drops on the surface of the ground before and since, have been hidden and preserved by burial under the castings of worms. No doubt the washing down of neighbouring soil and the deposition of dust have aided in the work of concealment; while the settling of the ground has had something to do with the subsidence of the walls. But after all allowances are freely made, the results are to be set down chiefly to the activity of worms.

The final subject of consideration is the action of worms in the disintegration and denudation of the soil. Worms are constantly forming new burrows, and old burrows are constantly collapsing, so that the mould is ever in slow movement, and the particles are ever rubbing together. Thus fresh surfaces are being continually exposed to the action of the carbonic acid in the soil, and to the humus acids which are such powerful agents in the decomposition of rocks. The acids generated in the alimentary canal of worms during the digestive process are probably nearly of the same nature as those in ordinary humus. It is through the vast quantity of leaves they draw into their burrows, partially digest, and commingle with earth, that worms communicate to vegetable mould its uniform dark tint. By these various means the amount of the soil will constantly tend largely to increase. But not only do worms aid directly in the chemical disintegration of rocks, but the particles of the softer rocks suffer some amount of mechanical trituration in their muscular gizzards, wherein small stones, beads of glass, fragments of bricks, &c., serve the purpose of mill stones. This is an important fact in a geological point of view, and Mr Darwin has given much study to it. If a weight of more than ten tons of earth (to take a safe average) annually pass through the bodies of worms on each suitable acre of land, then "the results for a country like Great Britain, within a period not very long in a geological sense, such as a million of years, cannot be insignificant." The product is estimated at 320 million million tons of earth!

Castings, which are viscid and soft on ejection, are rendered still softer during rain, at which time worms apparently prefer to eject them; and, if on an inclined surface, naturally flow more or less down the slope, the finest particles being washed farthest down. During dry weather castings often crumble into small rounded pellets, which from their mere weight tend to roll down any slope. Even on level ground, and in a humid climate, the castings are blown to leeward by a strong wind. Thus the superficial mould does not accumulate to a great thickness, which would in many ways check the disintegration of the underlying rocks. The ultimate consequences of this removal of worm castings are sufficiently startling:—

> It was found by measurements and calculations that on a surface with a mean inclination of 9° 21′ 2·4 cubic inches of earth which had been ejected by worms crossed, in the course of a year, a horizontal line one yard in length; so that 240 inches would cross a line a hundred yards in length. This latter amount in a damp state would weigh 11½ pounds. Thus a considerable weight of earth is continually moving down each side of every valley, and will in time reach its bed. Finally, this earth will be transported by the streams flowing in the valleys into the ocean, the great receptacle of all matter denuded from the land. It is known, from the amount of sediment annually delivered into the sea by the Mississippi, that its enormous drainage-area must on an average be lowered ·00263 of an inch each year; and this would suffice in four and a half million years to lower the whole drainage area to the level of the sea-shore. So that, if a small fraction of the layer of fine earth, 2 of an inch in thickness, which is annually brought to the surface by worms, is carried away, a great result cannot fail to be produced within a period which no geologist considers extremely long.

Worms are thus seen to co-operate with the farmer and gardener in preparing the ground to receive fibrous-rooted plants and seedlings of all kinds. They plough almost unceasingly. They labour to expose the mould to the air, to sift and to triturate it, to enrich it by mixture of partially digested leaves, bones of dead animals, the harder parts of insects, and other fertilising matters, and to fit it to retain moisture to absorb all soluble substances. They drain the surface water through their burrows, which often penetrate the ground almost perpendicularly to a depth of five or six feet; and similarly they facilitate the downward passage of plant roots. They frequently cover with their castings seeds that might not otherwise be able to

[illegible] some degree, though only to a small degree, they actually increase the soil: "but their chief work is to sift the finer from the coarser particles, to mingle the whole with vegetable *debris*, and to saturate it with their intestinal secretions." Comprehensively regarded, they are universal cultivators and fertilisers of the soil, while they plane down the elevated slopes into the alluvial valleys below. It is only the trained intellect of the scientific student that is able to appreciate, in its full significance, the influence thus exerted by worms through geological tracts of time. "It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organised creatures."

It is of special local interest to observe that Mr Darwin acknowledges on many pages his indebtedness to our distinguished townsman, Dr King, superintendent of the Botanic Garden in Calcutta. All the observations at Nice, and many of those in India, were made by Dr King.

THE DAI[illegible] NEWS,
DEC[illegible]BER 26, 1859.

LITERATURE.

On the Origin of Species by Means of Natural Selection, or, the Preservation of Favoured Races in the Struggle for Life. By CHARLES DARWIN, M.A. London: Murray. 1859.

An inquiry as to the origin of an hypothesis might be almost as interesting a psychological problem as that of the species of animal and vegetable beings. Mr. Darwin has favoured the philosophical world with a new hypothesis on the origin of species. This hypothesis bears such a striking resemblance to that of the author of the "Vestiges of the Natural History of Creation," that we can but regard one as the development of the other. The author of the "Vestiges" meets with scant justice at the hands of Mr. Darwin. The theory of the former has done much to clear away the ground for that of the latter. Both have so many features in common, that we are certainly surprised to find the "Vestiges" only once alluded to in Mr. Darwin's work, and that only in these terms. "The author of the 'Vestiges of Creation' would, I presume, say that after a certain unknown number of generations, some bird had given birth to a woodpecker, and some plant to the mistletoe, and that these had been produced perfect as we now see them; but this assumption seems to me to be no explanation, for it leaves the case of the adaptations of organic beings to each other, and to their physical conditions of life, untouched and unexplained." This is a most unfair representation of the hypothesis of the author of the "Vestiges"—one which we are sure any person perusing his work with ordinary care would feel satisfied he would repudiate—one which gives a most imperfect and distorted view of his hypothesis. As Mr. Darwin's work is written professedly to supply this supposed deficiency in the scheme of the "Vestiges" plan of creation, it may be as well to review both hypotheses in their mutual relations to each other.

The vulgar, that is the ordinary view taken by most scientific naturalists, is, that each distinct species of animal owes its origin to a distinct and separate act of divine creation. These distinct and separate acts of creation are regarded both in the "Vestiges" and by Mr. Darwin as so many miracles or deviations from the law of nature. The object of both writers is to diminish the number of these. The "Vestiges" reduces all to one act of creation—that act of creation being the one which gave to the particles of created matter those laws by means of, or according to, which all combinations, whether as organic or inorganic bodies, are formed, and without which they could not be made. These laws are immutable, and admit of no exceptions. Mr. Darwin does not go so far as this. "I believe," he says, "that animals have descended from at most only four or five progenitors, and plants from an equal or lesser number." This is his creed. All the animals and vegetables which have ever lived on our globe owe their origin to ten distinct acts of creation at the most. The miracles of creation are ten in number; they may be less. This far he believes he can reduce the acts of creation by direct logical proof. Analogy, he admits, would lead him one step further—namely, to the belief that all animals and plants have descended from some one prototype. But analogy he considers a deceitful guide. Being sceptical, he thinks it therefore only probable that "all the organic beings which have ever lived on this earth have descended from some one primordial form, into which life was first breathed."

The author of the "Vestiges" claims nothing more than probability for his hypothesis. With respect, then, to the origin of all species of living beings by the operation of one law, both the "Vestiges" and Mr. Darwin are agreed. In this they differ. The author of the "Vestiges" takes a step further back. He does not admit the miracle of breathing life into one primordial form. His primordial forms owe their existence to no new creative act. They have been evolved from dead matter simply by the ordinary laws of matter, and are simply products of certain [illegible] of matter. Make precisely [illegible], and life appears as the result.

[illegible] series to pass through all the grades [illegible] and animated nature up to the same climax of [illegible] as Mr. Darwin's one *primordial form*. The great object of both writers is to sweep away the vulgar idea of miracles from the book of nature. One goes a little in advance of the other. Mr. Darwin has not yet reached the rationalism of his master. Both scout the idea of irreverence. Both believe they are doing service to the God of nature. Both repudiate atheism. Both think the honour of God diminished by the belief that any deviations from the first laws of creation are necessary.

This may perhaps be made clearer by a reference to the arguments of the author of the "Vestiges." The objection of Hume to miracles is known to every one. The laws of nature are invariable. It is necessary to our experience that they should be suspended. A miracle is the suspension of the laws of nature. It is not contrary to our experience that human testimony should be false, therefore no amount of human testimony can render the fact of a miracle credible. This objection has been answered in many ways. Mr. Babbage, in his ninth, or supplementary "Bridgewater Treatise," gave an exemplification of what appeared to him its fallacy. According to Mr. Babbage a miracle is only an apparent, not a real suspension of the laws of nature. I can, he says, construct a calculating machine. I can so arrange it, according to a particular law, that it shall, by a handle being turned, produce a certain series of numbers, the law of the succession of those numbers being determined by the mechanical arrangements I have made for the motion of the machine. A person ignorant of this law and its consequences sees that this machine produces the natural numbers 1, 2, 3, 4, &c., in a regular and unbroken series, from one up to a hundred million. By all ordinary laws of induction, surely a person who has observed this has the right to anticipate that the next number will be one hundred million and two. The code, calculated according to the mathematical theory of probabilities, are a hundred million to one that it will be so. The handle is turned, and the next number that actually appears is greater by 10,000, and the next greater by 30,000, than we should have predicted from the successive occurrences of one hundred million events. The machine has not deviated from the law of its constructor; the apparent suspension is only a proof that no amount of observation of successive facts will necessarily lead us to a knowledge of the law which regulates their occurrence. No knowledge, therefore, that we can obtain by experience of the laws of nature, even though that experience be the cumulative experience of the whole human race, can enable us to assume that an event which we may call miraculous cannot take place. This event, though contrary to our experience, may only be a consequence of the law which has regulated all the other events from which our experience is derived.

This illustration of Mr. Babbage the author of the "Vestiges" takes as the key-note for his hypothesis. He supposes the Creator, on the creation of the world—or even further back than that, at the creation of the starry host of heaven—to have impressed certain laws on matter. By the evolution of these laws stars are created out of nebulæ. These stars or suns, when cooling, throw off their planets, and these planets their satellites. These all move according to the laws originally impressed upon them. Thus day and night and seasons are produced for planets and satellites. Then, not by any special act of creation—not by any breathing of life into a primordial form, but according to laws strictly impressed on matter at its creation, matter gives birth to living beings. This origin of life may have often occurred, or it may only have happened once on this earth during the eons of years it has, according to the "Vestiges," revolved round its central luminary. Then from simple germs of life, like has produced its like, till, strictly in accord with its primordially impressed law, it gives birth to another unlike itself. This proceeds in regular

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series by regular gradations, all alike guided by statistical law. Thus man may trace his origin through monkeys—perhaps to sloths—from them to some lower animal; from this in a long series to a fishy progenitor, and at the end of a dim ancestry, a genuine metempsychosis, to some microscopic animalcule, or cell of a fungus. This progressive series may have taken many directions; in one the simplest germ may terminate in the highest and most perfect development of vegetable beings; in another, or in many concurrent lines of progress, to these of the most perfect forms of animal being. All this may be conceived without reducing the God of Nature to an Epicurean deity, leaving matter to arrange itself according to the laws supposed to be impressed upon it. The author of the "Vestiges" conceives his laws of nature, by which all animate and all inanimate creatures have been called into being—by which all these have ever been, and ever will be, united in perfect harmony and most perfect and wise adaptation—not only ordained primarily by the will of the Deity, but that these laws are ever sustained in action by the will of the same Divine Originator. He represents a system of nature "in which all is regularity and order, and all flows from and is obedient to a Divine code of laws of unbending operation." "That all the secular destinies of our race, from generation to generation, are but evolutions of a law statuted and sustained in action by an All-wise Deity." More than this, he enunciates this idea still more forcibly:—"But in reality, God may be presumed to be revealed to us in every one of the phenomena of the system—in the suspension of globes in space, in the degradation of rocks and the upthrowing of mountains, in the development of plants and animals, in each movement of our minds, and in all that we enjoy and suffer, seeing that the system requiring a sustainer as well as an originator, He must be present in every part of it, albeit He does not permit a single law to swerve from its appointed course of operation. Thus we may still feel that He is the immediate breather of our life and ruler of our spirits—that we may, by rightly directed thought, come into communion with Him, and feel that, even when His penal ordinances are enforced upon us, His hand and arm are closely about us. Nor is this all. It may be that, while we are committed to take our chance in a natural system of undeviating operation, and are left, with apparent ruthlessness, to endure the consequences of every collision into which we, knowingly or unknowingly, come with each of its regulations, there is a system of mercy and grace behind the screen of nature, towards which we stand in a peculiar class of relations, which is capable of compensating for all casualties endured here, and whose very largeness is what makes these casualties a matter of indifference to God."

We have thus stated at some length the hypothesis of the author of the "Vestiges," not only because it has been so often misconceived and misrepresented, but because the passage we have quoted from Mr. Darwin shows that he has utterly lost sight of the scope of his arguments. The author of the "Vestiges" nowhere says what Mr. Darwin presumes that he would say—"That after a certain number of generations some bird has given birth to a woodpecker, and some plant to the mistletoe, and that these had been produced perfect as we now see them." We cannot see anywhere in the "Vestiges" any foundation for this presumption. According to the "Vestiges" theory, the woodpecker and the mistletoe would be produced from a bird or a plant, in much the same order, indeed by perhaps the very same progressive series of transformations, as Mr. Darwin would have us believe on his own theory they have been produced. Nor does the "Vestiges" hypothesis leave "the case of the co-adaptations of organic beings to each other and to their physical conditions of life untouched and unexplained." It makes these very co-adaptations depend upon the same laws by which their existence was produced, and which, so to speak, were from the very commencement of those laws foreseen to provide for these very co-adaptations.

These remarks are not beside the purpose of a review of Mr. Darwin's "Origin of Species," because to a very great extent Mr. Darwin's own hypothesis is only a partial development of the more comprehensive one of the "Vestiges." He commences at one portion of the scheme of the "Vestiges," where his five primordial forms of vegetable and five primordial forms of animal life, at the most, take their origin. These primordial forms pass through just such a series towards perfection as they do in the "Vestiges" theory. The only divergence between the two theories in this [illegible] all the forms of animate nature, fossil and recent, to these ten progenitors at the most, perhaps to one. The author of the "Vestiges" would allow for many distinct centres of new beings, from which the animated tribes of the earth may have radiated. He makes an advance on the Theory of the "Vestiges." He believes he can enunciate the particular law by which these transformations have taken place. That law he calls the "law of natural selection," and this law, he conceives, is produced by another law—"the preservation of favoured races in the struggle for life." To refer again to Mr. Babbage's illustration from his calculating machine, a series of like animals have been produced from like, up to perhaps the hundred-millionth term, when a variety appears. The "Vestiges" would say that this variety appeared in conformity with the laws of nature, because at that particular time its presence was necessary for the completion of the scheme of nature and the harmony of its parts—that it then appeared because its appearance had been then foreordained by the laws impressed on the being of the first of its progenitors in the long series. Mr. Darwin would regard its appearance, so far as his theory is concerned, as accidental or inexplicable. If fitted for the harmony of creation, pre-supposed by the author of the "Vestiges," or as expressed by Mr. Darwin's law; if the variety were better adapted for struggling in the battle of life than its progenitor, it would be preserved—if not it would fall out of existence; if better adapted than its predecessors for maintaining its ground in the struggle for life, it would be so from some advance in the perfection of the adaptation of its organs for obtaining victory. Hence, during a long series of ages, during millions of years, along the course of time, this struggle for life has been eliminating from all accidental varieties—those only fitted by their progressive perfection for obtaining mastery. The circumstances of the battle of life have varied both in time and in different portions of the globe. Hence a variation in the circumstances of the struggle for life may give rise to the preservation or selection of as varied a series of creatures, giving rise to as great a variety of species. To use Mr. Darwin's own illustration:

> The affinities of all the beings of the same class have sometimes been represented by a great tree. I believe this simile largely speaks the truth. The green and budding twigs may represent existing species; and those produced during each former year may represent the long succession of extinct species. At each period of growth all the growing twigs have tried to branch out on all sides, and to overtop and kill the surrounding twigs and branches, in the same manner as species and groups of species have tried to overmaster other species in the great battle for life. The limbs divided into great branches, and these into lesser and lesser branches, were themselves once, when the tree was small, budding twigs; and this connexion of the former and present buds by ramifying branches may well represent the classification of all extinct and living species in groups subordinate to groups. Of the many twigs which flourished when the tree was a mere bush, only two or three, now grown into great branches, yet survive and bear all the other branches; so with the species which lived during long-past geological periods, very few now have living and modified descendants. From the first growth of the tree, many a limb and branch has decayed and dropped off; and these lost branches of various sizes may represent those whole orders, families, and genera which have now no living representatives, and which are known to us only from having been found in a fossil state. As we forward there see a thin straggling branch springing from a fork low down in a tree, and which by some chance has been favoured and is still alive on its summit, so we occasionally see an animal like the Ornithorhynchus or Lepidosiren, which in some small degree connects by its affinities two large branches of life, and which has apparently been saved from fatal competition by having inhabited a protected station. As buds give rise by growth to fresh buds, and these, if vigorous, branch out and overtop on all sides many a feebler branch, so by generation I believe it has been with the great Tree of Life, which fills with its dead and broken branches the crust of the earth, and covers the surface with its ever branching and beautiful ramifications.

The struggle for existence—the battle of life, as Mr. Darwin calls it—which produces the law of selection, ever preserving the highest forms of perfection, and gradually eliminating all inferior forms, is the result of another simple law. This law is the law that all plants and animals increase in a series, which is one of geometrical progression.

> A struggle for existence inevitably follows from the high rate at which all organic beings tend to increase. Every being, which during its natural lifetime produces several eggs or seeds, must suffer destruction during some period of its life, and during some season or occasional year, otherwise, on the principle of geometrical increase, its numbers would quickly become so inordinately great that no country could support the product. Hence, as more individuals are produced than can possibly survive, there must in every case be a struggle for existence, either one individual with another of the same species, or with the individuals of distinct species, or with the physical conditions of life. It is the doctrine of Malthus applied with manifold force to the whole animal and vegetable kingdom; for in this case there can be no artificial increase of food, and no prudential restraint from marriage. Although some species may be now increasing, more or less rapidly in numbers, all cannot do so, for the world would not hold them.
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> There is no exception to the rule that every organic being naturally increases at so high a rate, that if not destroyed, the earth would soon be covered by the progeny of a single pair. Even slow-breeding man has doubled in twenty-five years, and at this rate, in a few thousand years, there would literally not be standing room for his progeny. Linnæus has calculated that if an annual plant produced only two seeds—and there is no plant so unproductive as this—and their seedlings next year produced two, and so on, then in twenty years there would be a million plants. The elephant is reckoned to be the slowest breeder of all known animals, and I have taken some pains to estimate its probable minimum rate of natural increase; it will be under the mark to assume that it breeds when thirty years old, and goes on breeding till ninety years old, bringing forth three pair of young in this interval; if this be so, at the end of the fifth century there would be alive fifteen million elephants, descended from the first pair.

If Mr. Darwin can support this law of natural selection, he has made this advance on the "Vestiges" theory; he has simply shown the nature of the law which that theory supposes to govern the natural laws which regulate the production of new species. We cannot admit that this law has been rendered even probable as the only cause of variety, though we assume, in common with both the theory of the "Vestiges" and that of Mr. Darwin, that that variation exists in nature. According to this theory of Mr. Darwin's, that most perfect of all perfect instruments, the eye, owes its adaptation to man's wants and its correlation to the laws of sight, to the exercise only of this one law of natural selection, urged only by the necessity of victory in the struggle for life.

It is scarcely possible to avoid comparing the eye to a telescope. We know that this instrument has been perfected by the long-continued efforts of the highest human intellects; and we naturally infer that the eye has been formed by a somewhat analogous process. But may not this inference be presumptuous? Have we any right to assume that the Creator works by intellectual powers like those of man? If we must compare the eye to an optical instrument, we ought in imagination to take a thick layer of transparent tissue, with a nerve sensitive to light beneath, and then suppose every part of this layer to be continually changing slowly in density, so as to separate into layers of different densities and thicknesses, placed at different distances from each other, and with the surfaces of each layer slowly changing in form. Further we must suppose that there is a power always intently watching each slight accidental alteration in the transparent layers; and carefully selecting each alteration which, under varied circumstances, may in any way, or in any degree, tend to produce a distincter image. We must suppose each new state of the instrument to be multiplied by the million; and each to be preserved till a better be produced, and then the old ones to be destroyed. In living bodies, variation will cause the slight alterations, generation will multiply them almost infinitely, and natural selection will pick out with unerring skill each improvement. Let this process go on for millions on millions of years; and during each year on millions of individuals of many kinds; and may we not believe that a living optical instrument might thus be formed as superior to one of glass, as the works of the Creator are to those of man?

Mr. Darwin makes his law as sweeping and universal as the Newtonian law of gravitation. He tells us that his present work is but an abstract of a great Principia yet to come. He must furnish us with a very different logic from what he has used in his abstract—a far more formidable series of facts than he has done, before any sober man of common sense will believe that the operation of any such law as he describes can produce such an organ as the human eye, or any other eye in animated nature. He tells us that he believes from certain facts—reserved, we suppose, for his future work—that any sensitive nerve may be rendered sensitive to light. Hence, at one end of the series we have a nerve of sensation by some law of variation exposed to the action of light; at the other end of the series, by the law of natural selection, the human eye, with all its marvellous adaptations to the laws of light—perfect achromatism, perfect correction of spherical aberration, a perfect telescope, and a perfect microscope, combined in one organ. Mr. Darwin evidently conceives this application of his law, and its application to the cell-building instinct of the bee, as an *experimentum crucis* of his theory. In both we humbly conceive he meets with a signal discomfiture.

It may be asked how the kindred hypotheses of the formation of new species, as enunciated by Mr. Darwin and the author of the "Vestiges," leaving out of consideration the laws by which they are evolved, are supported by argument. To a certain extent both use the same arguments for the existence of a continuous evolution of new species, each new species tending towards a greater perfection in its organs than those of its predecessor. Both authors conceive that their theories not only account for the unity of plan shown to exist throughout animated nature, but that that unity has been caused by the very method by which they believe new species have been produced. In point of fact, both theories have been invented to account for this unity—this universal law of harmony reigning throughout animated nature—the law, according to which a Cuvier or an Owen could build up an accurate representation of the skeleton of an extinct animal by the sight of a single bone, or even a portion of one. Next, both authors appeal to geology as affording them the means of substantiating the theoretical structure of animated progression which they have enunciated. In the treatment of these two arguments both differ. The author of the "Vestiges," referring to the illustration of Babbage's calculating machine, conceives that he has no occasion to show the origin of any

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new species. His hundred-millionth-and-first term may be the new term never as yet witnessed by the human observer of the evolution of the laws of nature. Mr. Darwin conceives himself bound to show the origin of his new term, the probable appearance of a new species. He refers us to the creation, as it were, by man of an innumerable variety of new forms in the plants and animals which he has brought under culture or domestication. He tells us that we have produced varieties of pigeons, horses, and dogs—not to mention the varieties of plants produced by horticultural science—which, if their origin were not known, would be classed by scientific naturalists not only as new species, but even as distinct *genera*. What man has been enabled to do, by watching accidental variations, to produce such a wide divergence of form in his domestic plants and animals, that he assumes nature has done by her laws of natural selection. His argument is one of analogy, not of direct proof, for he brings no proof whatever of this natural selection of improved varieties, only their extreme probability of occurrence. Now, this argument is met by a law conceived by scientific naturalists, with but very few exceptions, to exist in nature. Nature has placed a bar to any such origin of species—namely this, that though two distinct species may unite to produce a hybrid, such hybrids cannot continue their species. Rarely such hybrids may breed with either species from the union with which they were produced, but the result is only to cause the new form to revert to the form of a pure progenitor. This law Mr. Darwin denies, without, as we conceive, adducing anything like a proof of its non-existence. For instance, he denies the generally received notion that all varieties either of plants or animals revert, when left to nature, to the form of the wild species from which man first procured them. Yet he adduces as a reason for his belief that all the varieties of domestic pigeons have been produced only by that species of wild rock pigeon which is called *columba intermedia*, inhabiting India, that the colour of this pigeon, its slaty blue, with two black bars terminating the tail, has a constant tendency to appear in spite and in the midst of all the artificial crossings and varieties produced by man. In like manner, he admits the frequent appearance of certain marks in the domestic horse as identifying the nature of the species from which all its varieties have been produced. Here, then, we have the admission of the tendency of all man's artificial variations from the course of the natural wild species to recur back again to the old form—a law somewhat opposed to the law of progressive improvement. Then we have the law of perfect fertility among all the varieties produced artificially, if they invade not the domains of distinct species, met by the argument that in some few doubtful instances, cases where the doubt may arise from confounding natural species with natural varieties, we meet with fertile hybrids. Mr. Darwin admits that all recorded examples of attempts to produce new species by means of hybrids, if they have succeeded at all, have succeeded only with difficulty. How is this difficulty of propagation to succeed against and in the teeth of his law of natural selection by the battle of life, against the overwhelming force of more fertile opponents? Man has never converted his pigeon into any other bird than an undoubted pigeon. In spite of the sterility of the mule, and careful culture, he has not succeeded in producing a new species intermediate between the horse and the ass, though both these species range so close together in the scheme of animated nature, that without this fact we might readily doubt whether they were distinct species, or only varieties of one common progenitor.

We think, so far as any argument from our present knowledge of the facts of animated nature goes, Mr. Darwin must be content, like the author of the "Vestiges," to refer the origin of species to some occurrence far beyond the ken of present observers. With regard to the geological evidence for the origin of species, our two theorists differ as wide as the poles from one another. The author of the "Vestiges" sees the exact order of animated progression displayed by the succession of fossils found in the successive strata of the earth. Upon the occurrence of these forms in a certain series, first only marine, and these only of the lowest order of development, then the gradual evolution of higher forms and the extinction of older and less perfect ones, the author of the "Vestiges" founds the demonstration of his system. Fiercely does he fight with every adversary who would adduce instances of more perfect forms in a lower series of strata than his theory will admit. But Mr. Darwin quietly admits all the geological evidence which the opponents of the "Vestiges" theory have brought to bear against it—evidence which seems to grow stronger by every day's discoveries of new treasures disentombed from the earth. His whole reference to geological evidence is one continuous outcry against the imperfection of that evidence. To him, instead of being a perfect record, it is most imperfect: it is but a few leaves, and these most imperfectly recorded, from the great book of nature. Mr. Darwin, so far as geological evidence is concerned, is the most destructive opponent of the geological proofs of the origin of species produced by the author of the "Vestiges" that has yet appeared. He is constrained to admit that geology affords no evidence of the first appearance of his ten primordial progenitors of animated nature. We must search for these far below any of the strata which were animated by the fossils yet observed by naturalists.

Consequently, if my theory be true, it is indisputable that before the lowest Silurian stratum was deposited, long periods elapsed, as long as, or probably far longer than, the whole interval from the Silurian age to the present day; and that during these vast, yet quite unknown, periods of time, the world swarmed with living creatures.

To the question why we do not find records of these vast primordial periods, I can give no satisfactory answer. Several of the most eminent geologists, with Sir R. Murchison at their head, are convinced that we see in the organic remains of the lowest Silurian stratum the dawn of life on this planet. Other highly competent judges, as Lyell and the late E. Forbes, dispute this conclusion. We should not forget that only a small portion of the world is known with accuracy. M. Barrande has lately added another and lower stage to the Silurian system, abounding with new and peculiar species. Traces of life have been detected in the Longmynd beds beneath Barrande's so-called primordial zone. The presence of phosphatic nodules and bituminous matter in some of the lowest azoic rocks, probably indicates the former existence of life at these periods. But the difficulty of understanding the absence of vast piles of fossiliferous strata, which on my theory no doubt were accumulated before the Silurian epoch, is very great. If these most ancient beds had been wholly worn away by denudation, or obliterated by metamorphic action, we ought to find only small remnants of the formations next succeeding them in age, and these ought to be very generally in a metamorphosed condition. But the descriptions which we now possess of the Silurian deposits over immense territories in Russia and in North America, do not support the view, that the older a formation is, the more it has suffered the extremity of denudation and metamorphism.

The case at present must remain inexplicable; and may be truly urged as a valid argument against the views here entertained.

Except, therefore, by hypotheses unsupported by the evidence of facts, Mr. Darwin admits there is no proof for his hypothesis from the records of geology.

If Mr. Darwin's hypothesis needed any further demolition than he has himself suggested to his adversaries, we should refer to the peculiar instance idiosyncracy which leads him in the support of his hypothesis to derogate from the marvellous wisdom which geometers and naturalists alike have concurred to recognise in the cell-building instinct of the common hive bee. At one time he admits that this instinct, as well as the formation of the eye, appeared to present the most formidable argument against his pet hypothesis. "Grant," he says of the bee, "whatever instincts you please, and it seems at first quite inconceivable how they can make all the necessary angles and planes, or even perceive when they are correctly made. But the difficulty is not so great as it first appears. All this beautiful work can be shown, I think, to follow from a few very simple instincts." And what are these simple instincts? Admit that the bee can measure equal distances from any given point, that it can construct a sphere or a hemisphere by hollowing out a mass of wax, then let it construct the following problem, and all the wonder ceases:

> If a number of equal spheres be described with their centres placed in two parallel layers; with the centre of each sphere at the distance of radius × $\sqrt{2}$, or radius × 1·41421 (or at some lesser distance), from the centres of the six surrounding spheres in the same layer; and at the same distance from the centres of the adjoining spheres in the other and parallel layer; then, if planes of intersection between the several spheres in both layers be formed, there will result a double layer of hexagonal prisms united together by pyramidal bases formed of three rhombs; and the rhombs and the sides of the hexagonal prisms will have every angle identically the same with the best measurements which have been made of the cells of the hive-bee.

The wonder ceases indeed. It ceases by the admission that the bee instinctively has learnt all that Pythagoras, Euclid, or Newton could have taught it. Multiply a radius by the square root of two. Let Mr. Darwin try to multiply a radius by the square root of two, and he will find that he can only do so, geometrically, by means of that problem in Euclid the discovery of which is said to have so delighted Pythagoras that he sacrificed a hecatomb of oxen to the gods for revealing it to his intellect. Passing over this commencement of his problem, let Mr. Darwin take his compass in hand, and strive to construct a series of hexagonal cells terminated by three equal rhombs, accurately reproducing the angles produced by the bee, according to his own construction. We are much mistaken in our estimate of the geometrical problem he has enunciated, if all his former admiration for the wisdom of the bee be not restored with greater intensity than he ever felt before. If any one can bring himself to believe that the marvellous instinct of the hive bee, manifested by creatures sterile and incapable of producing progeny—for the cell building is the work of the imperfect sterile female bee—can be handed down by hereditary descent; that the law of natural selection alone, urged by the battle of life, has taught a bee, originally as ignorant of the marvellous structure of the hive bee's cell as the common humble bee now is—if any man can accept this, then indeed he is worthy of being a disciple of Mr. Darwin. We know not one answer he can bring to the simple-minded inquiry how it is that the humble bee, in spite of his ignorance as regards cell building, still exists? How the ignorant humble bee allows his more subtle neighbour to rob him with impunity of his sweetest store of wax, and still remains a victor in that battle of life which ought only to have preserved the more geometrical robber.

We desire to express our unfeigned respect for Mr. Darwin as a painstaking and most accomplished naturalist. Whether his theory can or cannot withstand a serious discussion, we doubt not the work he promises us in support of it will contain a valuable assemblage of facts. But a collection of valuable facts, and the truth of an abstract speculation of the laws of animated being, are two different things. The misfortune of all hypotheses such as those of the "Vestiges" and Mr. Darwin, founded upon an imperfect induction of facts, is that they only forward our knowledge of nature by the accumulation of those facts necessary to show their fallacy. Mr. Darwin has not brought us one step nearer than the author of the "Vestiges" to the belief that species are originated by any law of variation. The analogy from domestic varieties can lead us to a law destructive of his law of natural selection. The present aspect of nature, the chain which he admires connecting the highest and lowest forms, gives no countenance to the idea that all these forms, high as well as low, are a series of progressive and improved developments of lower forms, whose previous existence geology has failed to reveal. Hypotheses, to be of any use in natural science, must be but the general expression produced by the

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