natural units of the organic world. And particularly, the first chapter of Genesis should not be brought into connection with Linnaeus's "Systema naturae". As far as the biological concept of species is concerned there is not up to the present time any decisive criterion by which we may determine in practice whether a given group of organisms constitute a particular species or not. Genuine species are differentiated from one another by the fact of their possessing some important morphological difference which remains constant during a series of generations without the production of any intermediate form. If the differences are of less importance, but constant, we speak of subspecies (elementary species, Jordan species), while intermediate forms and all deviations which are not strictly constant are set down as varieties. Are such distinctions and criteria acceptable? Expressions such as "considerable", "essential", "more or less considerable" signify relative propositions. Hence it follows that the morphological determination of species depends to a great extent on the subjective estimate of the naturalist and on his intimate knowledge of the geographical distribution and habits of the organism concerned. In fact, the force of the term species differs greatly in the different classes of organisms. On this account the fact that species do not crossbreed, or at least that after a cross they do not produce fertile descendants, was added as an auxiliary criterion. This criterion, however, is an impracticable one in the case of palaeontological species, and in the plant world in particular has many exceptions. In botany, therefore, the auxiliary criterion has been limited in the sense that within the species itself the fertility always maintains the same general level, while by the crossing of different species it diminishes very materially—propositions which do not admit of conversion and in their generalization can scarcely be called correct. Consequently, it would almost appear that Darwin was right when he said that the idea of species was "undefinable". Still, it is not to be denied that there are in nature definite and often important gradations and gaps by which the "good species", in contra-distinction to the "bad species", are separated from one another. The same is also proved by the modern "mutation theories" which, on account of unconnected differences, admit a development of species by jumps. The Darwinian principle of indefinite variability is contrary to facts, which in general show that, both in living nature and in geological strata, there exist types sharply discriminated from one another. However, it is quite impossible to say how many types compose the organic world. It will be the task of future research to determine the affinity which exists between the various groups of organisms, beginning with the lower limit of similar subspecies and ascending to the highest forms whose common ancestry can be proved. These highest forms, which per se have nothing in common with the Linnaean species or genera, or with any other systematic groups, are the true units of nature; for they are composed of those organisms only which are related among themselves without being connected with the rest by common descent. We may, if we wish, identify these highest units with Wasmann's "natural species", or primeval ancestral forms, but, according to our opinion, neither the Linnaean species nor any other of the so-called systematic groups can be considered as the natural subdivisions of it. The Linnaean species are indeed indispensable for an intelligible classification of organisms, but they are not suitable for the solution of the problem of development. In concluding this section we may add that the best example of a natural species, and one ratified by revelation, is the species Man, which, by reason of its wide range of variation and the relative constancy of its races, may offer many a happy point of comparison for defining the limits of the species in the vegetable and animal kingdoms. In the following sections we shall see that there cannot be any doubt as to the evolution of species, if by species we understand such groups of organisms as are generally styled by botanists and zoologists systematic, or Linnaean, species. But if by the term species we are to understand groups of organisms whose range of variability would correspond to that of "the human species", then we believe that up to the present day there are no clear facts in favor of specific evolution. In particular, it will be seen that thus far there is no evidence of fact as to an ascending development of organic forms, though we do not deny the possibility of it provided an innate power of development be assumed, which operates teleologically. III. VARIATION AND EXPERIMENTAL FACTS RELATING TO THE EVOLUTION OF SPECIES.—By variation we generally understand three groups of phenomena: (I) individual differences; (2) single variations; (3) forms produced by crossing and Mendelian segregation. The question is, what influence these variations actually have on the formation of species. (I) Individual Differences. Individual differences include all fluctuating inequalities of an individual and of its organs—e.g., the size of the leaves of a tree, the percentage of sugar contained in the beet, and even more important morphological and physiological features. These differences may be quantitative according to size and weight), meristic (as to numbers), and individually quantitative (e.g., the mountain and valley forms of a plant). They are generally recognized from the fact that they oscillate around a certain mean, from which they deviate in inverse proportion to their frequency, a rule which primarily pertains only to quantitative differences. According to Darwinians, useful individual differences can be increased indefinitely by selection and may finally become independent of it. In this manner new species would result: Darwin himself sometimes considered single variations as of greater importance. The same view is strongly defended by modern evolutionists, who defend, at the same time, a direct influence of environment to which an organism adapts itself. In order first of all to obtain a just estimate of the influence of selection, it must be pointed out that not everything that is attributed to selection has originated through selection. The origin of many pure breeds (e.g., of pigeons) is unknown, and cannot therefore without further investigation be ascribed to selection. Furthermore, many cultivated forms have arisen through crosses and segregation of characters, but not through merely strengthening individual characters. If we restrict our examination only to well attested facts, we find, first, that nothing new is brought about by selection; secondly that the maximum amount in quantitative modification is obtained in a few generations (mostly in three to five) and that this amount can only be maintained through constant selection. In case selection is stopped, a regression will follow proportional to the length of time required for the progress. In short, as far as facts teach us, new species do not arise by selection. But if qualitative changes were produced by some other cause, selection would probably be a potent principle in order to explain why some peculiarities survive and others disappear. The question is: Whether changes in the environment may furnish such a cause. There can be no doubt that the environment does influence organisms and mould them in many ways. As proof of this we need only draw attention to the different forms of Alpine and valley plants, to the formation of the leaves of plants according to the humidity, shadiness, or sunniness of the habitat, to the influence of light and temperature on the formation of pigment and coloring of the surface, to the strange and considerable differences produced, for instance, in knot-weeds by merely changing the environment, and so forth. But as far as actual experiments show, the changes of characteristics and niceties of adaptation go to and fro, as it were, without transgressing definite ranges of variation. Moreover, it is not at all clear how discontinuity of species could have arisen "by a continuous environment, whether acting directly, as Lamarck would have it, or as a selective agent, as Darwin would have it" (Bateson), unless one takes into account the accidental destruction and isolation of intermediate forms. In spite of these conclusions it has been assumed that individual differences might lead to the formation of new species under the continuous influence of natural selection. Wasmann's well-known Dinardaforms may serve as an example. The four forms of the rove-beetle, Dinarda, namely D. Märkeli, D. dentata, D. Hagensi and D. pygmoea, bear a certain relation with regard to size to the four forms of ants, Formica rufa, sanguinea, exsecta, fusco-rufibarbis, and to their nests, in which they live as tolerated guests. D. Märlceli, which is 5 mm. long, dwells with F. rufa, which is comparatively large and builds spacious hill-nests. D. dentata, which is 4 mm. long, lives with F. sanguinea, which is comparatively large, but builds small earth-nests. D. Hagensi, which is 3-4 mm. long, lives with F. exsecta, which is smaller than F. sanguinea, but builds a fairly roomy hill-nest. D. pygmoea, which is 3 mm. long, lives with F. fusco-rufibarbis, which is relatively small and builds small earth-nests. Moreover, the three first-named ants are two-colored (red and black), and so are the corresponding Dinarda. The last-named ant, however, is of a more uniform dark color, as is also the corresponding Dinarda. Now comparative zoo-geography contains some indications according to which the similarity of color and proportion of size must be attributed to actual adaptation. For (I) there are regions in Central Europe in which only F. sanguinea with D. dentata, and F. rufa with D. Märkeli are found, whereas F. exsecta and F. rufibarbis do not harbor any Dinardaforms at all. Secondly, there are districts in which the four forms of Dinarda are living with their four hosts and yet hardly ever showing transitional forms. Thirdly, in other parts there are more or less continuous intermediate forms, D. dentata-Hagensi living with F. exsecta, and D. Hagensi-pygmoea living with F. fusco-rufibarbis. The nearer a Dinarda approaches the form of D. pygmcea, the more frequently it is found with F. fusco-rufibarbis. To all this must be added, that the adaptation in general appears to have kept pace with the historical freeing of Central Europe from ice, though numerous exceptions must be explained by local circumstances, especially by isolation. Considering these facts, we are inclined to believe that D. pygmoea especially presents an example of real adaptation in fieri, though this adaptation cannot be called a progressive one, since the more recent forms, Hagensi and pygmoea, are only smaller in size and of a more uniform color. But at the same time it seems to us that the adaptation of the Dinarda cannot be considered as an example to illustrate specific evolution, because, as we have shown elsewhere, there are many instances in nature—we mention only the races and other subdivisions of the human species—that like-wise present different degrees of adaptation far more pronounced than that found in the Dinarda, but which are not, and cannot on that account be, quoted as examples of the formation of new specific characters. (2) Single Variations are presumably of far greater importance for the solution of the evolution problem than individual differences; for they are discontinuous and constant, and are therefore capable of explaining the gaps between existing species and those of paleontology. We use the term single variation when, from among a large number of offspring, some one particular individual stands out that differs from the rest in one or more characteristics which it transmits unchanged to posterity. It is said to be peculiar to the single variations that they cannot be reduced to crosses. If this is possible, we speak of "analytical variations". Favorable conditions for the appearance of single variations are altered environment, a liberal sowing of seed, and excellent nourishment. It is a remarkable fact that the fertility of single variations decreases considerably, and this the more so the greater the deviation from the parents. Besides, the newly produced forms are comparatively weak. This weakness and inclination to sterility are facts which must be carefully weighed when determining the probable importance of single variations for specific evolution. Besides, it is—to our knowledge—in no case excluded that the suddenly arising form may be traced back to former crossings. Probably the only case which is quite generally interpreted to demonstrate specific evolution experimentally is that of the primrose observed by de Vries. After many failures with more than 100 species, de Vries, in 1886, determined to cultivate the evening primrose (Enothera Lamarckiana), whose extraordinary fertility had attracted his attention. He chose nine well-developed specimens and transplanted them into the Botanical Garden of Amsterdam. The cultivation was at first continued through eight generations. In all he examined 50,000 plants, among which he discovered 800 deviating specimens, which could be arranged in seven different groups. The specimen of O. gigas (1895) was self-fertilized and yielded 450 O. gigas forms, among which there was only one dwarf form, O. gigas-nanella. The three following generations remained constant. O. albida was a very sickly form, though it succeeded, thanks to regular attention, in breeding constant offspring. Among the O. oblonga descendants there was one specimen albida, and in a later generation one specimen of O. rubrinervis. O. rubrinervis proved to be as fertile as Lamarckiana, and yielded besides a new variation, leptocarpa. The offspring of O. nanella was constant, though among the 1800 descendants of nanella in 1896 three specimens showed oblonga characteristics. O. lata was purely female; but, fertilized with pollen of other variants, it yielded 15 to 20 per cent O. lata descendants. O. scintillans was not constant. According to de Vries observations (since 1886), new forms also originated in nature, but they succumbed in the struggle for existence. The differences between the single forms relate to various parts and degrees of development, though in several they are very slight. The plants become either stronger or weaker, with broader or narrower leaves; the flowers become larger and darker yellow, or smaller and lighter, the fruit longer or shorter, the outer skin rougher or smoother, etc. It may be conceded that the Oenothera has developed constant forms corresponding to the so-called "small or elementary species". The question, however, is, whether the forms are really new ones or whether they owe their origin to some unexpected original cross. In fact, if we are to suppose a previous cross, perhaps O. Lamarckiana and O. sublinearis, then the O. Lamarckiana of Hilversum had contained the different variations in a latent form and through cultivation gradually reverted by throwing off the different variations. At any rate, there cannot be any question of a progressive development, for the reason that none of the new forms shows the slightest progress in organization or even development of any kind advancing in that direction. (3) Crosses and Mendelian Segregations. Crossbreeding can in nature hardly be considered as a factor in the progressive development of species; in particular, forms of different degrees of organization do not cross, and if they did, all deviations would soon be equalized according to the laws of chance and probability. All the greater seems to be the importance of the Mendelian segregations. It may be known to the reader that the famous experiments of the Abbot Mendel were carried on with seven different pairs of characters which he crossed with one another, and then, by letting the crossbreds self-fertilize, he continued the cultivation of the plants through a series of generations. In the first generation it was found that the offspring exhibited without exception the character of one of the parents, that of the other parent not appearing at all. Mendel therefore called the former—the prevailing—character the "dominant" and the other the "recessive". In the following generation, which was produced by letting the crossbreds fertilize themselves, the recessive character appeared and, moreover, in a definite proportion. On an average this proportion was 2.89:1 or 3:1. In the second generation 75 per cent of the whole number of plants exhibited the dominant character and 25 per cent the recessive. No intermediate forms were observed in any case. In the third generation the offspring of the recessives was constant and remained pure recessives, but among the offspring of the dominants some remained constant dominants, while others were hybrids. The average proportion of the constant dominants (D) to variable crossbreds (DR) was as 1:2. Thus, besides the 25 per cent of constant recessives (R), there was also 25 per cent (one-third of 75 per cent) variable crossbreds (DR) or 1D+2DR+1R. The same proportion resulted from the following generations of the crossbreds, and since 1900 this has been confirmed by other investigators in the case of other plants (e.g. maize) and also of animals (e.g. gray and white mice). Mendels rule of segregation, therefore, runs thus: The hybrids of any two different characters produce seeds, one half of which again develop the hybrid forms, while the other half yield offspring which remains constant, and possess the dominant and recessive characters in equal proportion. A simple analysis of this rule shows that it consists of three parts: (a) By fertilization the characters of the parents are united, without, however, thereby losing their purity and independence; (b) In the offspring the characters of both parents may again be separated from each other; (c) The character of one of the parents may completely conceal that of the other. This last part of the rule is not, according to later investigators, necessarily connected with the other two parts. We may add that Mendel's rule also holds good for the offspring of hybrids, in which several constant characters are combined, and that in it there is found a splendid confirmation of the modern theory of the cell. Crossbreeding, therefore, does not by any means lead to the mixing of characteristics. These, on the contrary, remain pure, or, at most, form new combinations or split up into simpler components. Hence, the idea that gaps in nature originate through such segregation is well founded. But the question, whether the idea is to be applied to the formation of species, and how this is to be carried out, can scarcely be answered at present. This much, however, is evident: that there is no progress in organization any more than there is any progressive specific development, brought about by segregation. Hence this important conclusion follows: That the central idea of modern evolution theories—namely, progressive specific development—has not up to the present received any confirmation from observation of the world of organisms as it now exists. It is quite true, however, that the plasticity of organisms has been proved by a number of experiments to be very considerable; so that, in a constant environment, and by single variations, changes may be brought about which a systematist would classify as specific or even generic, if it were not clear from other sources that they are not such. In the same way forms could be developed by segregation, the characteristics of which would suffice "to constitute specific differences in the eyes of most systematists, were the plants or animals brought home by collectors" (Bateson). Yet such criteria are meaningless for the demonstration of the formation of species. The question as to the transmission of acquired characters is not by any means decided. It follows from the doctrine of propagation that only such characters can be transmitted as are contained in the germ-cells or which have been either directly or indirectly transmitted to them. Hence it is clear that all peculiarities acquired by the cells of the body through the influence of environment, or by use or disuse, can only be inherited if they are handed over, as it were, to the germ-cells. But it is useless to discuss the question before we have sufficient experimental evidence that acquired characters are at all inherited. IV. THE PALAEONTOLOGICAL ARGUMENT.—(I) Historical Method. Before entering upon the discussion of the evidence furnished by palaeontology we must briefly refer to the method which ought to be employed in the interpretation of the paleontological records. The great archives of the geological strata are very incomplete. Almost three-quarters of the earth's surface is covered with water, and another part with perpetual ice, while of the rest but a fraction has remained free from the ravages of water and the elements; of this small portion, again, only certain regions are accessible to the investigator, and these have been but partially examined. Besides, in most cases only the hard portions of organisms are preserved, and even these are often so badly mutilated that their correct classification is sometimes difficult. Many of them, especially in the oldest rocks, must have perished under the crushing force of metamorphic processes. Further, the geographic distribution of plants and animals must have varied according to climatological and topographical mutations. It may suffice to cite the glacial periods of which there are clear indications in various geological epochs. Finally, the geological strata themselves underwent many violent strains and displacements, being upheaved, tilted, folded again, and even entirely inverted. It is evident that every one of these phenomena increases the chaos in its own way and makes the work of classifying and restoring all the harder. It gives at the same time to the scientist the right to formulate hypotheses probable in themselves and adapted to bridge over the numerous gaps in the work of reconstruction in the organic world. But these working hypotheses ought never to assume the form of scientific dogmas. For after all, the documents which have really been deciphered are the only deciding factor. At all events, the chronological succession and the genetic relation of organisms cannot be determined by aprioristic reasoning, or by means of our present system of classification, or by applying the results of ontogenetic studies. One illustration may suffice. Some maintain that trilobites are descended from blind ancestors because certain blind forms exhibit a number of simple characteristics which are common to all specimens. And yet we know that, e.g., Irinucleus possesses eyes in the earlier stages of its development, and only becomes blind in the later stages. The non-existence of eyes is, therefore, due to degeneration, and does not point to a former eyeless state. As a matter of fact, specimens of trilobites possessing eyes are found side by side with eyeless specimens in the lower Cambrian strata. Other examples of false A priori conclusions are to be found in the extraordinary genealogies constructed by extreme evolutionists, and which dissolve like so many mists in the light of advancing investigations. In fact, up to the present the agreement on ontogeny and phylogeny has not been proved in any single instance. In short, if we disregard observation and experiment on living organisms, it is the historical method alone which can decide the limits of evolution and the succession and genetic relations of the different forms. "In the substitution of the hypothetical ancestors by real ones lies the future of true phylogenetic science" (Handlisch). (2) The Oldest Fossils. Now let us turn to the documents themselves and see what they have to show us. The foundation of the Archives is formed of gneiss and crystallized slate, a rigid mass containing no trace of organic life, and one which offers to the palaeontologist the hopeless outlook that his science must remain in a very incomplete state, perhaps forever. Immediately above this foundation, nature has imbedded the multitudinous, highly-developed Cambrian fauna, without leaving the slightest trace of their antecedents, origin, birth, or age. Some 800 species of this remotest period are known to us. They belong almost without exception to marine fauna, and are distributed over all the chief groups of the invertebrates. Nearly one-half of them are arthropods. They are the well-known trilobites which occupy a position about the middle of the scale of animal development. Other groups belong to coelenterates, brachiopods, gastropods, and cephalopods. Sponges, too, and traces of worms are found, as also very imperfect fragments of scorpions and other insects. Moreover, there can be no doubt that various types of fishes must have existed, since in the Silurian age numerous representatives, such as selachians, ganoids, marsipobranchs, dipnoans, are found from the very beginning side by side. Where are the ancestors of these highly specialized beings? The one thing we may affirm is that we know absolutely nothing whatever of a primitive fauna and of the numberless series of organisms which must have followed them up to the Cambrian era, for the simple reason that we possess absolutely no evidence. Moreover, there is not the least trace of palaeontological evidence in favor of the spontaneous awakening of life or of the ascending development out of primitive protoplasmic masses up to the time of the Cambrian era. The Cambrian types were all of them specialized forms perfectly adapted to time and environments, and not generalized types of zoological systems. The origin of the plant world is also shrouded in impenetrable darkness for the palaeontologist. The enormous layers of anthracite and graphite are, according to the most recent investigations, of inorganic origin. Clearly established evidence of plant life only dates from post-Silurian times, and consists of contents of the oldest turf moors—giant-ferns and horsetails, plants akin to the club-mosses, like the Lepidodendron, and Gymnosperms, like the slender Cordaites. One is astounded at the rich forms of this long-lost flora, and we search in vain for their ancestors. It is certainly remarkable, and a fact which clearly proves the transformation of species, that plants belonging to these remote times vary considerably from their later representatives. But, as Kerner von Marilaun insists, the "fundamental structure of the type" is never obliterated, and the degree of organization has at least remained the same. In particular, the present dwarf-forms of the horse-tails and club-mosses are but miserable remains of their mighty ancestors, and the Cordaites, though different from the present conifers, were as highly organized as they. To this must be added the recently discovered fact that seed-bearing plants, which constitute a considerable part of the fern flora of the Carboniferous, are found among the ferns of the Devonian era. (3) Angiosperms and Vertebrates. But how did the undoubtedly higher forms of a later period originate? To begin with the angiosperms, we are confronted with the fact that these organisms appear quite suddenly in the Cretaceous era and, what is more remarkable, in forms as highly organized as their present representatives. It is a fact that principally the dicotyledons (at least those in the more recent strata) correspond more and more to the present-day forms, clearly indicating the relationship they bear to one another. But whence the earliest forms of the cretaceous came, is shrouded in mystery. Similarly, the gradual transformation of one species into another cannot be proved in any concrete case. Only this much is certain, that if evolution took place, it involved a change which did not imply attainment to a higher stage of organization. It must be borne in mind, moreover, that we know of no intermediate forms capable of justifying even as much as a hypothesis that angiosperms were evolved from lower plants. If the origin of the angiosperms is for the present an insoluble problem, the genesis of the vertebrates is no less so. However, in order not to pass entirely over the post-Cambrian history of the invertebrates, we must at least make mention of the significant fact that this fauna seems to be constantly changing, but without ascending to higher forms of organization. The modification is especially manifest in the shell-bearing groups, owing to the changed size, form, and ornamentation of their shells, and in this offers a very acceptable basis for the establishment of a series of kindred forms—e.g., with the gastropod genusPaludina of the Slavonian tertiary strata. But since such structures depend almost entirely on the calcareous nature of the medium, and on the varying kind and amount of movement, we can scarcely be inclined to regard an increased ornamentation of the shell as a mark of real progress in organization, but at most as a temporary development of actual dispositions due to varying conditions of life. The first authenticated ancestors of the vertebrates are the fish-remains of the lower Silurian era. Widely removed from them we find in the carboniferous strata the oldest remains of the amphibian quadrupeds and, associated with them, forms of reptiles whose sudden appearance and equally sudden disappearance belong to the unsolved problems of palaeontology. Among the Mesozoic fishes we encounter old forms together with teleosts which suddenly appear in the Jurassic strata without producing any transitional forms. It is generally supposed that the teleosts represent a higher grade of organization than the ganoids; as a matter of fact, the teleosts, it would seem, have no structural advantage over the cartilaginous fishes in the lesser hardness of the scale and the greater hardness of the skeleton. This is, however, but a shifting, as it were, of development, as the disappearance of the rigid body-covering is compensated for by the ossification of the skeleton. At any rate, the origin of the teleosts is an unsolved problem, as is that of the Silurian ganoids. The appearance of birds and mammals is likewise very mysterious. The first known bird is the famous "bird-reptile" Archoeopteryx of the Jurassic strata at Soluhofen. In spite of some characteristics that remind one of reptiles—as for instance the twenty homologous caudal vertebrae, the talons, the separated metacarpal bones and the toothed jaw—yet the true bird nature is evinced by the plumage, the pinions, and the bill. In fact Archoeopteryx is far removed from the reptiles, nor does it constitute any connecting link with the later birds, not even with the toothed Ichthyornis and Hesperonis of the upper Cretaceous era. Certainly the two isolated specimens from Soluhofen indicate that birds must have existed a long time before; but where their place of origin is, none can tell. Palaeontology is silent likewise about the early history of mammals. The mesozoic representation of this class may have some connection with marsupials, monotremes, and insectivorous animals, but as to the early history of the great majority of placental mammals we have no evidence whatever. A vast number of intermediate forms would certainly be required to connect the mammals with the reptiles. No such series of forms is known. Even the genealogy of the horse, which is considered the most striking example of an evolutionary series within a mammalian family, is scarcely more than a very moderately supported hypothesis. Let the reader consider the accompanying table of differences in the palaeontological representatives of the Equidae. Upon the facts embodied in this table, which chiefly refer to fossils found in North American strata, the following comments are suggested: The genera of the Equinae lived contemporaneously, though it must be conceded that in some sedimentary deposits their series seems to be continuous. Secondly, the subfamilies show great differences between one another. Of the Merychippus, which connects the Equine with the Paloeotherinae, we know only the teeth. Thirdly, if we take the European material into consideration as well, we are confronted with widely divergent opinions, so much so that the brilliant pedigree becomes greatly dimmed. In particular, the Eocene forms and the still more remote genus Phenacodus are avowedly very dubious ancestors of the horse. Lastly, it is well within the range of possibility that the ancestors of the Equinoe and the descendants of the older sub-families have remained undiscovered up to the present time. (4) Man. It remains for us briefly to examine the historical records to see if we can obtain reliable information concerning the last and most important "ascent" to Homo sapiens. The oldest authenticated traces of man consist of stone implements, and they are derived from the lower Quaternary strata. Whether the so-called "eoliths" of the Tertiary Era are really the handiwork of man, cannot be decided with certainty. Eminent scientists, as Houle, Obermaier, de Lapparent, in their works published in 1905, have denied the human origin of these objects. Concerning the first stages in the civilization of diluvian man little can be said. This period, according to Hoernes, falls under three sub-groups, separated from one another and preceded by a glacial period. The first intermediate epoch (epoque du grand ours) lies close to the Pliocene age, and is called, after the principal place of its discovery, the stage of Tilloux-Taubach (Krapina), or Chelleo-Mousterien. The fauna is mostly tropical and includes, among others, Elephas antiquus, Rhinoceros Merckii, and, most important of all, Ursus speloeus. Taubach's field of discovery was a camp in which the fireplace, remnants of food, and the simple utensils of Germany's first inhabitants were found in situ (Hoernes). The second intermediate epoch (epoque du mammouth) is named the Solutreen stage, after the place where important discoveries were made in France. It contains, besides the mammoth, the wild horse and numerous predatory animals such as Leo, Ursus, Hyoena, etc., though the numbers greatly decrease as we draw to the end of the period, while the Ursus speloeus becomes entirely extinct. A large number of the stone implements are of fine workmanship and there are, besides these, various kinds of carving on bone and ivory, plastic figures of men, and drawings of animals on the walls of the caves. The cave of Combarelles (Dordogne), for example, is decorated with 109 drawings of animals. The ornamentation in the Solutreen, with its wavelike curves and spirals, indicates an almost enigmatical degree of development which would appear to be more in keeping with the culture of the metal age than with the more remote stone age. The third intermediate epoch (epoque du renne) had a bleaker climate. It is called the Magdaleine stage, after La Magdaleine, in France. The stone implements are homely, but often very finely constructed, "small implements made for delicate hands by delicate hands" (Hoernes). Pointed and hooked hunting weapons were also found, as well as numerous instruments of various kinds manufactured out of bone and horn, and all of them reveal considerable artistic taste and judgment. Real frescoes adorn the walls of the Font-de-Faune cave. In all, eighty figures are represented, of which number forty-nine are those of bisons. From what has been said we may conclude that man, in the first stage of civilization known to us, appears as a true Homo sapiens; but how he arrived at that stage is a problem we are quite unable to answer, because all records are wanting. The bones, too, which are supposed to date from the primeval age of man are little calculated to solve the problem. A short resume of the results of recent investigations will make this clear. Pithecanthropus erectus, the famous apeman of Trinil (Java), cannot be considered "the long-sought missing link in the chain of the highest Primates". As is well known, we have to do with a cranium of 850 sq. cm. capacity, a thigh-bone, and two molar teeth; the skull and the thigh-bone were found lying about 16 yards apart. It is true the skull differs somewhat from the skulls of present-day anthropoids; it is, however, in general characteristics thoroughly apelike, as was pointed out recently by Schwalbe, Klaatsch, Macnamara, and Kohlbrugge. The thigh-bone, according to Bumüller, bears the closest resemblance to the femur of the ape Hylobates. Hence the appellation erectus is a misnomer. Add to this that, according to the latest researches, Pithecanthropus must have been a contemporary of primitive man, since the strata in which the bones were found are diluvial. Hence Pithecanthropus cannot belong to the ancestral line of man. The bones of the Neandertal race of the Homo primigenius are undoubtedly human, and have given rise to renewed interest through the valuable discoveries made in Krapina. The Neandertal skull itself serves as a type which, owing to the low, receding forehead and the strongly developed supra-orbital ridges, appears to be very primitive, though no one knows the actual geological conditions of the place where it was originally deposited. We pass over the fact that twenty scientists have expressed twelve different opinions on this mysterious cranium, and confine ourselves to the latest opinion of Schwalbe, who says that the Neandertal cranium exhibits forms which are never found in either a normal or a pathologically altered Homo sapiens, whether Negro, European, or Australian, and yet at the same time the skull does exhibit human characteristics. In a word, the Neandertal skull does not belong to any variety of Homo sapiens. Kohlbrugge very aptly compares Schwalbe's hypothesis to an upturned pyramid balancing on a fine point, since a single Australian or Negroid skull which may be found to agree with the Neandertal skull suffices to over-throw the hypothesis. Such a skull has not as yet been found, but there are other factors which suffice to shake Schwalbe's hypothesis. These have reference to the other diluvial bone remains of Homo primigenius, amongst others to the petrified Gibraltar skull, to two molar teeth from the Taubach cave, to the two fragments of a skull from the mammoth caves of Spy, and the jawbones from La Naulette, Schipka, Ochos, and, finally, to considerable remains of bones, such as fragments of skulls, lower jawbones, pelvic bones, thigh and shin bones, from a cave near Krapina in Croatia. To these must be added the "Moustier skull" which was dug up in August, 1908, in Vezeretal (Dordogne). All these fragments possess fairly uniform characteristics. Especially worthy of note are, above all, the cranium with its prominent supra-orbital ridges and receding forehead. These qualities, however, are not infrequently found in men of the present day. Australians exhibit here and there even the genuine supra-orbital ridges (Gorjanowic-Kramberger). It cannot be clearly decided whether we are dealing with purely individual characteristics or with peculiarities which would justify us in classifying the Krapina fragments as belonging to a special race. But this much is clear, that the formation of the skull and the degree of civilization of that race are quite sufficient to permit of our designating Homo primigenius not as a species of itself, but merely as a local sub-division of the Homo sapiens. The Galley-Hill skull, from England, which is still older than the Krapina bones, points to the same conclusion and corresponds with the more recent skulls of post-diluvial man. Hence, to sum up, we may affirm that we are acquainted with no records of Tertiary man, that the most ancient remains of the Quaternary belong to the Galley Hill man, whose skull worthily represents Homo sapiens. The same is to be said of the oldest traces of civilization as yet known to us. Palaeontology, therefore, can assert nothing whatever of a development of the body of man from the animal. It may be added that Haeckel's curious "Progonotaxis", or genealogy of man, is a pure fiction. It consists of thirty stages, beginning with the "moners" and ending with homo loquax. The first fifteen stages have no fossil representatives. As to the rest, we may concede that many of these groups actually exist, but we do not see a single argument of any probability for Haeckel's assertion that these groups are genetically related. As to the age of the human species, no assertion can be made with any degree of certainty; thus far there are no indications whatever that would justify an estimate of more than 10,000 years. Still less are we enabled to say anything definite as to the probable age of life. The numbers given by different authors vary between twenty-four and upwards of one hundred million years. De Vries's calculation is of especial interest because it is based on his Enothera studies. Mainly to show the superiority of the mutation theory to the selection theory, De Vries assumes that the primrose contains 6000 characteristics, and that a "mutation", or acquisition of a new character, takes place after every 4000 years; so that 4000×6000=24,000,000 (=Lord Kelvin's average value) would represent the biothronic equation, which of course consists of unknown variables only, and rests, moreover, on the unproved assumption that a mutation consists in the acquisition of a new character and that such mutations have really occurred. IV. THE MORPHOLOGICAL ARGUMENT.—(I) In General.—The groups and sub-groups of the plant and animal world are built up according to the same fundamental plan of organization. This important fact, on which all classification rests, is said to be explained by the hypothesis that the different groups (e.g. the vertebrates) have been evolved from forms possessing the peculiarities of the type, while the differences are said to have been brought about by modifications (e.g. adaptation to the environment). The original form or type is imagined to be as primitive as possible, while its modification is said to mark progress, so that those organisms which have the simplest structure are said to correspond to the most ancient forms, the more perfect specialized forms being the most recent. Are these conclusions well founded?—The plain facts are these: (a) Groups of organisms exhibit similar fundamental forms, which, however, (b) show various differences, so that (c) the groups fall into similar divisions with a more or less perfect degree of organization. In the first place it is difficult to understand why the lower organized forms should be historically the older. According to the evidence furnished by palaeontology, this is in many instances positively false, and in no ease is it demonstrable, while philosophically it is only possible in as far as the simple forms actually possess the peculiarities of their descendants at least in some latent condition. Secondly, it is hard to see why similarity of structure should prove common origin. As a matter of fact, palaeontology knows nothing of common primeval forms; on the contrary, it points to parallel series whose origins are unknown. It is not improbable, moreover, that resemblances of structure and function in nature frequently represent instances of convergence, through which widely different organisms assume similar modifications of form under similar conditions of life. For example, certain species of the asclepiadaceoe (Stapelia), euphorbiaceoe (Euphorbia), and cactus have, in all probability, acquired their similar fleshy form from the adaptation of leafy forms to the aridity of the locality in which they grew, and only preserved the different family characteristics in the structure of the flower. The similarity which exists between whales and fishes can be considered merely as an instance of convergence, and no one will assert that the whale has developed from the fish because it happens to be provided with fins. As a matter of fact there are numberless analogies which no serious student would ever dream of reducing to a common origin. Take, for example, the cell-division in plants and animals, the method of fertilization, and other analogies of structure and function in vastly different groups. Finally, the chief problem, which refers to teleology of adaptive modifications, is not even touched by the doctrine of descent from common ancestors. (2) Man and the Anthropoids.—Palaeontology knows of no records that point to the relationship between the body of man and that of the anthropoid. Hence it follows that the argument of analogy and classification is of little worth. But, as ever and again attempts are made to discover analogies between every bone of man and the corresponding part of the ape (e.g. Wiedersheim), it will be useful to gather a few of the more important morphological discrepancies which exist between man's body and that of the anthropoids (orang-utang, chimpanzee, gorilla). It is, however, far from our intention to attribute to these differences any great argumentative force, especially against those who suppose that there was a common primeval ancestor from which both man and ape finally descend; nor do we wish to deny that zoologically the human body belongs to the class of the mammalia, nor that within this class there is any representative more similar to it than the anthropoids. Of these differences the most important lies in the development of the brain of man and of the anthropoid, which is seen from the comparison of the weights. According to Wiedersheim we are forced to admit that the relative mass of the human brain is twice that of the chimpanzee, while; absolutely; it is from three to four times as great. The same is probably true of the orang-utang, while the brain of the gorilla, which, according to Wiedersheim, is the most humanlike of any of the anthropoid brains, is relatively only one-fifth that of man's. The human skull is from three to four times as large as that of the anthropoids. The difference becomes much more striking still when we compare the cerebral hemispheres and their convolutions. The weight of the brain of a male Teuton of from thirty to forty years of age is on the average 1424 grams, that of a female 1273 grams, and that of a full-grown orang only 79.7 grams (Wundt). The proportion is therefore from 18:1 to 16:1. If we measure the superficial area of man's brain with all its convolutions and that of the orang we have, according to Wagner, from 1877 sq. cm. to 2196 sq. cm. for the human brain and 533.5 sq. cm. for that of the orang—that is a proportion of 4.4:1. It is further to be taken into consideration that, as Wiedersheim points out, the human brain is not to be looked upon as an enlarged anthropoidal one, but as a "new acquisition with structures which the anthropoidal does not as yet [!] possess". These new acquisitions are presumably qualitative and refer mainly to the center within the great cerebral hemispheres. Intimately connected with the development of the brain is the moderate development of the dentition of man in comparison with the chinless snout of the monkey, which is armed with powerful teeth. Again, "the human face slides as it were down from the forehead and appears as an appendix to the front half of the skull. The gorilla's face, on the contrary, protrudes from the skull, which on return slides almost entirely backwards from the face. It is only on account of its protruding, strongly developed lower parts that the small skull-cap of the animal can mask as a kind of human face" (Ranke). A second group of differences is obtained by comparing the limbs of man and the anthropoid. Owing to his upright stature, man's appendicular skeleton is quite different in form and structure from that of the anthropoid. This is shown not merely by the length of the single parts, which, strangely enough, exhibit inverse proportions, but also in the interior structure of the bones, as was proved by Walkhoff (1905) in the case of the femur. If we suppose the length of the body to be 100 we have, according to Ranke, the following proportions: Part Gorilla Chimpanzee Orang Negro German Arm and hand 64'9 67'7 80'7 45'16 45'43 Leg 34'9 35'2 34'7 48'5 48'8 Special measurements taken from the skeletons of an adult Frenchman and an orang, represented in the accompanying plate, gave the following particulars: Humerus Radius Ulna Femur Tibia Man 28 cm. 22 cm. 25 cm. 47 cm. 37 cm. Orang 36 cm. 39'8 cm. 41 cm. 31 cm. 25 cm The sponge-like structure in the femur of man and anthropoid exhibits considerable difference, so that it could be established by means of radiograms whether the femur was that of an upright walking individual or not; e.g., it was possible to prove the Neandertal and Spy femora to be human. The foot of man is, moreover, very characteristic. It is not furnished with a thumb that can be bent across the whole member, and hence it does not represent a typical prehensile organ, as is the case with the hind feet of the monkey. In general, each bone and organ of man could in some sense be styled ape-like, but in no case does this similarity go so far that the form peculiar to man would pass over into the form which is peculiar to the ape. This conclusion is confirmed by the fact that, according to Ranke and Weisbach, all the efforts to discover a series of bodily formations which would lead from the most apelike savages to the least apelike Caucasians have till now resulted in utter failure, since the apelike forms of organs actually found in some individuals are not confined to a single race or nation, but are distributed throughout all of them. Tailed ape-men, in the proper sense of the word, have no existence. If sometimes taillike appendages occur, they are genuine deformities, pathological remnants of the individual's embryonic life. Cretins and microcephali are likewise pathological cases. The theory that such were the ancestors of the human species is certainly excluded by the fact that they are unable to procure independently the necessary means of existence. (3) "Blood Relationship" between Man and the Anthropoid.—In 1900 Friedental thought that he was able to prove the kinship of man and the anthropoid biochemically by showing, first, that the transfusion of human blood-serum into the chimpanzee was not followed by any signs of blood-poisoning, as usually happens on the introduction of foreign blood, and, secondly, that human serum did not produce a reaction when introduced into a solution of the blood of the orang and gibbon, while on the other hand it dissolved the blood corpuscles of the lower apes. A little later Nutall and others proved that anti-sera exercised an opposite effect. An "anti-man-serum" was prepared by injecting subcutaneously sterile human serum into a rabbit till the animal became immune to poisoning from the foreign blood-serum. The "antiman-serum" of rabbit-blood thus prepared gave a precipitate with the blood-serum of man or of an animal with chemically similar blood, for instance anthropoids, but not with the serum of chemically different blood. The force of the argument lies, therefore, in this, that the chemical reaction obtained seems to be on the whole proportional to the degree of their chemical affinity. What follows from these facts?—Only this, that the blood of man is chemically similar to that of the anthropoids; but it does not follow that this chemical similarity must be attributed to any kinship of race. The mistake arises from the confusion of the ideas "similarity of blood "and" blood-relationship" in the genealogical sense of the term; otherwise it would be at once perceived that the fact of chemical similarity of blood is of no more importance for the theory of evolution than any other fact of comparative morphology or physiology. (4) Rudimentary Organs.—One of the special arguments commonly cited in favor of the evolution theory is based on the frequent occurrence of rudimentary structures in organisms. As examples we may mention the following: Pythons and boas possess vestiges of hind legs and of a pelvis separated from the vertebral column.—The slow-worm is without external limbs, and yet possesses the shoulder-girdle and the pelvis, as well as a slightly developed breast-bone.—The ostrich has merely stunted wing-bones, while the nearly extinct kiwi (apteryx) of New Zealand has only extremely small stumps of wings, which are clothed with hair-like feathers.—The gigantic birds of New Zealand which became extinct in past ages were entirely wingless.—Well worthy of note, also, are the rudimentary organs of the whale (Cetacea), since of the hind limbs only a few minute bones remain, and these are considered to be the pelvic bones, while the Greenland whale (Baloena mysticetus) also possesses thigh and leg bones. The bones of the forelimbs are not movable independently of one another, being bound together by means of tendons—.Other remarkable vestigial structures are the teeth of the Arctic right whale, which never penetrate the gums and are reabsorbed before birth, the upper teeth of the ox, the milk teeth and the eyes of the mole. The deep sea fish, like the Barathronus, have instead of eyes "two golden metallic concave mirrors" (Chun).—Nor is man devoid of rudimentary organs. Wiedersheim mentions no fewer than one hundred. But of these only a few are genuine. The vermiform appendix may serve as an example, though according to recent research it is not entirely functionless. Its length oscillates between 2 cm. and 23 cm., while its breadth and external form vary exceedingly. Probable reasons for its partially rudimentary character are, besides its extreme variability, Especially two facts in particular: the length of the organ compared with that of the large intestine is as 1:10 in the embryo, and as 1:20 in the adult; secondly, in 32 per cent of all cases among adults of over twenty years of age the appendix is found to be closed. Do such rudimentary organs furnish us with an acceptable proof for the theory of evolution? It is to be admitted that in many instances the organs were formerly in a more perfect condition, so as to perform their typical functions—e.g., the eyes of the mole as organs of sight; and the limbs of the kiwi as means of locomotion for running or even for flying. Hence those individuals which now possess rudimentary organs are descended from ancestors which were in possession of these same organs in a less degenerated condition. But it cannot be ascertained from the structures whether those ancestors were of another kind than their offspring. The vermiform appendix in man is fully explained by supposing it to have had in antediluvian man a more perfect function of secretion, or even of digestion. Until the palaeontological records furnish us with more evidence we can only conclude from the occurrence of rudimentary structures that in former ages the whale possessed better developed limbs, that the moles had better eyes, the kiwi wings, etc. In short, rudimentary organs per se do not prove more than that structures may dwindle away by disuse. Haeckel's endeavor to invalidate the teleological argument has no foundation in fact. In many cases the function of rudimentary organs has been discovered—e.g., the rudimentary teeth of the whale are probably of use in the growth of the jaw; the breast-bone of the slow-worm as a protection of the chest. But even in instances in which we have not succeeded in discovering the function of such structures, it must not be forgotten that degeneration may be eminently teleological in furnishing material for other organs whose functions become more important. Moreover, as long as rudimentary organs remain, they may become, under altered circumstances, the starting point for an appropriately modified reorganization. It is indeed difficult to see how "dysteleology", as Haeckel calls it, follows from the fact that an organ adapted to specified means of livelihood disappears, probably in order to strengthen other organs when those means of livelihood are changed; and, until the contrary is proved, we may assume that we have to deal with instances of teleological adaptation and correlation, as has already been demonstrated in many cases—e.g., in the development of amphibians. VI. THE ONTOGENETIC ARGUMENT.—Comparisons between the embryos of higher forms and the adult stages of lower groups were made long before the evolution theory was generally accepted by biologists. But it was only after 1859 that the facts of embryology were interpreted by means of that theory. Fritz Muller (1864) was one of the first to advance the view that the ontogenetic development of an individual is a short and simplified repetition of the stages through which the species had passed. Haeckel modified the proposition by introducing the term "kenogenesis", which should account for all points of disagreement between the two series of development. In its new form the theory of recapitulation received the name "the biogenetic law of development". Later on Hertwig reformed the law a second time by changing the expression "repetition of forms of extinct ancestors", into "repetition of forms necessary for organic development and leading from the simple to the complex". Besides, considerable changes, generally in an advancing direction, are said to have been brought about by the action of external and internal factors, so that in reality "a later condition can never correspond to a preceding one". Both Haeckel's and Hertwig's views were rejected by Morgan, who does not believe in the recapitulation of ancestral adult stages by the embryo, but tries to show that the resemblance between the embryos of higher forms might be due to "the presence in the embryos of the lower groups of certain organs that remain in the adult forms of this group". According to Morgan, we are justified in comparing "the embryonic stages of the two groups" only—a theory which he calls "the repetition theory". Perhaps the most striking fact to illustrate the onto-genetic argument is the resemblance between the gill-system of fishes and certain analogous structures in the embryos of the other vertebrates, man included. However, contrary to the statements of most scientists, we do not think that the resemblance is such as to justify us in concluding "with complete certainty that all vertebrates must in the course of their history have passed through stages in which they were gill-breathing animals" (Wiedersheim). The embryos of fishes are at a certain very early stage of development furnished with vertical pouches which grow out from the wall of the pharynx till they fuse with the skin. Then a number of vertical clefts (gill-slits) are formed by the fact that the walls of the pouches separate. In the adult fishes the corresponding openings serve to let water pass from the mouth through the gill-slits, which are covered by the capillaries of the gill-filaments. In this way the animal is enabled to provide the blood with the necessary oxygen and to remove the carbon dioxide. Now it is quite true that in all vertebrates there is some resemblance as to the first formation of the pouches, the slits, and the distribution of blood-vessels. But it is only in fishes that real gill-structures are formed. In the other vertebrates the development does not proceed beyond the formation of the apparently indifferent pouches which never perform any respiratory function nor show the least tendency to develop into such organs. On the contrary, the gill-slits and arches seem to have, from the very beginning, a totally different function, actually subserving, at least in part, the formation of other organs. Even the amphibians that are furnished with temporary gills form them in quite a peculiar manner, which cannot be compared with that of fish-embryos. Besides, the distribution of blood-vessels and the gradual disappearance of seemingly useless structures, as the "gill-systems" of vertebrates seem to be, may likewise be observed in cases where no one would seriously suspect a relation to former specific characteristics. In short, there is (I) no evidence that the embryos of mammals and birds have true Incipient gill-structures; (2) it is probable that the structures interpreted as such really subserve from the very beginning quite different functions, perhaps only of a temporary nature. In general it may be said that the biogenetic law of development is as yet scarcely more than a petitio principii. Because (I) the agreement between ontogeny and phylogeny has not been proved in a single Instance; on the contrary—e.g., the famous pedigree of the horse's foot begins ontogenetically with a single digit; (2) the ontogenetic similarity which may be observed, for instance, in the larval stages of insects may be explained by the similarity of the environment; (3) the ontogenetic stages of organisms are throughout specifically dissimilar, as is proved by a careful concrete comparison. The same conclusion is indicated by Hertwig's and Morgan's modifications of the biogenetic law, which, in turn, are of a merely hypothetical nature. In addition to this a short reference to Weismann's "confirmation" of Haeckel's law may be useful. Weismann knew that in the larval development of certain butterflies transverse stripes were preceded by longitudinal ones. Hence he concluded that in certain similar butterflies, whose early larval stages were then unknown, a similar succession of markings ought to be found. Ten years later the "predicted" marking was discovered. It is plain that such facts are no confirmation of the biogenetic law, but find their simple explanation in the fact that similar organisms will show similar ontogenetic stages. This fact, too, seems to account sufficiently for the observations advanced by Morgan in support of his theory of repetition. VII. THE BIOGEOGRAPHICAL ARGUMENT.—The biogeographical argument is a very complex one, composed of a vast number of single facts whose correlation among one another, and whose bearing upon the problem of evolution, can hardly be determined before many years of detailed research have gone by. The theories established, for instance, by Wallace are certainly not sufficiently supported by facts. On the contrary, they have serious defects. One of them is the well-known "Wallace line"; another, much more important, the unfounded assertion that the higher vertebrates must have originated from marsupials and monotremes because these animals are almost entirely extinct in all countries except in isolated Australia, where they survive, as the highest representatives of the Australian vertebrates, in greatly varying forms till today. Besides, in most cases we have no sufficient knowledge of the geographical distribution of organisms and of its various causes. But in order to give the reader an idea of the argument, we shall briefly refer him to a group of facts which is well adapted to support the view of evolution explained in the preceding pages. Volcanic islands and such as are separated from the continent by a sea or strait of great depth exhibit a fauna and flora which have certainly come from the neighboring continents, but which at the same time possess features altogether peculiar to them. The flora of Socotra, in the Indian Ocean, for instance, comprises 565 systematic species; among these there are 206 endemic ones. Similarly, on Madagascar there are 3000 endemic plant-species among 4100; on the Hawaian Islands, 70 endemic species of birds among 116; on the Galapagos, 84 among 108. Many such facts are known. They certainly form an excellent demonstration in favor of the proposition defended throughout this article: that such forms as the endemic species, which may well be compared with the races of the human species, were not directly created, but arose by some process of modification which was greatly facilitated by their complete isolation. The most important GENERAL CONCLUSIONS to be noted are as follows: 1. The origin of life is unknown to science. 2. The origin of the main organic types and their principal subdivisions are likewise unknown to science. 3. There is no evidence in favor of an ascending evolution of organic forms. 4. There is no trace of even a merely probable argument in favor of the animal origin of man. The earliest human fossils and the most ancient traces of culture refer to a true Homo sapiens as we know him today. 5. Most of the so-called systematic species and genera were certainly not created as such, but originated by a process of either gradual or saltatory evolution. Changes which extend beyond the range of variation observed in the human species have thus far not been strictly demonstrated, either experimentally or historically. 6. There is very little known as to the causes of evolution. The greatest difficulty is to explain the origin and constancy of "new" characters and the teleology of the process. Darwin's "natural selection" is a negative factor only. The moulding influence of the environment cannot be doubted; but at present we are unable to ascertain how far that influence may extend. Lamarck's "inheritance of acquired characters" is not yet exactly proved, nor is it evident that really new forms can arise by "mutation". In our opinion the principal of "Mendelian segregation", together with Darwin's natural selection and the moulding influence of environment, will probably be some of the chief constituents of future evolutionary theories. H. MUCKERMANN

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