DARWINISM

STATED BY DARWIN HIMSELF.

CHARACTERISTIC PASSAGES FROM THE WRITINGS OF CHARLES DARWIN.

SELECTED AND ARRANGED

BY

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"There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, while this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been and are being evolved."—*The Origin of Species*, page 429.

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PREFACE.

WHILE these selections can not but be useful to those who are perfectly familiar with the writings of Darwin, they are designed especially for those who know little, or nothing, about his line of research and argument, and yet would like to obtain a general idea of it in a form which shall be at once authentic, brief, and inexpensive.

This volume contains, of course, only an outline of the contents of the twelve volumes from which it is compiled, and for which it is by no means intended as a substitute. It will, on the contrary, we should hope, create an appetite which can be satisfied only by a careful reading of the works themselves.

Darwin's repetitions, necessitated by his method of investigation and publication, and his unexampled candor in controversy, have been something of an embarrassment in the classification of these passages; so that we have been obliged in some instances to sacrifice continuity to perspicuity. But, as one object of this book is to correct misrepresentations by giving Darwin's views in his own language, some of his own repetitions must be given also, in order to leave no doubt as to precisely what he said and did not say. It will probably be a long while before the dispute over the theory that he advocated will cease, but there is certainly no excuse for a difference of opinion with regard to the language that he used, and the meaning he attached to it. That language and that meaning will be found in these pages. Darwinism stated by its opponents is one thing, Darwinism stated by Darwin himself will be found to be quite another thing, for, to use his own exclamation, "great is the power of steady misrepresentation!"

The order followed in the arrangement of these extracts is not that of the books, but the one naturally suggested by our plan, which is designed to conduct the reader through the vegetable up to the animal kingdom, and up from the lowest to the highest animal, man, "the wonder and glory of the universe."

The references are to the American edition of Darwin's works published by D. Appleton & Co., New York.

It is no part of our purpose to discuss the theory expounded here, but we can not refrain from joining in the general expression of admiration for its illustrious expounder. Lord Derby says, "He was one of half a dozen men of this century who will be remembered a century hence"; and yet his friends were "more impressed with the dignified simplicity of his nature than by the great work he had done." Professor Huxley compares him to Socrates in wisdom and humility; and there could be no better authority than Mr. A. R. Wallace for the statement that "there are none to stand beside him as equals in the whole domain of science." He has been extolled, since his death, by a host of religious leaders in press and pulpit (some of whose utterances will be found on another page), and we concur with them in the opinion that science never had a champion whose temper and behavior were more nearly in accord with the practical injunctions of the Christian religion. Whatever we or any one may think of Darwin's scientific theories, no one can gainsay the value of his personal example, and few can be so prejudiced as to resist the fascination that will always be felt at the mention of his name.

NEW YORK, *February 1, 1884.*

INTRODUCTORY PASSAGES QUOTED BY DARWIN IN HIS "ORIGIN OF SPECIES."

"But with regard to the material world, we can at least go so far as this—we can perceive that events are brought about not by insulated interpositions of divine power, exerted in each particular case, but by the establishment of general laws."—Whewell: *Bridgewater Treatise.*

"The only distinct meaning of the word 'natural' is *stated, fixed,* or *settled;* since what is natural as much requires and presupposes an intelligent agent to render it so, i. e., to effect it continually or at stated times, as what is supernatural or miraculous does to effect it for once."—Butler: *Analogy of Revealed Religion.*

"To conclude, therefore, let no man out of a weak conceit of sobriety, or an ill-applied moderation, think or maintain, that a man can search too far or be too well studied in the book of God's word, or in the book of God's works; divinity or philosophy; but rather let men endeavor an endless progress or proficience in both."—Bacon: *Advancement of Learning.*

DARWIN AND HIS THEORIES FROM A RELIGIOUS POINT OF VIEW.

"Surely in such a man lived that true charity which is the very essence of the true spirit of Christ."—Canon PROTHERO.

"The moral lesson of his life is perhaps even more valuable than is the grand discovery which he has stamped on the world's history."—*The Observer* (London).

"Darwin's writings may be searched in vain for an irreverent or unbelieving word."—*The Church Review.*

"The doctrine of evolution with which Darwin's name would always be associated lent itself at least as readily to the old promise of God as to more modern but less complete explanations of the universe."—Canon BARRY.

"The fundamental doctrine of the theist is left precisely as it was. The belief in the great Creator and Ruler of the Universe is, as we have seen, confessed by the author of these doctrines. The grounds remain untouched of faith in the personal Deity who is in intimate relation with individual souls, who is their guide and helper in life, and who can be trusted in regard to the great hereafter."—*The Church Quarterly Review.*

"It appears impossible to overrate the gain we have won in the stupendous majesty of this (Darwin's) idea of the Creator and creation."—*Sunday-School Chronicle.*

"It is certain that Mr. Darwin's books contain a marvelous store of patiently accumulated and most interesting facts. Those facts seem to point in the direction of the belief that the Great Spirit of the Universe has wrought slowly and with infinite patience, through innumerable ages, rather than by abrupt intervention and by means of great catastrophes, in the production of the results, in the animate and inanimate world, which now offer to the student of nature boundless scope for observation and inquiry." —*The Christian World.*

"Let us see, in the funeral honors paid within these holy precincts to our greatest naturalist, a happy trophy of the reconciliation between faith and science."—*The Guardian.*

"That there is some truth in the theory of evolution, however, most scientists, including those of Christian faith, believe, and Mr. Darwin certainly has done much to make the facts plain; but no scientific principle established by him ever has undermined any truth of the Gospel."—*The Congregationalist.*

"Christian believers are found among the ranks of evolutionists without apparent prejudice to their faith. Professor Mivart, the zoölogist; Professor Asa Gray, the botanist; Professor Le Conte and Professor Winchell, the geologists, may be named as among these.—*The Presbyterian.*

"In all his simple and noble life Mr. Darwin was influenced by the profoundly religious conviction that nothing was beneath the earnest study of man which had been worthy of the mighty hand of God."—Canon Farrar.

"He has not one word to say against religion; . . . by-and-by it may be seen that he has done much to put religious faith as well as scientific knowledge on a higher plane."—*Independent.*

"A celebrated author and divine has written to me that 'he has gradually learned to see that it is just as noble a conception of the Deity to believe that he created a few original forms capable of self-development into other and needful forms, as to believe that he required a fresh act of creation to supply the voids caused by the action of his laws.'"—*Origin of Species*, page 422.

"I am at the head of a college where to declare against it [evolution] would perplex my best students. They would ask me which to give up, science or the Bible. . . . It is but the evolution of Genesis when each 'brings forth after its kind.' Science tells the same story. But what is the limit of the fixedness of the law? I believe that the evolution of new species is a question in science, and not of religion. It should be left to scientific men." —President McCosh.

CONTENTS.

I.

PAGE

THE MOVEMENTS AND HABITS OF PLANTS.

II.

III.

IV.

V.

Natural Selection; or, the Survival of the Fittest.

VI.

Geographical Distribution of Organic Beings.

VII.

Evidence of the Descent of Man from some Lower Form.

VIII.

Mental Powers of Man and the Lower Animals compared.

IX.

Development of the Moral Sense.

X.

The Genealogy of Man.

XI.

Sexual Selection as an Agency to account for the Differences between the Races of Man.

XII.

The Expression of the Emotions in Man and other Animals.

XIII.

Means of the Expression of the Emotions.

XIV.

The Provisional Hypothesis of Pangenesis.

XV.

Objections to the Theory of Descent with Modification considered.

DARWINISM

STATED BY DARWIN HIMSELF.

I.

THE MOVEMENTS AND HABITS OF PLANTS.

The Power of Movement in Plants, page 1.

THE most widely prevalent movement is essentially of the same nature as that of the stem of a climbing plant, which bends successively to all points of the compass, so that the tip revolves. This movement has been called by Sachs "revolving nutation"; but we have found it much more convenient to use the terms *circumnutation* and *circumnutate.* As we shall have to say much about this movement, it will be useful here briefly to describe its nature. If we observe a circumnutating stem, which happens at the time to be bent, we will say toward the north, it will be found gradually to bend more and more easterly, until it faces the east; and so onward to the south, then to the west, and back again to the north. If the movement had been quite regular, the apex would have described a circle, or rather, as the stem is always growing upward, a circular spiral. But it generally describes irregular elliptical or oval figures; for the apex, after pointing in any one direction, commonly moves back to the opposite side, not, however, returning along the same line. Afterward other irregular ellipses or ovals are successively described, with their longer axes directed to different points of the compass. While describing such figures, the apex often travels in a zigzag line, or makes small subordinate loops or triangles. In the case of leaves the ellipses are generally narrow.

Page 3.

Even the stems of seedlings before they have broken through the ground, as well as their buried radicles, circumnutate, as far as the pressure of the surrounding earth permits. In this universally present movement we have the basis or groundwork for the acquirement, according to the requirements of the plant, of the most diversified movements.

THE MOVEMENT OF PLANTS IN RELATION TO THEIR WANTS.

The Movements and Habits of Climbing Plants, page 202.

The most interesting point in the natural history of climbing plants is the various kinds of movement which they display in manifest relation to their wants. The most different organs—stems, branches, flower-peduncles, petioles, mid-ribs of the leaf aud leaflets, and apparently aërial roots—all possess this power.

1. The first action of a tendril is to place itself in a proper position. For instance, the tendril of *Cobœa* first rises vertically up, with its branches divergent and with the terminal hooks turned outward; the young shoot at the extremity of the stem is at the same time bent to one side, so as to be out of the way. The young leaves of clematis, on the other hand, prepare for action by temporarily curving themselves downward, so as to serve as grapnels.

2. If a twining plant or a tendril gets by any accident into an inclined position, it soon bends upward, though

secluded from the light. The guiding stimulus no doubt is the attraction of gravity, as Andrew Knight showed to be the case with germinating plants. If a shoot of any ordinary plant be placed in an inclined position in a glass of water in the dark, the extremity will, in a few hours, bend upward; and, if the position of the shoot be then reversed, the downward-bent shoot reverses its curvature; but if the stolon of a strawberry, which has no tendency to grow upward, be thus treated, it will curve downward in the direction of, instead of in opposition to, the force of gravity. As with the strawberry, so it is generally with the twining shoots of the *Hibbertia dentata,* which climbs laterally from bush to bush; for these shoots, if placed in a position inclined downward, show little and sometimes no tendency to curve upward.

3. Climbing plants, like other plants, bend toward the light by a movement closely analogous to the incurvation which causes them to revolve, so that their revolving movement is often accelerated or retarded in traveling to or from the light. On the other hand, in a few instances tendrils bend toward the dark.

4. We have the spontaneous revolving movement which is independent of any outward stimulus, but is contingent on the youth of the part, and on vigorous health; and this again, of course, depends on a proper temperature and other favorable conditions of life.

5. Tendrils, whatever their homological nature may be, and the petioles or tips of the leaves of leaf-climbers, and apparently certain roots, all have the power of movement when touched, and bend quickly toward the touched side. Extremely slight pressure often suffices. If the pressure be not permanent, the part in question straightens itself and is again ready to bend on being touched.

6. Tendrils, soon after clasping a support, but not

after a mere temporary curvature, contract spirally. If they have not come into contact with any object, they ultimately contract spirally, after ceasing to revolve ; but in this case the movement is useless, and occurs only after a considerable lapse of time.

With respect to the means by which these various movements are effected, there can be little doubt, from the researches of Sachs and H. de Vries, that they are due to unequal growth ; but, from the reasons already assigned, I can not believe that this explanation applies to the rapid movements from a delicate touch.

Finally, climbing plants are sufficiently numerous to form a conspicuous feature in the vegetable kingdom, more especially in tropical forests. America, which so abounds with arboreal animals, as Mr. Bates remarks, likewise abounds, according to Mohl and Palm, with climbing plants ; and, of the tendril-bearing plants examined by me, the highest developed kinds are natives of this grand continent, namely, the several species of *Bignonia*, *Eccremocarpus*, *Cobæa*, and *Ampelopsis*. But even in the thickets of our temperate regions the number of climbing species and individuals is considerable, as will be found by counting them.

THE POWER OF MOVEMENT IN ANIMAL AND PLANT COMPARED.

Page 206. It has often been vaguely asserted that plants are distinguished from animals by not having the power of movement. It should rather be said that plants acquire and display this power only when it is of some advantage to them ; this being of comparatively rare occurrence, as they are affixed to the ground, and food is brought to them by the air and rain. We see how high in the scale of organization a plant may rise, when we look at one of the more perfect tendril-bearers. It first places its tendrils ready for action, as a polypus places its tentacula. If the tendril be displaced, it is acted on by the force of gravity and rights itself. It is acted on by the light, and bends toward or from it, or disregards it, whichever may be most advantageous. During several days the tendrils or internodes, or both, spontaneously revolve with a steady motion. The tendril strikes some object, and quickly curls round and firmly grasps it. In the course of some hours it contracts into a spire, dragging up the stem, and forming an excellent spring. All movements now cease. By growth the tissues soon become wonderfully strong and durable. The tendril has done its work, and has done it in an admirable manner.

The Power of Movement in Plants, page 571.

It is impossible not to be struck with the resemblance between the foregoing movements of plants and many of the actions performed unconsciously by the lower animals. With plants an astonishingly small stimulus suffices ; and even with allied plants one may be highly sensitive to the slightest continued pressure, and another highly sensitive to a slight momentary touch. The habit of moving at certain periods is inherited both by plants and animals ; and several other points of similitude have been specified. But the most striking resemblance is the localization of their sensitiveness, and the transmission of an influence from the excited part to another which consequently moves. Yet plants do not, of course, possess nerves or a central nervous system ; and we may infer that with animals such structures serve only for the more perfect transmission of impressions, and for the more complete intercommunication of the several parts.

ADVANTAGES OF CROSS-FERTILIZATION.

The Effects of Cross and Self Fertilization in the Vegetable Kingdom, page 443.

There are two important conclusions which may be deduced from my observations: 1. That the advantages of cross-fertilization do not follow from some mysterious virtue in the mere union of two distinct individuals, but from such individuals having been subjected during previous generations to different conditions, or to their having varied in a manner commonly called spontaneous, so that in either case their sexual elements have been in some degree differentiated; and, 2. That the injury from self-fertilization follows from the want of such differentiation in the sexual elements. These two propositions are fully established by my experiments. Thus, when plants of the *Ipomœa* and of the *Mimulus*, which had been self-fertilized for the seven previous generations, and had been kept all the time under the same conditions, were intercrossed one with another, the offspring did not profit in the least by the cross.

Page 451.

The curious cases of plants which can fertilize and be fertilized by any other individual of the same species, but are altogether sterile with their own pollen, become intelligible, if the view here propounded is correct, namely, that the individuals of the same species growing in a state of nature near together have not really been subjected during several previous generations to quite the same conditions.

POTENCY OF THE SEXUAL ELEMENTS IN PLANTS.

Page 446.

It is obvious that the exposure of two sets of plants during several generations to different conditions can lead to no beneficial results, as far as crossing is concerned, unless their sexual elements are thus affected. That every organism is acted on to a certain extent by a change in its environment will not, I presume, be disputed. It is hardly necessary to advance evidence on this head; we can perceive the difference between individual plants of the same species which have grown in somewhat more shady or sunny, dry or damp places. Plants which have been propagated for some generations under different climates or at different seasons of the year transmit different constitutions to their seedlings. Under such circumstances, the chemical constitution of their fluids and the nature of their tissues are often modified. Many other such facts could be adduced. In short, every alteration in the function of a part is probably connected with some corresponding, though often quite imperceptible, change in structure or composition.

Whatever affects an organism in any way, likewise tends to act on its sexual elements. We see this in the inheritance of newly acquired modifications, such as those from the increased use or disuse of a part, and even from mutilations if followed by disease. We have abundant evidence how susceptible the reproductive system is to changed conditions, in the many instances of animals rendered sterile by confinement; so that they will not unite, or, if they unite, do not produce offspring, though the confinement may be far from close; and of plants rendered sterile by cultivation. But hardly any cases afford more striking evidence how powerfully a change in the conditions of life acts on the sexual elements than those already given, of plants which are completely self-sterile in one country, and, when brought to another, yield, even in the first generation, a fair supply of self-fertilized seeds.

But it may be said, granting that changed conditions act on the sexual elements, How can two or more plants growing close together, either in their native country or in a garden, be differently acted on, inasmuch as they appear to be exposed to exactly the same conditions?

EXPERIMENTS IN CROSSING.

Page 447. In my experiments with *Digitalis purpurea,* some flowers on a wild plant were self-fertilized, and others were crossed with pollen from another plant growing within two or three feet distance. The crossed and self-fertilized plants raised from the seeds thus obtained produced flower-stems in number as 100 to 47, and in average height as 100 to 70. Therefore, the cross between these two plants was highly beneficial; but how could their sexual elements have been differentiated by exposure to different conditions? If the progenitors of the two plants had lived on the same spot during the last score of generations, and had never been crossed with any plant beyond the distance of a few feet, in all probability their offspring would have been reduced to the same state as some of the plants in my experiments —such as the intercrossed plants of the ninth generation of *Ipomœa,* or the self-fertilized plants of the eighth generation of *Mimulus,* or the offspring from flowers on the same plant; and in this case a cross between the two plants of *Digitalis* would have done no good. But seeds are often widely dispersed by natural means, and one of the above two plants, or one of their ancestors, may have come from a distance, from a more shady or sunny, dry or moist place, or from a different kind of soil containing other organic seeds or inorganic matter.

THE STRUGGLE FOR EXISTENCE AMONG SEEDS.

Page 449. Seeds often lie dormant for several years in the ground, and germinate when brought near the surface by any means, as by burrowing animals. They would probably be affected by the mere circumstance of having long lain dormant; for gardeners believe that the production of double flowers, and of fruit, is thus influenced. Seeds, moreover, which were matured during different seasons will have been subjected during the whole course of their development to different degrees of heat and moisture.

It has been shown that pollen is often carried by insects to a considerable distance from plant to plant. Therefore, one of the parents or ancestors of our two plants of *Digitalis* may have been crossed by a distant plant growing under somewhat different conditions. Plants thus crossed often produce an unusually large number of seeds; a striking instance of this fact is afforded by the *Bignonia*, which was fertilized by Fritz Müller with pollen from some adjoining plants and set hardly any seed, but, when fertilized with pollen from a distant plant, was highly fertile. Seedlings from a cross of this kind grow with great vigor, and transmit their vigor to their descendants. These, therefore, in the struggle for life, will generally beat and exterminate the seedlings from plants which have long grown near together under the same conditions, and will thus tend to spread.

PRACTICAL APPLICATION OF THESE VIEWS.

Page 458. Under a practical point of view, agriculturists and horticulturists may learn something from the conclusions at which we have arrived. Firstly, we see that the injury from the close breeding of animals and from the self-fertilization of plants does not necessarily depend on any tendency to disease or weakness of constitution common to the related parents, and only indirectly on their relationship, in so far as they are apt to resemble each other in all respects, including their sexual nature. And, secondly, that the advantages of cross-fertilization depend on the sexual elements of the parents having become in some degree differentiated by the exposure of their progenitors to different conditions, or from their having intercrossed with individuals thus exposed; or, lastly, from what we call in our ignorance spontaneous variation. He therefore who wishes to pair closely related animals ought to keep them under conditions as different as possible.

Page 459. As some kinds of plants suffer much more from self-fertilization than do others, so it probably is with animals from too close interbreeding. The effects of close interbreeding on animals, judging again from plants, would be deterioration in general vigor, including fertility, with no necessary loss of excellence of form; and this seems to be the usual result.

It is a common practice with horticulturists to obtain seeds from another place having a very different soil, so as to avoid raising plants for a long succession of generations under the same conditions; but, with all the species which freely intercross by the aid of insects or the wind, it would be an incomparably better plan to obtain seeds of the required variety, which had been raised for some generations under as different conditions as possible, and sow them in alternate rows with seeds matured in the old garden. The two stocks would then intercross, with a thorough blending of their whole organizations, and with no loss of purity to the variety; and this would yield far more favorable results than a mere exchange of seeds. We have seen in my experiments how wonderfully the offspring profited in height, weight, hardiness, and fertility, by crosses of this kind. For instance, plants of *Ipomœa* thus crossed were to the intercrossed plants of the same stock, with which they grew in competition, as 100 to 78 in height, and as 100 to 51 in fertility; and plants of *Eschscholtzia* similarly compared were as 100 to 45 in fertility. In comparison with self-fertilized plants the results are still more striking; thus cabbages derived from a cross with a fresh stock were to the self-fertilized as 100 to 22 in weight.

Florists may learn, from the four cases which have been fully described, that they have the power of fixing each fleeting variety of color, if they will fertilize the flowers of the desired kind with their own pollen for half a dozen generations, and grow the seedlings under the same conditions. But a cross with any other individual of the same variety must be carefully prevented, as each has its own peculiar constitution. After a dozen generations of self-fertilization, it is probable that the new variety would remain constant even if grown under somewhat different conditions; and there would no longer be any necessity to guard against intercrosses between the individuals of the same variety.

MARRIAGES OF FIRST COUSINS.

Page 460. With respect to mankind, my son George has endeavored to discover by a statistical investigation whether the marriages of first cousins are at all injurious, although this is a degree of relationship which would not be objected to in our domestic animals; and he has come to the conclusion from his own researches, and those of Dr. Mitchell, that the evidence as to any evil thus caused is conflicting, but on the whole points to its being very small. From the facts given in this volume we may infer that with mankind the marriages of nearly related persons, some of whose parents and ancestors had lived under very different conditions, would be much less injurious than that of persons who had always lived in the same place and followed the same habits of life. Nor can I see reason to doubt that the widely different habits of life of men and women in civilized nations, especially among the upper classes, would tend to counterbalance any evil from marriages between healthy and somewhat closely related persons.

DEVELOPMENT OF THE TWO SEXES IN PLANTS.

Page 461. Under a theoretical point of view it is some gain to science to know that numberless structures in hermaphrodite plants, and probably in hermaphrodite animals, are special adaptations for securing an occasional cross between two individuals; and that the advantages from such a cross depend altogether on the beings which are united, or their progenitors, having had their sexual elements somewhat differentiated, so that the embyro is benefited in the same manner as is a mature plant or animal by a slight change in its conditions of life, although in a much higher degree.

Another and more important result may be deduced from my observations. Eggs and seeds are highly serviceable as a means of dissemination, but we now know that fertile eggs can be produced without the aid of the male. There are also many other methods by which organisms can be propagated asexually. Why then have the two sexes been developed, and why do males exist which can not themselves produce offspring? The answer lies, as I can hardly doubt, in the great good which is derived from the fusion of two somewhat differentiated individuals; and with the exception of the lowest organisms this is possible only by means of the sexual elements, these consisting of cells separated from the body, containing the germs of every part, and capable of being fused completely together.

It has been shown in the present volume that the offspring from the union of two distinct individuals, especially if their progenitors have been subjected to very different conditions, have an immense advantage in height, weight, constitutional vigor and fertility over the self-fertilized offspring from one of the same parents. And this fact is amply sufficient to account for the development of the sexual elements, that is, for the genesis of the two sexes.

It is a different question why the two sexes are sometimes combined in the same individual, and are somctimes separated. As with many of the lowest plants and animals the conjugation of two individuals, which are either quite similar or in some degree different is a common phenomenon, it seems probable, as remarked in the last chapter, that the sexes were primordially separate. The individual which receives the contents of the other, may be called the female; and the other, which is often smaller and more locomotive, may be called the male; though these sexual names ought hardly to be applied as long as the whole contents of the two forms are blended into one. The object gained by the two sexes becoming united in the same hermaphrodite form probably is to allow of occasional or frequent self-fertilization, so as to insure the propagation of the species, more especially in the case of organisms affixed for life to the same spot.

There does not seem to be any great difficulty in understanding how an organism, formed by the conjugation of two individuals which represented the two incipient sexes, might have given rise by budding first to a monœcious and then to an hermaphrodite form; and in the case of animals even without budding to an hermaphrodite form, for the bilateral structure of animals perhaps indicates that they were aboriginally formed by the fusion of two individuals.

WHY THE SEXES HAVE BEEN RESEPARATED.

Page 463. It is a more difficult problem why some plants, and apparently all the higher animals, after becoming hermaphrodites, have since had their sexes reseparated. This separation has been attributed by some naturalists to the advantages which follow from a division of physiological labor. The principle is intelligible when the same organ has to perform at the same time diverse functions; but it is not obvious why the male and female glands, when placed in different parts of the same compound or simple individual, should not perform their functions equally well as when placed in two distinct individuals. In some instances the sexes may have been reseparated for the sake of preventing too frequent self-fertilization; but this explanation does not seem probable, as the same end might have been gained by other and simpler means, for instance, dichogamy. It may be that the production of the male and female reproductive elements and the maturation of the ovules was too great a strain and expenditure of vital force for a single individual to withstand, if endowed with a highly complex organization; and that at the same time there was no need for all the individuals to produce young, and consequently that no injury, on the contrary, good, resulted from half of them, or the males, failing to produce offspring.

COMPARATIVE FERTILITY OF MALE AND FEMALE PLANTS.

The Different Forms of Flowers, page 290.

Thirteen bushes (of the spindle-tree) growing near one another in a hedge consisted of eight females quite destitute of pollen, and of five hermaphrodites with well-developed anthers. In the autumn the eight females were well covered with fruit, excepting one which bore only a moderate number. Of the five hermaphrodites, one bore a dozen or two fruits, and the remaining four bushes several dozen; but their number was as nothing compared with those on the female bushes, for a single branch, between two and three feet in length, from one of the latter, yielded more than any one of the hermaphrodite bushes. The difference in the amount of fruit produced by the two sets of bushes is all the more striking, as from the sketches above given it is obvious that the stigmas of the polleniferous flowers can hardly fail to receive their own pollen; while the fertilization of the female flowers depends on pollen being brought to them by flies and the smaller *Hymenoptera*, which are far from being such efficient carriers as bees.

I now determined to observe more carefully during successive seasons some bushes growing in another place about a mile distant. As the female bushes were so highly productive, I marked only two of them with the letters A and B, and five polleniferous bushes with the letters C to G. I may premise that the year 1865 was highly favorable for the fruiting of all the bushes, especially for the polleniferous ones, some of which were quite barren, except under such favorable conditions. The season of 1864 was unfavorable. In 1863 the female A produced "some fruit"; in 1864 only nine; and in 1865 ninety-seven fruit. The female B in 1863 was "covered with fruit"; in 1864 it bore twenty-eight; and in 1865 "innumerable very fine fruits." I may add that three other female trees growing close by were observed, but only during 1863, and they then bore abundantly. With respect to the polleniferous bushes, the one marked C did not bear a single fruit during the years 1863 and 1864, but during 1865 it produced no less than ninety-two fruit, which, however, were very poor. I selected one of the finest branches with fifteen fruit, and these contained twenty seeds, or on an average 1·33 per fruit. I then took by hazard fifteen fruit from an adjoining female bush, and these contained forty-three seeds; that is, more than twice as many, or on an average 2·86 per fruit. Many of the fruits from the female bushes included four seeds, and only one had a single seed; whereas, not one fruit from the polleniferous bushes contained four seeds. Moreover, when the two lots of seeds were compared, it was manifest that those from the female bushes were the larger. The second polleniferous bush, D, bore in 1863 about two dozen fruit, in 1864 only three very poor fruit, each containing a single seed; and in 1865, twenty equally poor fruit. Lastly, the three polleniferous bushes, E, F, and G, did not produce a single fruit during the three years 1863, 1864, and 1865.

EFFECT OF CLIMATE ON REPRODUCTION.

Page 293. A tendency to the separation of the sexes in the cultivated strawberry seems to be much more strongly marked in the United States than in Europe; and this appears to be the result of the direct action of climate on the reproductive organs. In the best account which I have seen, it is stated that many of the varieties in the United States consist of three forms, namely, females, which produce a heavy crop of fruit; of hermaphrodites, which "seldom produce other than a very scanty crop of inferior and imperfect berries"; and of males, which produce none. The most skillful cultivators plant "seven rows of female plants, then one row of hermaphrodites, and so on throughout the field." The males bear large, the hermaphrodites mid-sized, and the females small flowers. The latter plants produce few runners, while the two other forms produce many; consequently, as has been observed both in England and in the United States, the polleniferous forms increase rapidly and tend to supplant the females. We may therefore infer that much more vital force is expended in the production of ovules and fruit than in the production of pollen.

CAUSES OF STERILITY AMONG PLANTS.

The Different Forms of Flower, page 345.

If the sexual elements belonging to the same form are united, the union is an illegitimate one, and more or less sterile. With dimorphic species two illegitimate unions, and with trimorphic species twelve are possible. There is reason to believe that the sterility of these unions has not been specially acquired, but follows as an incidental result from the sexual elements of the two or three forms having been adapted to act on one another in a particular manner, so that any other kind of union is inefficient, like that between distinct species. Another and still more remarkable incidental result is that the seedlings from an illegitimate union are often dwarfed and more or less completely barren, like hybrids from the union of two widely distinct species.

AN "IDEAL TYPE" OR INEVITABLE MODIFICATION?

Fertilization of Orchids by Insects, page 245.

It is interesting to look at one of the magnificent exotic species (orchids), or, indeed, at one of our humblest forms, and observe how profoundly it has been modified, as compared with all ordinary flowers—with its great labellum, formed of one petal and two petaloid stamens; with its singular pollen-masses, hereafter to be referred to; with its column formed of seven cohering organs, of which three alone perform their proper function, namely, one anther and two generally confluent stigmas; with the third stigma modified into the rostellum and incapable of being fertilized; and with three of the anthers no longer functionally active, but serving either to protect the pollen of the fertile anther or to strengthen the column, or existing as mere rudiments, or entirely suppressed. What an amount of modification, cohesion, abortion, and change of function do we here see! Yet hidden in that column, with its surrounding petals and sepals, we know that there are fifteen groups of vessels, arranged three within three, in alternate order, which probably have been preserved to the present time from being developed at a very early period of growth, before the shape or existence of any part of the flower is of importance for the well-being of the plant.

Can we feel satisfied by saying that each orchid was created, exactly as we now see it, on a certain "ideal type"; that the omnipotent Creator, having fixed on one plan for the whole order, did not depart from this plan; that he, therefore, made the same organ to perform diverse functions—often of trifling importance compared with their proper function—converted other organs into mere purposeless rudiments, and arranged all as if they had to stand separate, and then made them cohere? Is it not a more simple and intelligible view that all the *Orchideæ* owe what they have in common to descent from some monocotyledonous plant, which, like so many other plants of the same class, possessed fifteen organs, arranged alternately, three within three, in five whorls; and that the now wonderfully changed structure of the flower is due to a long course of slow modification—each modification having been preserved which was useful to the plant, during the incessant changes to which the organic and inorganic world has been exposed?

SPECIAL ADAPTATIONS TO A CHANGING PURPOSE.

Fertilization of Orchids, page 282.

It has, I think, been shown that the *Orchideæ* exhibit an almost endless diversity of beautiful adaptations. When this or that part has been spoken of as adapted for some special purpose, it must not be supposed that it was originally always formed for this sole purpose. The regular course of events seems to be, that a part which originally served for one purpose becomes adapted by slow changes for widely different purposes. To give an instance: in all the *Ophreæ,* the long and nearly rigid caudicle manifestly serves for the application of the pollen-grains to the stigma, when the pollinia are transported by insects to another flower; and the anther opens widely in order that the pollinium should be easily withdrawn; but, in the *Bee ophrys,* the caudicle, by a slight increase in length and decrease in its thickness, and by the anther opening a little more widely, becomes specially adapted for the very different purpose of self-fertilization, through the combined aid of the weight of the pollen-mass and the vibration of the flower when moved by the wind. Every gradation between these two states is possible—of which we have a partial instance in *O. aranifera.*

Again, the elasticity of the pedicel of the pollinium in some *Vandeæ* is adapted to free the pollen-masses from their anther-cases; but, by a further slight modification, the elasticity of the pedicel becomes specially adapted to shoot out the pollinium with considerable force, so as to strike the body of the visiting insect. The great cavity in the labellum of many *Vandeæ* is gnawed by insects, and thus attracts them; but in *Mormodes ignea* it is greatly reduced in size, and serves in chief part to keep the labellum in its new position on the summit of the column. From the analogy of many plants we may infer that a long, spur-like nectary is primarily adapted to secrete and hold a store of nectar; but in many orchids it has so far lost this function that it contains fluid only in the intercellular spaces. In those orchids in which the nectary contains both free nectar and fluid in the intercellular spaces, we can see how a transition from the one state to the other could be effected, namely, by less and less nectar being secreted from the inner membrane, with more and more retained within the intercellular spaces. Other analogous cases could be given.

Although an organ may not have been originally formed for some special purpose, if it now serves for this end, we are justified in saying that it is specially adapted for it. On the same principle, if a man were to make a machine for some special purpose, but were to use old wheels, springs, and pulleys, only slightly altered, the whole machine, with all its parts, might be said to be specially contrived for its present purpose. Thus throughout nature almost every part of each living being has probably served, in a slightly modified condition, for diverse purposes, and has acted in the living machinery of many ancient and distinct specific forms.

In my examination of orchids, hardly any fact has struck me so much as the endless diversities of structure —the prodigality of resources—for gaining the very same end, namely, the fertilization of one flower by pollen from another plant. This fact is to a large extent intelligible on the principle of natural selection. As all the parts of a flower are co-ordinated, if slight variations in any one part were preserved from being beneficial to the plant, then the other parts would generally have to be modified in some corresponding manner. But these latter parts might not vary at all, or they might not vary in a fitting manner, and these other variations, whatever their nature might be, which tended to bring all the parts into more harmonious action with one another, would be preserved by natural selection.

AN ILLUSTRATION.

Page 284. To give a simple illustration: in many orchids the ovarium (but sometimes the footstalk) becomes for a period twisted, causing the labellum to assume the position of a lower petal, so that insects can easily visit the flower; but from slow changes in the form or position of the petals, or from new sorts of insects visiting the flowers, it might be advantageous to the plant that the labellum should resume its normal position on the upper side of the flower, as is actually the case with *Malaxis paludosa,* and some species of *Catasetum,* etc. This change, it is obvious, might be simply effected by the continued selection of varieties which had their ovaria less and less twisted; but, if the plant only afforded varieties with the ovarium more twisted, the same end could be attained by the selection of such variations, until the flower was turned completely round on its axis. This seems to have actually occurred with *Malaxis paludosa,* for the labellum has acquired its present upward position by the ovarium being twisted twice as much as is usual.

Again, we have seen that in most *Vandeæ* there is a plain relation between the depth of the stigmatic chamber and the length of the pedicel, by which the pollen-masses are inserted; now, if the chamber became slightly less deep from any change in the form of the column, or other unknown cause, the mere shortening of the pedicel would be the simplest corresponding change; but, if the pedicel did not happen to vary in shortness, the slightest tendency to its becoming bowed from elasticity, as in *Phalænopsis,* or to a backward hygrometric movement, as in one of the *Maxillarias,* would be preserved, and the tendency would be continually augmented by selection; thus the pedicel, as far as its action is concerned, would be modified in the same manner as if it had been shortened. Such processes carried on during many thousand generations in various ways, would create an endless diversity of co-adapted structures in the several parts of the flower for the same general purpose. This view affords, I believe, the key which partly solves the problem of the vast diversity of structure adapted for closely analogous ends in many large groups of organic beings.

AS INTERESTING ON THE THEORY OF DEVELOPMENT AS ON THAT OF DIRECT INTERPOSITION.

Page 285. The more I study nature, the more I become impressed, with ever-increasing force, that the contrivances and beautiful adaptations slowly acquired through each part occasionally varying in a slight degree but in many ways, with the preservation of those variations which were beneficial to the organism under complex and ever-varying conditions of life, transcend in an incomparable manner the contrivances and adaptations which the most fertile imagination of man could invent.

The use of each trifling detail of structure is far from a barren search to those who believe in natural selection. When a naturalist casually takes up the study of an organic being, and does not investigate its whole life (imperfect though that study will ever be), he naturally doubts whether each trifling point can be of any use, or, indeed, whether it be due to any general law. Some naturalists believe that numberless structures have been created for the sake of mere variety and beauty—much as a workman would make different patterns. I, for one, have often and often doubted whether this or that detail of structure in many of the *Orchideæ* and other plants could be of any service; yet, if of no good, these structures could not have been modeled by the natural preservation of useful variations; such details can only be vaguely accounted for by the direct action of the conditions of life, or the mysterious laws of correlated growth.

Fertilization of Orchids, page 2.

This treatise affords me also an opportunity of attempting to show that the study of organic beings may be as interesting to an observer who is fully convinced that the structure of each is due to secondary laws as to one who views every trifling detail of structure as the result of the direct interposition of the Creator.

THE SLEEP OF THE PLANTS.

The Power of Movement in Plants. page 280.

The so-called sleep of leaves is so conspicuous a phenomenon that it was observed as early as the time of Pliny; and since Linnæus published his famous essay, "Somnus Plautarum," it has been the subject of several memoirs. Many flowers close at night, and these are likewise said to sleep; but we are not here concerned with their movements, for although effected by the same mechanism as in the case of young leaves, namely, unequal growth on the opposite sides (as first proved by Pfeffer), yet they differ essentially in being excited chiefly by changes of temperature instead of light; and in being effected, as far as we can judge, for a different purpose. Hardly any one supposes that there is any real analogy between the sleep of animals and that of plants, whether of leaves or flowers. It seems, therefore, advisable to give a distinct name to the so-called sleep-movements of plants. These have also generally been confounded, under the term "periodic," with the slight daily rise and fall of leaves, as described in the fourth chapter; and this makes it all the more desirable to give some distinct name to sleep-movements. Nyctitropism and nyctitropic, i. e., night-turning, may be applied both to leaves and flowers, and will be occasionally used by us; but it would be best to confine the term to leaves.

Page 281.

Leaves, when they go to sleep, move either upward or downward, or, in the case of the leaflets of compound leaves, forward, that is, toward the apex of the leaf, or backward, that is, toward its base; or, again, they may rotate on their own axis without moving either upward or downward. But in almost every case the plane of the blade is so placed as to stand nearly or quite vertically at night. Therefore the apex, or the base, or either lateral edge, may be directed toward the zenith. Moreover, the upper surface of each leaf, and more especially of each leaflet, is often brought into close contact with that of the opposite one; and this is sometimes effected by singularly complicated movements. This fact suggests that the upper surface requires more protection than the lower one. For instance, the terminal leaflet in trifolium, after turning up at night so as to stand vertically, often continues to bend over until the upper surface is directed downward, while the lower surface is fully exposed to the sky; and an arched roof is thus formed over the two lateral leaflets, which have their upper surfaces pressed closely together. Here we have the unusual case of one of the leaflets not standing vertically, or almost vertically, at night.

Considering that leaves in assuming their nyctitropic positions often move through an angle of 90°; that the movement is rapid in the evening; that in some cases it is extraordinarily complicated; that with certain seedlings, old enough to bear true leaves, the cotyledons move vertically upward at night, while at the same time the leaflets move vertically downward; and that in the same genus the leaves or cotyledons of some species move upward, while those of other species move downward—from these and other such facts, it is hardly possible to doubt that plants must derive some great advantage from such remarkable powers of movement.

SELF-PROTECTION DURING SLEEP.

Page 284. The fact that the leaves of many plants place themselves at night in widely different positions from what they hold during the day, but with the one point in common, that their upper surfaces avoid facing the zenith, often with the additional fact that they come into close contact with opposite leaves or leaflets, clearly indicates, as it seems to us, that the object gained is the protection of the upper surfaces from being chilled at night by radiation. There is nothing improbable in the upper surface needing protection more than the lower, as the two differ in function and structure. All gardeners know that plants suffer from radiation. It is this, and not cold winds, which the peasants of Southern Europe fear for their olives. Seedlings are often protected from radiation by a very thin covering of straw; and fruit-trees on walls by a few fir-branches, or even by a fishing-net, suspended over them. There is a variety of the gooseberry, the flowers of which, from being produced before the leaves, are not protected by them from radiation, and consequently often fail to yield fruit. An excellent observer has remarked that one variety of the cherry has the petals of its flowers much curled backward, and after a severe frost all the stigmas were killed; while, at the same time, in another variety with incurved petals, the stigmas were not in the least injured.

Page 285. We are far from doubting that an additional advantage may be thus gained; and we have observed with several plants, for instance, *Desmodium gyrans*, that while the blade of the leaf sinks vertically down at night, the petiole rises, so that the blade has to move through a greater angle in order to assume its vertical position than would otherwise have been necessary; but with the result that all the leaves on the same plant are crowded together, as if for mutual protection.

We doubted at first whether radiation would affect in any important manner objects so thin as are many cotyledons and leaves, and more especially affect differently their upper and lower surfaces; for, although the temperature of their upper surfaces would undoubtedly fall when freely exposed to a clear sky, yet we thought that they would so quickly acquire by conduction the temperature of the surrounding air, that it could hardly make any sensible difference to them whether they stood horizontally, and radiated into the open sky, or vertically, and radiated chiefly in a lateral direction toward neighboring plants and other objects. We endeavored, therefore, to ascertain something on this head, by preventing the leaves of several plants from going to sleep, and by exposing to a clear sky, when the temperature was beneath the freezing-point, these as well as the other leaves on the same plants, which had already assumed their nocturnal vertical position. Our experiments show that leaves thus compelled to remain horizontal at night suffered much more injury from frost than those which were allowed to assume their normal vertical position. It may, however, be said that conclusions drawn from such observations are not applicable to sleeping plants, the inhabitants of countries where frosts do not occur. But in every country, and at all seasons, leaves must be exposed to nocturnal chills through radiation, which might be in some degree injurious to them, and which they would escape by assuming a vertical position.

The Power of Movement in Plants, page 403.

Any one who had never observed continuously a sleeping plant would naturally suppose that the leaves moved only in the evening when going to sleep, and in the morning when awaking; but he would be quite mistaken, for we have found no exception to the rule that leaves which sleep continue to move during the whole twenty-four hours; they move, however, more quickly when going to sleep and when awaking than at other times.

INFLUENCE OF LIGHT UPON PLANTS.

The Power of Movement in Plants, page 565.

The extreme sensitiveness of certain seedlings to light is highly remarkable. The cotyledons of *Phalaris* became curved toward a distant lamp, which emitted so little light that a pencil held vertically close to the plants did not cast any shadow which the eye could perceive on a white card. These cotyledons, therefore, were affected by a difference in the amount of light on their two sides, which the eye could not distinguish. The degree of their curvature within a given time toward a lateral light did not correspond at all strictly with the amount of light which they received; the light not being at any time in excess. They continued for nearly half an hour to bend toward a lateral light, after it had been extinguished. They bend with remarkable precision toward it, and this depends on the illumination of one whole side, or on the obscuration of the whole opposite side. The difference in the amount of light which plants at any time receive in comparison with what they have shortly before received seems in all cases to be the chief exciting cause of those movements which are influenced by light. Thus seedlings brought out of darkness bend toward a dim lateral light, sooner than others which had previously been exposed to daylight. We have seen several analogous cases with the nyctitropic movements of leaves. A striking instance was observed in the case of the periodic movements of the cotyledons of a cassia: in the morning a pot was placed in an obscure part of a room, and all the cotyledons rose up closed; another pot had stood in the sun-light, and the cotyledons of course remained expanded; both pots were now placed close together in the middle of the room, and the cotyledons which had been exposed to the sun immediately began to close, while the others opened; so that the cotyledons in the two pots moved in exactly opposite directions while exposed to the same degree of light.

We found that if seedlings, kept in a dark place, were laterally illuminated by a small wax-taper for only two or three minutes at intervals of about three quarters of an hour, they all became bowed to the point where the taper had been held. We felt much surprised at this fact, and, until we had read Wiesner's observations, we attributed it to the after-effects of the light; but he has shown that the same degree of curvature in a plant may be induced in the course of an hour by several interrupted illuminations lasting altogether for twenty minutes as by a continuous illumination of sixty minutes. We believe that this case, as well as our own, may be explained by the excitement from light being due not so much to its actual amount, as to the difference in amount from that previously received; and in our case there were repeated alternations from complete darkness to light. In this and in several of the above-specified respects, light seems to act on the tissues of plants almost in the same manner as it does on the nervous system of animals.

INFLUENCE OF GRAVITATION UPON PLANTS.

Page 567. Gravitation excites plants to bend away from the center of the earth, or toward it, or to place themselves in a transverse position with respect to it. Although it is impossible to modify in any direct manner the attraction of gravity, yet its influence could be moderated indirectly, in the several ways described in the tenth chapter; and under such circumstances the same kind of evidence as that given in the chapter on heliotropism showed in the plainest manner that apogeotropic and geotropic, and probably diageotropic movements, are all modified forms of circumnutation.

Different parts of the same plant and different species are affected by gravitation in widely different degrees and manners. Some plants and organs exhibit hardly a trace of its action. Young seedlings, which, as we know, circumnutate rapidly, are eminently sensitive; and we have seen the hypocotyl of *Beta* bending upward through 109° in three hours and eight minutes. The after-effects of apogeotropism last for above half an hour; and horizontally-laid hypocotyls are sometimes thus carried temporarily beyond an upright position. The benefits derived from geotropism, apogeotropism, and diageotropism, are generally so manifest that they need not be specified. With the flower-peduncles of *Oxalis,* epinasty causes them to bend down, so that the ripening pods may be protected by the calyx from the rain. Afterward they are carried upward by apogeotropism in combination with hyponasty, and are thus enabled to scatter their seeds over a wider space. The capsules and flower-heads of some plants are bowed downward through geotropism, and they then bury themselves in the earth for the protection and slow maturation of the seeds. This burying process is much facilitated by the rocking movement due to circumnutation.

In the case of the radicles of several, probably of all seedling plants, sensitiveness to gravitation is confined to the tip, which transmits an influence to the adjoining upper part, causing it to bend toward the center of the earth. That there is transmission of this kind was proved in an interesting manner when horizontally extended radicles of the bean were exposed to the attraction of gravity for an hour or an hour and a half, and their tips were then amputated. Within this time no trace of curvature was exhibited, and the radicles were now placed pointing vertically downward; but an influence had already been transmitted from the tip to the adjoining part, for it soon became bent to one side, in the same manner as would have occurred had the radicle remained horizontal and been still acted on by geotropism. Radicles thus treated continued to grow out horizontally for two or three days, until a new tip was reformed; and this was then acted on by geotropism, and the radicle became curved perpendicularly downward.

THE POWER OF DIGESTION IN PLANTS.

Insectivorous Plants, page 85.

As we have seen that nitrogenous fluids act very differently on the leavesof *Drosera* from non-nitrogenous fluids, and as the leaves remain clasped for a much longer time over various organic bodies than over inorganic bodies, such as bits of glass, cinder, wood, etc., it becomes an interesting inquiry whether they can only absorb matter already in solution, or render it soluble; that is, have the power of digestion. We shall immediately see that they certainly have this power, and that they act on albuminous compounds in exactly the same manner as does the gastric juice of mammals; the digested matter being afterward absorbed. This fact, which will be clearly proved, is a wonderful one in the physiology of plants.

Page 86.

It may be well to premise, for the sake of any reader who knows nothing about the digestion of albuminous compounds by animals, that this is effected by means of a ferment, pepsin, together with weak hydrochloric acid, though almost any acid will serve. Yet neither pepsin nor an acid by itself has any such power. We have seen that when the glands of the disk are excited by the contact of any object, especially of one containing nitrogenous matter, the outer tentacles and often the blade become inflected; the leaf being thus converted into a temporary cup or stomach. At the same time the discal glands secrete more copiously, and the secretion becomes acid. Moreover, they transmit some influence to the glands of the exterior tentacles, causing them to pour forth a more copious secretion, which also becomes acid or more acid than it was before.

As this result is an important one, I will give the evidence. The secretion of many glands on thirty leaves, which had not been in any way excited, was tested with litmus-paper; and the secretion of twenty-two of these leaves did not in the least affect the color, whereas that of eight caused an exceedingly feeble and sometimes doubtful tinge of red. Two other old leaves, however, which appeared to have been inflected several times, acted much more decidedly on the paper. Particles of clean glass were then placed on five of the leaves, cubes of albumen on six, and bits of raw meat on three, on none of which was the secretion at this time in the least acid. After an interval of twenty-four hours, when almost all the tentacles on these fourteen leaves had become more or less inflected, I again tested the secretion, selecting glands which had not as yet reached the center or touched any object, and it was now plainly acid. The degree of acidity of the secretion varied somewhat on the glands of the same leaf. On some leaves a few tentacles did not, from some unknown cause, become inflected, as often happens; and in five instances their secretion was found not to be in the least acid; while the secretion of the adjoining and inflected tentacles on the same leaf was decidedly acid. With leaves excited by particles of glass placed on the central glands, the secretion which collects on the disk beneath them was much more strongly acid than that poured forth from the exterior tentacles, which were as yet only moderately inflected. When bits of albumen (and this is naturally alkaline) or bits of meat were placed on the disk, the secretion collected beneath them was likewise strongly acid. As raw meat moistened with water is slightly acid, I compared its action on litmus-paper before it was placed on the leaves, and afterward when bathed in the secretion; and there could not be the least doubt that the latter was very much more acid. I have indeed tried hundreds of times the state of the secretion on the disks of leaves which were inflected over various objects, and never failed to find it acid. We may, therefore, conclude that the secretion from unexcited leaves, though extremely viscid, is not acid or only slightly so, but that it becomes acid, or much more strongly so, after the tentacles have begun to bend over any inorganic or organic object; and still more strongly acid after the tentacles have remained for some time closely clasped over any object.

I may here remind the reader that the secretion appears to be to a certain extent antiseptic, as it checks the appearance of mold and infusoria, thus preventing for a time the discoloration and decay of such substances as the white of an egg, cheese, etc. It therefore acts like the gastric juice of the higher animals, which is known to arrest putrefaction by destroying the microzymes.

Page 98. Cubes of about one twentieth of an inch (1·27 millimetre) of moderately roasted meat were placed on five leaves, which became in twelve hours closely inflected. After forty-eight hours I gently opened one leaf, and the meat now consisted of a minute central sphere, partially digested, and surrounded by a thick envelope of transparent viscid fluid. The whole, without being much disturbed, was removed and placed under the microscope. In the central part the transverse striæ on the muscular fibers were quite distinct; and it was interesting to observe how gradually they disappeared, when the same fiber was traced into the surrounding fluid. They disappeared by the striæ being replaced by transverse lines formed of excessively minute dark points, which toward the exterior could be seen only under a very high power; and ultimately these points were lost.

Page 134. Finally, the experiments recorded in this chapter show us that there is a remarkable accordance in the power of digestion between the gastric juice of animals, with its pepsin and hydrochloric acid, and the secretion of *Drosera* with its ferment and acid belonging to the acetic series. We can, therefore, hardly doubt that the ferment in both cases is closely similar.

DIVERSE MEANS BY WHICH PLANTS GAIN THEIR SUBSISTENCE.

Insectivorous Plants, page 452. Ordinary plants of the higher classes procure the requisite inorganic elements from the soil by means of their roots, and absorb carbonic acid from the atmosphere by means of their leaves and stems. But we have seen in a previous part of this work that there is a class of plants which digest and afterward absorb animal matter, namely, all the *Droseraceæ*, *Pinguicula*, and, as discovered by Dr. Hooker, *Nepenthes*, and to this class other species will almost certainly soon be added. These plants can dissolve matter out of certain vegetable substances, such as pollen, seeds, and bits of leaves. No doubt their glands likewise absorb the salts of ammonia brought to them by the rain. It has also been shown that some other plants can absorb ammonia by their glandular hairs; and these will profit by that brought to them by the rain. There is a second class of plants which, as we have just seen, can not digest, but absorb, the products of the decay of the animals which they capture, namely, *Utricularia* and its close allies; and, from the excellent observations of Dr. Mellichamp and Dr. Canby, there can scarcely be a doubt that *Sarracenia* and *Darlingtonia* may be added to this class, though the fact can hardly be considered as yet fully proved. There is a third class of plants which feed, as is now generally admitted, on the products of the decay of vegetable matter, such as the bird's-nest orchis (*Neottia*), etc. Lastly, there is the well-known fourth class of parasites (such as the mistletoe), which are nourished by the juices of living plants. Most, however, of the plants belonging to these four classes obtain part of their carbon, like ordinary species, from the atmosphere. Such are the diversified means, as far as at present known, by which higher plants gain their subsistence.

HOW A PLANT PREYS UPON ANIMALS.

The genus described is Genlisea ornata.

Insectivorous Plants, page 446.

The utricle is formed by a slight enlargement of the narrow blade of the leaf. A hollow neck, no less than fifteen times as long as the utricle itself, forms a passage from the transverse slit-like orifice into the cavity of the utricle. A utricle which measured $\frac{1}{36}$ of an inch (·795 millimetre) in its longer diameter had a neck $\frac{15}{36}$ (10·583 millimetres) in length, and $\frac{1}{100}$ of an inch (·254 millimetre) in breadth. On each side of the orifice there is a long spiral arm, or tube; the structure of which will be best understood be the following illustration: Take a narrow ribbon and wind it spirally round a thin cylinder, so that the edges come tnto contact along its whole length; then pinch up the two edges so as to form a little crest, which will, of course, wind spirally round the cylinder, like a thread round a screw. If the cylinder is now removed, we shall have a tube like one of the spiral arms. The two projecting edges are not actually united, and a needle can be pushed in easily between them. They are indeed in many places a little separated, forming narrow entrances into the tube; but this may be the result of the drying of the specimens. The lamina of which the tube is formed seems to be a lateral prolongation of the lip of the orifice; and the spiral line between the two projecting edges is continuous with the corner of the orifice. If a fine bristle is pushed down one of the arms, it passes into the top of the hollow neck. Whether the arms are open or closed at their extremities could not be determined, as all the specimens were broken; nor does it appear that Dr. Warming ascertained this point.

So much for the external structure. Internally the lower part of the utricle is covered with spherical papillæ, formed of four cells (sometimes eight, according to Dr. Warming), which evidently answer to the quadrifid processes within the bladders of *Utricularia.* These papillæ extend a little way up the dorsal and ventral surfaces of the utricle; and a few, according to Warming may be found in the upper part. This upper region is covered by many transverse rows, one above the other, of short, closely approximate hairs, pointing downward.

These hairs have broad bases, and their tips are formed by a separate cell. They are absent in the lower part of the utricle where the papillæ abound. The neck is likewise lined throughout its whole length with transverse rows of long, thin, transparent hairs, having broad bulbous bases, with similarly constructed sharp points. They arise from little projecting ridges, formed of rectangular epidermic cells. The hairs vary a little in length, but their points generally extend down to the row next below; so that, if the neck is split open and laid flat, the inner surface resembles a paper of pins—the hairs representing the pins, and the little transverse ridges representing the folds of paper through which the pins are thrust. These rows of hairs are indicated in the previous figure by numerous transverse lines crossing the neck. The inside of the neck is also studded with papillæ; those in the lower part are spherical and formed of four cells, as in the lower part of the utricle; those in the upper part are formed of two cells, which are much elongated downward beneath their points of attachment. These two-celled papillæ apparently correspond with the bifid process in the upper part of the bladders of *Utricularia.* The narrow transverse orifice is situated between the bases of the two spiral arms. No valve could be detected here, nor was any such structure seen by Dr. Warming. The lips of the orifice are armed with many short, thick, sharply pointed, somewhat incurved hairs or teeth.

The two projecting edges of the spirally-wound lamina, forming the arms, are provided with short incurved hairs or teeth, exactly like those on the lips. These project inward at right angles to the spiral line of junction between the two edges. The inner surface of the lamina supports two-celled, elongated papillæ, resembling those in the upper part of the neck, but differing slightly from them, according to Warming, in their footstalks being formed by prolongations of large epidermic cells; whereas the papillæ within the neck rest on small cells sunk amid the larger ones. These spiral arms form a conspicuous difference between the present genus and *Utricularia*.

Lastly, there is a bundle of spiral vessels which, running up the lower part of the linear leaf, divides close beneath the utricle. One branch extends up the dorsal and the other up the ventral side of both the utricle and neck. Of these two branches, one enters one spiral arm, and the other branch the other arm.

The utricles contained much *débris*, or dirty matter, which seemed organic, though no distinct organisms could be recognized. It is, indeed, scarcely possible that any object could enter the small orifice and pass down the long, narrow neck, except a living creature. Within the necks, however, of some specimens, a worm, with retracted horny jaws, the abdomen of some articulate animal, and specks of dirt, probably the remnants of other minute creatures, were found. Many of the papillæ within both the utricles and necks were discolored, as if they had absorbed matter.

From this description it is sufficiently obvious how genlisea secures its prey. Small animals entering the narrow orifice—but what induces them to enter is not known any more than in the case of *Utricularia*—would find their egress rendered difficult by the sharp incurved hairs on the lips, and, as soon as they passed some way down the neck, it would be scarcely possible for them to return, owing to the many transverse rows of long, straight, downward-pointing hairs, together with the ridges from which these project. Such creatures would, therefore, perish either within the neck or utricle; and the quadrifid and bifid papillæ would absorb matter from their decayed remains. The transverse rows of hairs are so numerous that they seem superfluous merely for the sake of preventing the escape of prey, and, as they are thin and delicate, they probably serve as additional absorbents, in the same manner as the flexible bristles on the infolded margins of the leaves of aldrovanda. The spiral arms, no doubt, act as accessory traps. Until fresh leaves are examined, it can not be told whether the line of junction of the spirally-wound lamina is a little open along its whole course or only in parts, but a small creature which forced its way into the tube at any point would be prevented from escaping by the incurved hairs, and would find an open path down the tube into the neck, and so into the utricle. If the creature perished within the spiral arms, its decaying remains would be absorbed and utilized by the bifid papillæ. We thus see that animals are captured by genlisea, not by means of an elastic valve, as with the foregoing species, but by a contrivance resembling an eel-trap, though more complex.

II.

THE PART PLAYED BY WORMS IN THE HISTORY OF THIS PLANET.

The Formation of Vegetable Mold through the Action of Earthworms, page 305.

page 305.

WORMS have played a more important part in the history of the world than most persons would at first suppose. In almost all humid countries they are extraordinarily numerous, and for their size possess great muscular power. In many parts of England a weight of more than ten tons (10,516 kilogrammes) of dry earth annually passes through their bodies and is brought to the surface on each acre of land; so that the whole superficial bed of vegetable mold passes through their bodies in the course of every few years. From the collapsing of the old burrows the mold is in constant though slow movement, and the particles composing it are thus rubbed together. By these means fresh surfaces are continually exposed to the action of the carbonic acid in the soil, and of the humus-acids which appear to be still more efficient in the decomposition of rocks. The generation of the humus-acids is probably hastened during the digestion of the many half-decayed leaves which worms consume. Thus the particles of earth, forming the superficial mold, are subjected to conditions eminently favorable for their decomposition and disintegration. Moreover, the particles of the softer rocks suffer some amount of mechanical trituration in the muscular gizzards of worms, in which small stones serve as mill-stones.

The finely levigated castings, when brought to the surface in a moist condition, flow during rainy weather down any moderate slope; and the smaller particles are washed far down even a gently inclined surface. Castings when dry often crumble into small pellets, and these are apt to roll down any sloping surface. Where the land is quite level and is covered with herbage, and where the climate is humid so that much dust can not be blown away, it appears at first sight impossible that there should be any appreciable amount of subaërial denudation; but worm-castings are blown, especially while moist and viscid, in one uniform direction by the prevalent winds which are accompanied by rain. By these several means the superficial mold is prevented from accumulating to a great thickness; and a thick bed of mold checks in many ways the disintegration of the underlying rocks and fragments of rock.

The removal of worm-castings by the above means leads to results which are far from insignificant. It has been shown that a layer of earth, ·2 of an inch in thickness, is in many places annually brought to the surface per acre; and if a small part of this amount flows, or rolls, or is washed, even for a short distance down every inclined surface, or is repeatedly blown in one direction, a great effect will be produced in the course of ages. It was found by measurements and calculations that on a surface with a mean inclination of 9° 26′, 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 cubic inches would cross a line a hundred yards in length. This latter amount in a damp state would weigh eleven and a half 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 for 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 can not fail to be produced within a period which no geologist considers extremely long.

THEY PRESERVE VALUABLE RUINS.

Page 308. Archæologists ought to be grateful to worms, as they protect and preserve for an indefinitely long period every object, not liable to decay, which is dropped on the surface of the land, by burying it beneath their castings. Thus, also, many elegant and curious tesselated pavements and other ancient remains have been preserved; though no doubt the worms have in these cases been largely aided by earth washed and blown from the adjoining land, especially when cultivated. The old tesselated pavements have, however, often suffered by having subsided unequally from being unequally undermined by the worms. Even old massive walls may be undermined and subside; and no building is in this respect safe, unless the foundations lie six or seven feet beneath the surface, at a depth at which worms can not work. It is probable that many monoliths and some old walls have fallen down from having been undermined by worms.

THEY PREPARE THE GROUND FOR SEED.

Page 309. Worms prepare the ground in an excellent manner for the growth of fibrous-rooted plants and for seedlings of all kinds. They periodically expose the mold to the air, and sift it so that no stones larger than the particles which they can swallow are left in it. They mingle the whole intimately together, like a gardener who prepares fine soil for his choicest plants. In this state it is well fitted to retain moisture and to absorb all soluble substances, as well as for the process of nitrification. The bones of dead animals, the harder parts of insects, the shells of land-mollusks, leaves, twigs, etc., are before long all buried beneath the accumulating castings of worms, and are thus brought in a more or less decayed state within reach of the roots of plants. Worms likewise drag an infinite number of dead leaves and other parts of plants into their burrows, partly for the sake of plugging them up and partly as food.

The leaves which are dragged into the burrows as food, after being torn into the finest shreds, partially digested, and saturated with the intestinal and urinary secretions, are commingled with much earth. This earth forms the dark-colored, rich humus which almost everywhere covers the surface of the land with a fairly well-defined layer or mantle. Von Hensen placed two worms in a vessel eighteen inches in diameter, which was filled with sand, on which fallen leaves were strewed; and these were soon dragged into their burrows to a depth of three inches. After about six weeks an almost uniform layer of sand, a centimetre (·4 inch) in thickness, was converted into humus by having passed through the alimentary canals of these two worms. It is believed by some persons that worm-burrows, which often penetrate the ground almost perpendicularly to a depth of five or six feet, materially aid in its drainage; notwithstanding that the viscid castings piled over the mouths of the burrows prevent or check the rain-water directly entering them. They allow the air to penetrate deeply into the ground. They also greatly facilitate the downward passage of roots of moderate size; and these will be nourished by the humus with which the burrows are lined. Many seeds owe their germination to having been covered by castings; and others buried to a considerable depth beneath accumulated castings lie dormant, until at some future time they are accidentally uncovered and germinate.

Page 313. When we behold a wide, turf-covered expanse, we should remember that its smoothness, on which so much of its beauty depends, is mainly due to all the inequalities having been slowly leveled by worms. It is a marvelous reflection that the whole of the superficial mold over any such expanse has passed, and will again pass, every few years through the bodies of worms. The plow is one of the most ancient and most valuable of man's inventions; but long before he existed the land was in fact regularly plowed, and still continues to be thus plowed, by earth-worms. 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 organized creatures. Some other animals, however, still more lowly organized, namely corals, have done far more conspicuous work in having constructed innumerable reefs and islands in the great oceans; but these are almost confined to the tropical zones.

INTELLIGENCE OF WORMS.

Page 91. We can hardly escape from the conclusion that worms show some degree of intelligence in their manner of plugging up their burrows. Each particnlar object is seized in too uniform a manner, and from causes which we can generally understand, for the result to be attributed to mere chance. That every object has not been drawn in by its pointed eud, may be accounted for by labor having been saved through some being inserted by their broader or thicker ends. No doubt worms are led by instinct to plug up their burrows; and it might have been expected that they would have been led by instinct how best to act in each particular case, independently of intelligence. We see how difficult it is to judge whether intelligence comes into play, for even plants might sometimes be thought to be thus directed; for instance, when displaced leaves redirect their upper surfaces toward the light by extremely complicated movements and by the shortest course. With animals, actions appearing due to intelligence may be performed through inherited habit without any intelligence, although aboriginally thus acquired. Or the habit may have been acquired through the preservation and inheritance of beneficial variations of some other habit; and in this case the new habit will have been acquired independently of intelligence throughout the whole course of its development. There is no *a priori* improbability in worms having acquired special instincts through either of these two latter means. Nevertheless, it is incredible that instincts should have been developed in reference to objects, such as the leaves or petioles of foreign plants, wholly unknown to the progenitors of the worms which act in the described manner. Nor are their actions so unvarying or inevitable as are most true instincts.

As worms are not guided by special instincts in each particular case, though possessing a general instinct to plug up their burrows, and, as chance is excluded, the next most probable conclusion seems to be that they try in many different ways to draw in objects, and at last succeed in some one way. But it is surprising that an animal so low in the scale as a worm should have the capacity for acting in this manner, as many higher animals have no such capacity.

Page 95. Mr. Romanes, who has specially studied the minds of animals, believes that we can safely infer intelligence only when we see an individual profiting by its own experience. Now, if worms try to drag objects into their burrows first in one way and then in another, until they at last succeed, they profit at least in each particular instance by experience.

Page 98. One alternative alone is left, namely, that worms, although standing low in the scale of organization, possess some degree of intelligence. This will strike every one as very improbable ; but it may be doubted whether we know enough about the nervous system of the lower animals to justify our natural distrust of such a conclusion. With respect to the small size of the cerebral ganglia, we should remember what a mass of inherited knowledge, with some power of adapting means to an end, is crowded into the minute brain of a worker-ant.

III.

THE LAWS OF VARIABILITY WITH RESPECT TO ANIMALS AND PLANTS.

The Variation of Animals and Plants under Domestication, vol. i, page 3.

I SHALL in this volume treat, as fully as my materials permit, the whole subject of variation under domestication. We may thus hope to obtain some light, little though it be, on the causes of variability, on the laws which govern it—such as the direct action of climate and food, the effects of use and disuse, and of correlation of growth—and on the amount of change to which domesticated organisms are liable.

Although man does not cause variability and can not even prevent it, he can select, preserve, and accumulate the variations given to him by the hand of Nature almost in any way which he chooses; and thus he can certainly produce a great result. Selection may be followed either methodically and intentionally, or unconsciously and unintentionally. Man may select and preserve each successive variation, with the distinct intention of improving and altering a breed, in accordance with a preconceived idea; and by thus adding up variations, often so slight as to be imperceptible by an uneducated eye, he has effected wonderful changes and improvements. It can, also, be clearly shown that man, without any intention or thought of improving the breed, by preserving in each successive generation the individuals which he prizes most, and by destroying the worthless individuals, slowly, though surely, induces great changes. As the will of man thus comes into play, we can understand how it is that domesticated breeds show adaptation to his wants and pleasures. We can further understand how it is that domestic races of animals and cultivated races of plants often exhibit an abnormal character, as compared with natural species; for they have been modified not for their own benefit, but for that of man.

INHERITED EFFECT OF CHANGED HABITS.

Origin of Species, page 5.

When we compare the individuals of the same variety or subvariety of our older cultivated plants and animals, one of the first points which strikes us is, that they generally differ more from each other than do the individuals of any one species or variety in a state of nature. And if we reflect on the vast diversity of the plants and animals which have been cultivated, and which have varied during all ages under the most different climates and treatment, we are driven to conclude that this great variability is due to our domestic productions having been raised under conditions of life not so uniform as, and somewhat different from, those to which the parent species had been exposed under nature.

Page 8.

Changed habits produce an inherited effect, as in the period of the flowering of plants when transported from one climate to another. With animals the increased use or disuse of parts has had a more marked influence; thus I find in the domestic duck that the bones of the wing weigh less and the bones of the leg more, in proportion to the whole skeleton, than do the same bones in the wild-duck; and this change may be safely attributed to the domestic duck flying much less, and walking more, than its wild parents. The great and inherited development of the udders in cows and goats in countries where they are habitually milked, in comparison with these organs in other countries, is probably another instance of the effects of use. Not one of our domestic animals can be named which has not in some country drooping ears; and the view which has been suggested that the drooping is due to the disease of the muscles of the ear, from the animals being seldom much alarmed, seems probable.

Page 9. From facts collected by Heusinger, it appears that white sheep and pigs are injured by certain plants, while dark-colored individuals escape, Professor Wyman has recently communicated to me a good illustration of this fact: on asking some farmers in Virginia how it was that all their pigs were black, they informed him that the pigs ate the paint-root (*Lachnanthes*), which colored their bones pink, and which caused the hoofs of all but the black varieties to drop off; and one of the "crackers" (i. e., Virginia squatters) added, "We select the black members of a litter for raising, as they alone have a good chance of living." Hairless dogs have imperfect teeth; long-haired and coarse-haired animals are apt to have, as is asserted, long or many horns; pigeons with feathered feet have skin between their outer toes; pigeons with short beaks have small feet, and those with long beaks large feet. Hence, if man goes on selecting, and thus agmenting, any peculiarity, he will almost certainly modify unintentionally other parts of the structure, owing to the mysterious laws of correlation.

EFFECTS OF THE USE AND DISUSE OF PARTS.

Origin of Species, page 108.

From the facts alluded to in the first chapter, I think there can be no doubt that use in our domestic animals has strengthened and enlarged certain parts, and disuse diminished them, and that such modifications are inherited. Under free nature we have no standard of comparison by which to judge of the effects of long-continued use or disuse, for we know not the parent forms; but many animals possess structures which can be best explained by the effects of disuse. As Professor Owen has remarked, there is no greater anomaly in nature than a bird that can not fly; yet there are several in this state. The logger-headed duck of Sonth America can only flap along the surface of the water, and has its wings in nearly the same condition as the domestic Aylesbury duck: it is a remarkable fact that the young birds, according to Mr. Cunningham, can fly, while the adults have lost this power. As the larger ground-feeding birds seldom take flight, except to escape danger, it is probable that the nearly wingless condition of several birds, now inhabiting or which lately inhabited several oceanic islands, tenanted by no beast of prey, has been caused by disuse. The ostrich, indeed, inhabits continents, and is exposed to danger from which it can not escape by flight, but it can defend itself by kicking its enemies as efficiently as many quadrupeds. We may believe that the progenitor of the ostrich genus had habits like those of the bustard, and that, as the size and weight of its body were increased during successive generations, its legs were used more, and its wings less, until they became incapable of flight.

Page 109. The insects in Madeira which are not ground-feeders, and which, as certain flower-feeding *Coleoptera* and *Lepidoptera*, must habitually use their wings to gain their subsistence, have, as Mr. Wollaston suspects, their wings not at all reduced, but even enlarged. This is quite compatible with the action of natural selection. For, when a new insect first arrived on the island, the tendency of natural selection to enlarge or to reduce the wings would depend on whether a greater number of individuals were saved by successfully battling with the winds, or by giving up the attempt and rarely or never flying. As with mariners shipwrecked near a coast, it would have been better for the good swimmers if they had been able to swim still farther, whereas it would have been better for the bad swimmers if they had not been able to swim at all and had stuck to the wreck.

The eyes of moles and of some burrowing rodents are rudimentary in size, and in some cases are quite covered by skin and fur. This state of the eyes is probably due to gradual reduction from disuse, but aided, perhaps, by natural selection. In South America a burrowing rodent —the tuco-tuco, or ctenomys—is even more subterranean in its habits than the mole; and I was assured by a Spaniard, who had often caught them, that they were frequently blind. One which I kept alive was certainly in this condition, the cause, as appeared on dissection, having been inflammation of the nictitating membrane. As frequent inflammation of the eyes must be injurious to any animal, and as eyes are certainly not necessary to animals having subterranean habits, a reduction in their size, with the adhesion of the eyelids and growth of fur over them, might in such case be an advantage; and, if so, natural selection would aid the effects of disuse.

VAGUE ORIGIN OF OUR DOMESTIC ANIMALS.

Origin of Species, page 13.

In the case of most of our anciently domesticated animals and plants, it is not possible to come to any definite conclusion whether they are descended from one or several wild species. The argument mainly relied on by those who believe in the multiple origin of our domestic animals is, that we find in the most ancient times, on the monuments of Egypt, and in the lake-habitations of Switzerland, much diversity in the breeds; and that some of these ancient breeds closely resemble or are even identical with, those still existing. But this only throws far backward the history of civilization, and shows that animals were domesticated at a much earlier period than has hitherto been supposed. The lake-inhabitants of Switzerland cultivated several kinds of wheat and barley, the pea, the poppy for oil, and flax; and they possessed several domesticated animals. They also carried on commerce with other nations. All this clearly shows, as Heer has remarked, that they had at this early age progressed considerably in civilization; and this again implies a long-continued previous period of less advanced civilization, during which the domesticated animals, kept by different tribes in different districts, might have varied and given rise to distinct races. Since the discovery of flint tools in the superficial formations of many parts of the world, all geologists believe that barbarian man existed at an enormously remote period; and we know that at the present day there is hardly a tribe so barbarous as not to have domesticated at least the dog.

The origin of most of our domestic animals will probably forever remain vague.

Page 12. In attempting to estimate the amount of structural difference between allied domestic races, we are soon involved in doubt, from not knowing whether they are descended from one or several parent species. This point, if it could be cleared up, would be interesting; if, for instance, it could be shown that the greyhound, bloodhound, terrier, spaniel, and bull-dog, which we all know propagate their kind truly, were the offspring of any single species. Then such facts would have great weight in making us doubt about the immutability of the many closely allied natural species—for instance, of the many foxes—inhabiting different quarters of the world.

DESCENT OF THE DOMESTIC PIGEON.

Origin of Species, page 17. Great as are the differences between the breeds of the pigeon, I am fully convinced that the common opinion of naturalists is correct, namely, that all are descended from the rock-pigeon (*Columba livia*), including under this term several geographical races or subspecies, which differ from each other in the most trifling respects. As several of the reasons which have led me to this belief are in some degree applicable in other cases, I will here briefly give them. If the several breeds are not varieties, and have not proceeded from the rock-pigeon, they must have descended from at least seven or eight aboriginal stocks; for it is impossible to make the present domestic breeds by the crossing of any lesser number: how, for instance, could a pouter be produced by crossing two breeds unless one of the parent-stocks possessed the characteristic enormous crop? The supposed aboriginal stocks must all have been rock-pigeons—that is, they did not breed or willingly perch on trees. But besides *C. livia*, with its geographical sub-species, only two or three other species of rock-pigeons are known, and these have not any of the characters of the domestic breeds. Hence the supposed aboriginal stocks must either still exist in the countries where they were originally domesticated, and yet be unknown to ornithologists—and this, considering their size, habits, and remarkable characters, seems improbable—or they must have become extinct in the wild state. But birds breeding on precipices, and good fliers, are unlikely to be exterminated; and the common rock-pigeon, which has the same habits with the domestic breeds, has not been exterminated even on several of the smaller British islets, or on the shores of the Mediterranean. Hence the supposed extermination of so many species having similar habits with the rock-pigeon seems a very rash assumption. Moreover, the several above-named domesticated breeds have been transported to all parts of the world, and therefore some of them must have been carried back again into their native country; but not one has become wild or feral, though the dovecot-pigeon, which is the rock-pigeon in a very slightly altered state, has become feral in several places. Again, all recent experience shows that it is difficult to get wild animals to breed freely under domestication; yet, on the hypothesis of the multiple origin of our pigeons, it must be assumed that at least seven or eight species were so thoroughly domesticated in ancient times by half-civilized man as to be quite prolific under confinement.

An argument of great weight, and applicable in several other cases, is, that the above-specified breeds, though agreeing generally with the wild rock-pigeon in constitution, habits, voice, coloring, and in most parts of their structure, yet are certainly highly abnormal in other parts; we may look in vain through the whole great family of

Columbidæ for a beak like that of the English carrier, or that of the short-faced tumbler, or barb; for reversed feathers like those of the Jacobin; for a crop like that of the pouter; for tail-feathers like those of the fantail. Hence it must be assumed not only that half-civilized man succeeded in thoroughly domesticating several species, but that he intentionally or by chance picked out extraordinarily abnormal species; and, further, that these very species have since all become extinct or unknown. So many strange contingencies are improbable in the highest degree.

ORIGIN OF THE DOG.

Animals and Plants under Domestication, vol. i, page 15.

The first and chief point of interest in this chapter is, whether the numerous domesticated varieties of the dog have descended from a single wild species, or from several. Some authors believe that all have descended from the wolf, or from the jackal, or from an unknown and extinct species. Others again believe, and this of late has been the favorite tenet, that they have descended from several species, extinct and recent, more or less commingled together. We shall probably never be able to ascertain their origin with certainty. Paleontology does not throw much light on the question, owing, on the one hand, to the close similarity of the skulls of extinct as well as living wolves and jackals, and owing, on the other hand, to the great dissimilarity of the skulls of the several breeds of the domestic dogs. It seems, however, that remains have been found in the later tertiary deposits more like those of a large dog than of a wolf, which favors the belief of De Blainville that our dogs are the descendants of a single extinct species. On the other hand, some authors go so far as to assert that every chief domestic breed must have had its wild prototype. This latter view is extremely improbable: it allows nothing for variation; it passes over the almost monstrous character of some of the breeds; and it almost necessarily assumes that a large number of species have become extinct since man domesticated the dog; whereas we plainly see that wild members of the dog-family are extirpated by human agency with much difficulty; even so recently as 1710 the wolf existed in so small an island as Ireland.

Page 18. At a period between four and five thousand years ago, various breeds—viz., pariah dogs, greyhounds, common hounds, mastiffs, house-dogs, lapdogs, and turnspits—existed, more or less closely resembling our present breeds. But there is not sufficient evidence that any of these ancient dogs belonged to the same identical sub-varieties with our present dogs. As long as man was believed to have existed on this earth only about six thousand years, this fact of the great diversity of the breeds at so early a period was an argument of much weight that they had proceeded from several wild sources, for there would not have been sufficient time for their divergence and modification. But now that we know, from the discovery of flint tools imbedded with the remains of extinct animals, in districts which have since undergone great geographical changes, that man has existed for an incomparably longer period, and bearing in mind that the most barbarous nations possess domestic dogs, the argument from insufficient time falls away greatly in value.

Page 26. From this resemblance of the half-domesticated dogs in several countries to the wild species still living there—from the facility with which they can often be crossed together—from even half-tamed animals being so much valued by savages—and from the other circumstances previously remarked on which favor their domestication, it is highly probable that the domestic dogs of the world are descended from two well-defined species of wolf (viz., *C. lupus* and *C. latrans*), and from two or three other doubtful species (namely, the European, Indian, and North African wolves); from at least one or two South American canine species; from several races or species of jackal; and perhaps from one or more extinct species.

ORIGIN OF THE HORSE.

Animals and Plants under Domestication, vol. i, page 51.

The history of the horse is lost in antiquity. Remains of this animal in a domesticated condition have been found in the Swiss lake-dwellings, belonging to the Neolithic period. At the present time the number of breeds is great, as may be seen by consulting any treatise on the horse. Looking only to the native ponies of Great Britain, those of the Shetland Isles, Wales, the New Forest, and Devonshire are distinguishable; and so it is, among other instances, with each separate island in the great Malay Archipelago. Some of the breeds present great differences in size, shape of ears, length of mane, proportions of the body, form of the withers and hind-quarters, and especially in the head. Compare the race-horse, dray-horse, and a Shetland pony in size, configuration, and disposition; and see how much greater the difference is than between the seven or eight other living species of the genus *Equus*.

Page 52.

Horses have often been observed, according to M. Gaudry, to possess a trapezium and a rudiment of a fifth metacarpal bone, so that "one sees appearing by monstrosity, in the foot of the horse, structures which normally exist in the foot of the hipparion"—an allied and extinct animal. In various countries horn-like projections have been observed on the frontal bones of the horse: in one case described by Mr. Percival they arose about two inches above the orbital processes, and were "very like those in a calf from five to six months old," being from half to three quarters of an inch in length.

CAUSES OF MODIFICATIONS IN THE HORSE.

Page 54. With respect to the causes of the modifications which horses have undergone, the conditions of life seem to produce a considerable direct effect. Mr. D. Forbes, who has had excellent opportunities of comparing the horses of Spain with those of South America, informs me that the horses of Chili, which have lived under nearly the same conditions as their progenitors in Andalusia, remain unaltered, while the Pampas horses and the Puno ponies are considerably modified. There can be no doubt that horses become greatly reduced in size and altered in appearance by living on mountains and islands; and this apparently is due to want of nutritious or varied food. Every one knows how small and rugged the ponies are on the northern islands and on the mountains of Europe. Corsica and Sardinia have their native ponies; and there were, or still are, on some islands on the coast of Virginia, ponies like those of the Shetland Islands, which are believed to have originated through exposure to unfavorable conditions. The Puno ponies, which inhabit the lofty regions of the Cordillera, are, as I hear from Mr. D. Forbes, strange little creatures, very unlike their Spanish progenitors. Farther south, in the Falkland

Islands, the offspring of the horses imported in 1764 have already so much deteriorated in size and strength, that they are unfitted for catching wild cattle with the lasso; so that fresh horses have to be brought for this purpose from La Plata at a great expense. The reduced size of the horses bred on both southern and northern islands, and on several mountain-chains, can hardly have been caused by the cold, as a similar reduction has occurred on the Virginian and Mediterranean islands.

Page 56. It is scarcely possible to doubt that the long-continued selection of qualities serviceable to man has been the chief agent in the formation of the several breeds of the horse. Look at a dray-horse, and see how well adapted he is to draw heavy weights, and how unlike in appearance to any allied wild animal. The English race-horse is known to be derived from the commingled blood of Arabs, Turks, and Barbs; but selection, which was carried on during very early times in England, together with training, have made him a very different animal from his parent stocks.

"MAKING THE WORKS OF GOD A MERE MOCKERY."

Origin of Species, page 130. We see several distinct species of the horse-genus becoming, by simple variation, striped on the legs like a zebra, or striped on the shoulders like an ass. In the horse we see this tendency strong whenever a dun tint appears—a tint that approaches to that of the general coloring of the other species of the genus. The appearance of the stripes is not accompanied by any change of form or by any other new character. We see this tendency to become striped most strongly displayed in hybrids from between several of the most distinct species. Now observe the case of the several breeds of pigeons: they are descended from a pigeon (including two or three sub-species or geographical races) of a bluish color, with certain bars and other marks; and, when any breed assumes by simple variation a bluish tint, these bars and other marks invariably reappear; but without any other change of form or character. When the oldest and truest breeds of various colors are crossed, we see a strong tendency for the blue tint and bars and marks to reappear in the mongrels. I have stated that the most probable hypothesis to account for the reappearance of very ancient characters is—that there is a *tendency* in the young of each successive generation to produce the long-lost character, and that this tendency, from unknown causes, sometimes prevails. And we have just seen that in several species of the horse-genus the stripes are either plainer or appear more commonly in the young than in the old. Call the breeds of pigeons, some of which have bred true for centuries, species; and how exactly parallel is the case with that of the species of the horse-genus! For myself, I venture confidently to look back thousands on thousands of generations, and I see an animal striped like a zebra, but perhaps otherwise very differently constructed, the common parent of our domestic horse (whether or not it be descended from one or more wild stocks), of the ass, the hemionus, quagga, and zebra.

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

VARIABILITY OF CULTIVATED PLANTS.

Animals and Plants, vol. i, page 322.

I shall not enter into so much detail on the variability of cultivated plants as in the case of domesticated animals. The subject is involved in much difficulty. Botanists have generally neglected cultivated varieties, as beneath their notice. In several cases the wild prototype is unknown or doubtfully known; and in other cases it is hardly possible to distinguish between escaped seedlings and truly wild plants, so that there is no safe standard of comparison by which to judge of any supposed amount of change. Not a few botanists believe that several of our anciently cultivated plants have become so profoundly modified that it is not possible now to recognize their aboriginal parent-forms. Equally perplexing are the doubts whether some of them are descended from one species, or from several inextricably commingled by crossing and variation. Variations often pass into, and can not be distinguished from, monstrosities; and monstrosities are of little significance for our purpose. Many varieties are propagated solely by grafts, buds, layers, bulbs, etc., and frequently it is not known how far their peculiarities can be transmitted by seminal generation.

Page 325. From innumerable experiments made through dire necessity by the savages of every land, with the results handed down by tradition, the nutritious, stimulating, and medicinal properties of the most unpromising plants were probably first discovered. It appears, for instance, at first an inexplicable fact that untutored man, in three distant quarters of the world, should have discovered, among a host of native plants, that the leaves of the tea-plant and mattee, and the berries of the coffee, all included a stimulating and nutritious essence, now known to be chemically the same. We can also see that savages suffering from severe constipation would naturally observe whether any of the roots which they devoured acted as aperients. We probably owe our knowledge of the uses of almost all plants to man having originally existed in a barbarous state, and having been often compelled by severe want to try as food almost everything which he could chew and swallow.

SAVAGE WISDOM IN THE CULTIVATION OF PLANTS.

Page 326. The savage inhabitants of each land, having found out by many and hard trials what plants were useful, or could be rendered useful by various cooking processes, would after a time take the first step in cultivation by planting them near their usual abodes. Livingstone states that the savage Batokas sometimes left wild fruit-trees standing in their gardens, and occasionally even planted them, "a practice seen nowhere else among the natives." But Du Chaillu saw a palm and some other wild fruit-trees which had been planted; and these trees were considered private property. The next step in cultivation, and this would require but little forethought, would be to sow the seeds of useful plants; and, as the soil near the hovels of the natives would often be in some degree manured, improved varieties would sooner or later arise. Or a wild and unusually good variety of a native plant might attract the attention of some wise old savage; and he would transplant it, or sow its seed. That superior varieties of wild fruit-trees occasionally are found is certain, as in the case of the American species of hawthorns, plums, cherries, grapes, and hickories, specified by Professor Asa Gray.

Page 336. We now know that man was sufficiently civilized to cultivate the ground at an immensely remote period; so that wheat might have been improved long ago up to that standard of excellence which was possible under the then existing state of agriculture. One small class of facts supports this view of the slow and gradual improvement of our cereals. In the most ancient lake-habitations of Switzerland, when men employed only flint-tools, the most extensively cultivated wheat was a peculiar kind, with remarkably small ears and grains. "While the grains of the modern forms are in section from seven to eight millimetres in length, the larger grains from the lake-habitations are six, seldom seven, and the smaller ones only four. The ear is thus much narrower, and the spikelets stand out more horizontally, than in our present forms." So again with barley, the most ancient and most extensively cultivated kind had small ears, and the grains were "smaller, shorter, and nearer to each other, than in that now grown; without the husk they were two and one half lines long, and scarcely one and one half broad, while those now grown have a length of three lines, and almost the same in breadth." These small-grained varieties of wheat and barley are believed by Heer to be the parent-forms of certain existing allied varieties, which have supplanted their early progenitors.

UNKNOWN LAWS OF INHERITANCE.

Origin of Species, page 10.

The laws governing inheritance are for the most part unknown. No one can say why the same peculiarity in different individuals of the same species, or in different species, is sometimes inherited and sometimes not so; why the child often reverts in certain characters to its grandfather or grandmother or more remote ancestor; why a peculiarity is often transmitted from one sex to both sexes, or to one sex alone, more commonly but not exclusively to the like sex. It is a fact of some importance to us that peculiarities appearing in the males of our domestic breeds are often transmitted either exclusively, or in a much greater degree, to the males alone. A much more important rule, which I think may be trusted, is that, at whatever period of life a peculiarity first appears, it tends to reappear in the offspring at a corresponding age, though sometimes earlier. In many cases this could not be otherwise: thus the inherited peculiarities in the horns of cattle could appear only in the offspring when nearly mature; peculiarities in the silkworm are known to appear at the corresponding caterpillar or cocoon stage. But hereditary diseases and some other facts make me believe that the rule has a wider extension, and that, when there is no apparent reason why a peculiarity should appear at any particular age, yet that it does tend to appear in the offspring at the same period at which it first appeared in the parent. I believe this rule to be of the highest importance in explaining the laws of embryology. These remarks are, of course, confined to the first *appearance* of the peculiarity, and not to the primary cause which may have acted on the ovules or on the male element; in nearly the same manner as the increased length of the horns in the offspring from a short-horned cow by a long-horned bull, though appearing late in life, is clearly due to the male element.

Variation of Animals and Plants, vol. i, page 445.

If animals and plants had never been domesticated, and wild ones alone had been observed, we should probably never have heard the saying that "like begets like." The proposition would have been as self-evident as that all the buds on the same tree are alike, though neither proposition is strictly true. For, as has often been remarked, probably no two individuals are identically the same. All wild animals recognize each other, which shows that there is some difference between them; and, when the eye is well practiced, the shepherd knows each sheep, and man can distinguish a fellow-man out of millions on millions of other men.

Page 446.

The whole subject of inheritance is wonderful. When a new character arises, whatever its nature may be, it generally tends to be inherited, at least in a temporary and sometimes in a most persistent manner. What can be more wonderful than that some trifling peculiarity, not primordially attached to the species, should be transmitted through the male or female sexual cells, which are so minute as not to be visible to the naked eye, and afterward through the incessant changes of a long course of development, undergone either in the womb or in the egg, and ultimately appear in the offspring when mature, or even when quite old, as in the case of certain diseases? Or, again, what can be more wonderful than the well-ascertained fact that the minute ovule of a good milking-cow will produce a male, from whom a cell, in union with an ovule, will produce a female, and she, when mature, will have large mammary glands, yielding an abundant supply of milk, and even milk of a particular quality? Nevertheless, the real subject of surprise is, as Sir H. Holland has well remarked, not that a character should be inherited, but that any should ever fail to be inherited.

LAWS OF INHERITANCE THAT ARE FAIRLY WELL ESTABLISHED.

Animals and Plants, vol. ii, page 61.

Though much remains obscure with respect to inheritance, we may look at the following laws as fairly well established: Firstly, a tendency in every character, new and old, to be transmitted by seminal and bud generation, though often counteracted by various known and unknown causes. Secondly, reversion or atavism, which depends on transmission and development being distinct powers: it acts in various degrees and manners through both seminal and bud generation. Thirdly, prepotency of transmission, which may be confined to one sex, or be common to both sexes. Fourthly, transmission, as limited by sex, generally to the same sex in which the inherited character first appeared; and this in many, probably most cases, depends on the new character having first appeared at a rather late period of life. Fifthly, inheritance at corresponding periods of life, with some tendency to the earlier development of the inherited character. In these laws of inheritance, as displayed under domestication, we see an ample provision for the production, through variability and natural selection, of new specific forms.

INHERITED PECULIARITIES IN MAN.

Animals and Plants, vol. i, page 450.

Gait, gestures, voice, and general bearing, are all inherited, as the illustrious Hunter and Sir A. Carlisle have insisted. My father communicated to me some striking instances, in one of which a man died during the early infancy of his son, and my father, who did not see this son until grown up and out of health, declared that it seemed to him as if his old friend had risen from the grave, with all his highly peculiar habits and manners. Peculiar manners pass into tricks, and several instances could be given of their inheritance; as in the case, often quoted, of the father who generally slept on his back, with his right leg crossed over the left, and whose daughter, while an infant in the cradle, followed exactly the same habit, though an attempt was made to cure her. I will give one instance which has fallen under my own observation, and which is curious from being a trick associated with a peculiar state of mind, namely, pleasurable emotion. A boy had the singular habit, when pleased, of rapidly moving his fingers parallel to each other, and, when much excited, of raising both hands, with the fingers still moving, to the sides of his face on a level with the eyes: when this boy was almost an old man, he could still hardly resist this trick when much pleased, but from its absurdity concealed it. He had eight children. Of these, a girl, when pleased, at the age of four and a half years, moved her fingers in exactly the same way, and, what is still odder, when much excited, she raised both her hands, with her fingers still moving, to the sides of her face, in exactly the same manner as her father had done, and sometimes even still continued to do so when alone. I never heard of any one, excepting this one man and his little daughter, who had this strange habit; and certainly imitation was in this instance out of the question.

INHERITED DISEASES.

Animals and Plants, vol. ii, page 54.

Large classes of diseases uusally appear at certain ages, such as St. Vitus's dance in youth, consumption in early mid-life, gout later, and apoplexy still later; and these are naturally inherited at the same period. But, even in diseases of this class, instances have been recorded, as with St. Vitus's dance, showing that an unusually early or late tendency to the disease is inheritable. In most cases the appearance of any inherited disease is largely determined by certain critical periods in each person's life, as well as by unfavorable conditions. There are many other diseases, which are not attached to any particular period, but which certainly tend to appear in the child at about the same age at which the parent was first attacked. An array of high authorities, ancient and modern, could be given in support of this proposition. The illustrious Hunter believed in it; and Piorry cautions the physician to look closely to the child at the period when any grave inheritable disease attacked the parent. Dr. Prosper Lucas, after collecting facts from every source, asserts that affections of all kinds, though not related to any particular period of life, tend to reappear in the offspring at whatever period of life they first appeared in the progenitor.

Page 55.

Esquirol gives several striking instances of insanity coming on at the same age as that of a grandfather, father, and son, who all committed suicide near their fiftieth year. Many other cases could be given, as of a whole family who became insane at the age of forty. Other cerebral affections sometimes follow the same rule—for instance, epilepsy and apoplexy. A woman died of the latter disease when sixty-three years old; one of her daughters at forty-three, and the other at sixty-seven: the latter had twelve children, who all died from tubercular meningitis. I mention this latter case because it illustrates a frequent occurrence, namely, a change in the precise nature of an inherited disease, though still affecting the same organ.

Two brothers, their father, their paternal uncles, seven cousins, and their paternal grandfather, were all similarly affected by a skin-disease, called pityriasis versicolor; "the disease, strictly limited to the males of the family (though transmitted through the females), usually appeared at puberty, and disappeared at about the age of forty or forty-five years." The second case is that of four brothers, who, when about twelve years old, suffered almost every week from severe headaches, which were relieved only by a recumbent position in a dark room. Their father, paternal uncles, paternal grandfather, and grand-uncles all suffered in the same way from headaches, which ceased at the age of fifty-four or fifty-five in all those who lived so long. None of the females of the family were affected.

CAUSES OF NON-INHERITANCE.

Animals and Plants, vol. i, page 470.

A large number of cases of non-inheritance are intelligible on the principle that a strong tendency to inheritance does exist, but that it is overborne by hostile or unfavorable conditions of life. No one would expect that our improved pigs, if forced during several generations to travel about and root in the ground for their own subsistence, would transmit, as truly as they now do, their short muzzles and legs, and their tendency to fatten. Dray-horses assuredly would not long transmit their great size and massive limbs, if compelled to live in a cold, damp, mountainous region; we have, indeed, evidence of such deterioration in the horses which have run wild on the Falkland Islands. European dogs in India often fail to transmit their true character. Our sheep in tropical countries lose their wool in a few generations. There seems also to be a close relation between certain peculiar pastures and the inheritance of an enlarged tail in fat-tailed sheep, which form one of the most ancient breeds in the world. With plants, we have seen that tropical varieties of maize lose their proper character in the course of two or three generations, when cultivated in Europe; and conversely so it is with European varieties cultivated in Brazil. Our cabbages, which here come so true by seed, can not form heads in hot countries. According to Carrière, the purple-leafed beech and barberry transmit their character by seed far less truly in certain districts than in others. Under changed circumstances, periodical habits of life soon fail to be transmitted, as the period of maturity in summer and winter wheat, barley, and vetches. So it is with animals: for instance, a person, whose statement I can trust, procured eggs of Aylesbury ducks from that town, where they are kept in houses, and are reared as early as possible for the London market; the ducks bred from these eggs in a distant part of England, hatched their first brood on January 24th, while common ducks, kept in the same yard and treated in the same manner, did not hatch till the end of March; and this shows that the period of hatching was inherited. But the grandchildren of these Aylesbury ducks completely lost their habit of early incubation, and hatched their eggs at the same time with the common ducks of the same place.

Many cases of non-inheritance apparently result from the conditions of life continually inducing fresh variability. We have seen that when the seeds of pears, plums, apples, etc., are sown, the seedlings generally inherit some degree of family likeness. Mingled with these seedlings, a few, and sometimes many, worthless, wild-looking plants commonly appear, and their appearance may be attributed to the principle of reversion. But scarcely a single seedling will be found perfectly to resemble the parent-form; and this may be accounted for by constantly recurring variability induced by the conditions of life.

STEPS BY WHICH DOMESTIC RACES HAVE BEEN PRODUCED.

Origin of Species, page 22.

Some effect may be attributed to the direct and definite action of the external conditions of life, and some to habit; but he would be a bold man who would account by such agencies for the differences between a dray and race horse, a greyhound and blood-hound, a carrier and tumbler pigeon. One of the most remarkable features in our domesticated races is that we see in them adaptation, not, indeed, to the animal's or plant's own good, but to man's use or fancy. Some variations useful to him have probably arisen suddenly, or by one step; many botanists, for instance, believe that the fuller's teasel, with its hooks, which can not be rivaled by any mechanical contrivance, is only a variety of the wild *Dipsacus;* and this amount of change may have suddenly arisen in a seedling. So it has probably been with the turnspit-dog; and this is known to have been the case with the ancon sheep. But when we compare the dray-horse and race-horse, the dromedary and camel, the various breeds of sheep fitted either for cultivated land or mountain-pasture, with the wool of one breed good for one purpose, and that of another breed for another purpose; when we compare the many breeds of dogs, each good for man in different ways; when we compare the game-cock, so pertinacious in battle, with other breeds so little quarrelsome, with "everlasting layers" which never desire to sit, and with the bantam, so small and elegant; when we compare the host of agricultural, culinary, orchard, and flower-garden races of plants, most useful to man at different seasons and for different purposes, or so beautiful in his eyes—we must, I think, look further than to mere variability. We can not suppose that all the breeds were suddenly produced as perfect and as useful as we now see them; indeed, in many cases, we know that this has not been their history. The key is man's power of accumulative selection: Nature gives successive variations; man adds them up in certain directions useful to him. In this sense he may be said to have made for himself useful breeds.

Page 23. If selection consisted merely in separating some very distinct variety, and breeding from it, the principle would be so obvious as hardly to be worth notice; but its importance consists in the great effect produced by the accumulation in one direction, during successive generations, of differences absolutely inappreciable by an uneducated eye—differences which I for one have vainly attempted to appreciate. Not one man in a thousand has accuracy of eye and judgment sufficient to become an eminent breeder. If gifted with these qualities, and he studies his subject for years, and devotes his lifetime to it with indomitable perseverance, he will succeed, and may make great improvements; if he wants any of these qualities, he will assuredly fail. Few would readily believe in the natural capacity and years of practice requisite to become even a skillful pigeon-fancier.

UNCONSCIOUS SELECTION.

Origin of Species, page 25.

A man who intends keeping pointers naturally tries to get as good dogs as he can, and afterward breeds from his own best dogs, but he has no wish or expectation of permanently altering the breed. Nevertheless, we may infer that this process, continued during centuries, would improve and modify any breed, in the same way as Bakewell, Collins, etc., by this very same process, only carried on more methodically, did greatly modify, even during their lifetimes, the forms and qualities of their cattle. Slow and insensible changes of this kind can never be recognized unless actual measurements or careful drawings of the breeds in question have been made long ago, which may serve for comparison. In some cases, however, unchanged or but little changed individuals of the same breed exist in less civilized districts, where the breed has been less improved. There is reason to believe that King Charles's spaniel has been unconsciously modified to a large extent since the time of that monarch. Some highly competent authorities are convinced that the setter is directly derived from the spaniel, and has probably been slowly altered from it. It is known that the English pointer has been greatly changed within the last century, and in this case the change has, it is believed, been chiefly effected by crosses with the fox-hound; but what concerns us is, that the change has been effected unconsciously and gradually, and yet so effectually, that, though the old Spanish pointer certainly came from Spain, Mr. Borrow has not seen, as I am informed by him, any native dog in Spain like our pointer.

By a similar process of selection, and by careful training, English race-horses have come to surpass in fleetness and size the parent Arabs, so that the latter, by the regulations for the Goodwood races, are favored in the weights which they carry. Lord Spencer and others have shown how the cattle of England have increased in weight and in early maturity, compared with the stock formerly kept in this country.

Page 26. If there exist savages so barbarous as never to think of the inherited character of the offspring of their domestic animals, yet any one animal particularly useful to them, for any special purpose, would be carefully preserved during famines and other accidents, to which savages are so liable, and such choice animals would thus generally leave more offspring than the inferior ones; so that in this case there would be a kind of unconscious selection going on. We see the value set on animals even by the barbarians of Tierra del Fuego, by their killing and devouring their old women, in times of dearth, as of less value than their dogs.

ADAPTATION OF ANIMALS TO THE FANCIES OF MAN.

Page 28. On the view here given of the important part which selection by man has played, it becomes at once obvious how it is that our domestic races show adaptation in their structure or in their habits to man's wants or fancies. We can, I think, further understand the frequently abnormal character of our domestic races, and likewise their differences being so great in external characters, and relatively so slight in internal parts or organs. Man can hardly select, or only with much difficulty, any deviation of structure excepting such as is externally visible; and, indeed, he rarely cares for what is internal. He can never act by selection, excepting on variations which are first given to him in some slight degree by nature. No man would ever try to make a fantail till he saw a pigeon with a tail developed in some slight degree in an unusual manner, or a pouter till he saw a pigeon with a crop of somewhat unusual size; and the more abnormal or unusual any character was when it first appeared, the more likely it would be to catch his attention. But to use such an expression as trying to make a fantail is, I have no doubt, in most cases, utterly incorrect. The man who first selected a pigeon with a slightly larger tail, never dreamed what the descendants of that pigeon would become through long-continued, partly unconscious and partly methodical, selection. Perhaps the parent-bird of all fantails had only fourteen tail-feathers somewhat expanded, like the present Java fantail, or like individuals of other and distinct breeds, in which as many as seventeen tail-feathers have been counted. Perhaps the first pouter-pigeon did not inflate its crop much more than the turbit now does the upper part of its œsophagus—a habit which is disregarded by all fanciers, as it is not one of the points of the breed.

DOUBTFUL SPECIES.

Origin of Species, page 36.

The forms which possess in some considerable degree the character of species, but which are so closely similar to other forms, or are so closely linked to them by intermediate gradations, that naturalists do not like to rank them as distinct species, are in several respects the most important for us. We have every reason to believe that many of these doubtful and closely allied forms have permanently retained their characters for a long time; for as long, as far as we know, as have good and true species. Practically, when a naturalist can unite by means of intermediate links any two forms, he treats the one as a variety of the other; ranking the most common, but sometimes the one first described, as the species, and the other as the variety. But cases of great difficulty, which I will not here enumerate, sometimes arise in deciding whether or not to rank one form as a variety of another, even when they are closely connected by intermediate links; nor will the commonly-assumed hybrid nature of the intermediate forms always remove the difficulty. In very many cases, however, one form is ranked as a variety of another, not because the intermediate links have actually been found, but because analogy leads the observer to suppose either that they do now somewhere exist, or may formerly have existed; and here a wide door for the entry of doubt and conjecture is opened.

Hence, in determining whether a form should be ranked as a species or a variety, the opinion of naturalists having sound judgment and wide experience seems the only guide to follow. We must, however, in many cases, decide by a majority of naturalists, for few well-marked and well-known varieties can be named which have not been ranked as species by at least some competent judges.

That varieties of this doubtful nature are far from uncommon can not be disputed. Compare the several floras of Great Britain, of France, or of the United States, drawn up by different botanists, and see what a surprising number of forms have been ranked by one botanist as good species, and by another as mere varieties. Mr. H.

C. Watson, to whom I lie under deep obligation for assistance of all kinds, has marked for me one hundred and eighty-two British plants, which are generally considered as varieties, but which have all been ranked by botanists as species; and in making this list he has omitted many trifling varieties, but which nevertheless have been ranked by some botanists as species, and he has entirely omitted several highly polymorphic genera. Under genera, including the most polymorphic forms, Mr. Babington gives two hundred and fifty-one species, whereas Mr. Bentham gives only one hundred and twelve—a difference of one hundred and thirty-nine doubtful forms!

SPECIES AN ARBITRARY TERM.

Page 41.

Certainly no clear line of demarkation has as yet been drawn between species and sub-species—that is, the forms which in the opinion of some naturalists come very near to, but do not quite arrive at, the rank of species; or, again, between sub-species and well-marked varieties, or between lesser varieties and individual differences. These differences blend into each other by an insensible series; and a series impresses the mind with the idea of an actual passage.

Hence I look at individual differences, though of small interest to the systematist, as of the highest importance for us, as being the first steps toward such slight varieties as are barely thought worth recording in works on natural history. And I look at varieties which are in any degree more distinct and permanent as steps toward more strongly-marked and permanent varieties; and at the latter, as leading to sub-species, and then to species. The passage from one stage of difference to another may, in many cases, be the simple result of the nature of the organism, and of the different physical conditions to which it has long been exposed; but with respect to the more important and adaptive characters, the passage from one stage of difference to another may be safely attributed to the cumulative action of natural selection, hereafter to be explained, and to the effects of the increased use or disuse of parts. A well-marked variety may therefore be called an incipient species; but whether this belief is justifiable must be judged by the weight of the various facts and considerations to be given throughout this work.

It need not be supposed that all varieties or incipient species attain the rank of species. They may become extinct, or they may endure as varieties for very long periods, as has been shown to be the case by Mr. Wollaston with the varieties of certain fossil land-shells in Madeira, and with plants by Gaston de Saporta. If a variety were to flourish so as to exceed in numbers the parent species, it would then rank as the species, and the species as the variety; or it might come to supplant and exterminate the parent species; or both might coexist, and both rank as independent species. But we shall hereafter return to this subject.

From these remarks it will be seen that I look at the term species as one arbitrarily given, for the sake of convenience, to a set of individuals closely resembling each other, and that it does not essentially differ from the term variety, which is given to less distinct and more fluctuating forms. The term variety, again, in comparison with mere individual differences, is also applied arbitrarily, for convenience' sake.

THE TRUE PLAN OF CREATION.

Origin of Species, page 425.

When the views advanced by me in this volume, and by Mr. Wallace, or when analogous views on the origin of species are generally admitted, we can dimly foresee that there will be a considerable revolution in natural history. Systematists will be able to pursue their labors as at present; but they will not be incessantly haunted by the shadowy doubt whether this or that form be a true species.

Page 426.

Hereafter we shall be compelled to acknowledge that the only distinction between species and well-marked varieties is, that the latter are known, or believed, to be connected at the present day by intermediate gradations, whereas species were formerly thus connected. Hence, without rejecting the consideration of the present existence of intermediate gradations between any two forms, we shall be led to weigh more carefully and to value higher the actual amount of difference between them. It is quite possible that forms now generally acknowledged to be merely varieties may hereafter be thought worthy of specific names; and in this case scientific and common language will come into accordance. In short, we shall have to treat species in the same manner as those naturalists treat genera who admit that genera are merely artificial combinations made for convenience. This may not be a cheering prospect; but we shall at least be freed from the vain search for the undiscovered and undiscoverable essence of the term species.

The other and more general departments of natural history will rise greatly in interest. The terms used by naturalists, of affinity, relationship, community of type, paternity, morphology, adaptive characters, rudimentary and aborted organs, etc., will cease to be metaphorical, and will have a plain signification. When we no longer look at an organic being as a savage looks at a ship, as something wholly beyond his comprehension; when we regard every production of nature as one which has had a long history; when we contemplate every complex structure and instinct as the summing up of many contrivances, each useful to the possessor, in the same way as any great mechanical invention is the summing up of the labor, the experience, the reason, and even the blunders of numerous workmen; when we thus view each organic being, how far more interesting—I speak from experience—does the study of natural history become!

A grand and almost untrodden field of inquiry will be opened, on the causes and laws of variation, on correlation, on the effects of use and disuse, on the direct action of external conditions, and so forth. The study of domestic productions will rise immensely in value. A new variety raised by man will be a more important and interesting subject for study than one more species added to the infinitude of already recorded species. Our classifications will come to be, as far as they can be so made, genealogies, and will then truly give what may be called the plan of creation.

IV.

THE STRUGGLE FOR EXISTENCE.

Origin of Species, page 50.

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 kingdoms; 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 can not do so, for the world would not hold them.

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 with the progeny of a single pair. Even slow-breeding man has doubled in twenty-five years, and at this rate, in less than a 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 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 safest to assume that it begins breeding when thirty years old, and goes on breeding till ninety years old, bringing forth six young in the interval, and surviving till one hundred years old; if this be so, after a period of from seven hundred and forty to seven hundred and fifty years, there would be nearly nineteen million elephants alive, descended from the first pair.

DEATH INEVITABLE IN THE FIGHT FOR LIFE.

Page 52.

In a state of nature almost every full-grown plant annually produces seed, and among animals there are very few which do not annually pair. Hence we may confidently assert that all plants and animals are tending to increase at a geometrical ratio, that all would rapidly stock every station in which they could anyhow exist, and that this geometrical tendency to increase must be checked by destruction at some period of life. Our familiarity with the larger domestic animals tends, I think, to mislead us: we see no great destruction falling on them, but we do not keep in mind that thousands are annually slaughtered for food, and that in a state of nature an equal number would have somehow to be disposed of.

The only difference between organisms which annually produce eggs or seeds by the thousand and those which produce extremely few is, that the slow breeders would require a few more years to people, under favorable conditions, a whole district, let it be ever so large. The condor lays a couple of eggs and the ostrich a score, and yet in the same country the condor may be the more numerous of the two; the Fulmar petrel lays but one egg, yet it is believed to be the most numerous bird in the world. One fly deposits hundreds of eggs, and another, like the *Hippobosca*, a single one; but this difference does not determine how many individuals of the two species can be supported in a district. A large number of eggs is of some importance to those species which depend on a fluctuating amount of food, for it allows them rapidly to increase in number. But the real importance of a large number of eggs or seeds is to make up for much destruction at some period of life; and this period in the great majority of cases is an early one. If an animal can in any way protect its own eggs or young, a small number may be produced, and yet the average stock be fully kept up; but, if many eggs or young are destroyed, many must be produced, or the species will become extinct. It would suffice to keep up the full number of a tree, which lived on an average for a thousand years, if a single seed were produced once in a thousand years, supposing that this seed were never destroyed, and could be insured to germinate in a fitting place. So that, in all cases, the average number of any animal or plant depends only indirectly on the number of its eggs or seeds.

In looking at Nature, it is most necessary to keep the foregoing considerations always in mind—never to forget that every single organic being may be said to be striving to the utmost to increase in numbers; that each lives by a struggle at some period of its life; that heavy destruction inevitably falls either on the young or old during each generation or at recurrent intervals. Lighten any check, mitigate the destruction ever so little, and the number of the species will almost instantaneously increase to any amount.

"INEXPLICABLE ON THE THEORY OF CREATION."

Origin of Species, page 413.

As each species tends by its geometrical rate of reproduction to increase inordinately in number, and as the modified descendants of each species will be enabled to increase by as much as they become more diversified in habits and structure, so as to be able to seize on many and widely different places in the economy of nature, there will be a constant tendency in natural selection to preserve the most divergent offspring of any one species. Hence, during a long-continued course of modification, the slight differences characteristic of varieties of the same species tend to be augmented into the greater differences characteristic of the species of the same genus. New and improved varieties will inevitably supplant and exterminate the older, less improved, and intermediate varieties; and thus species are rendered to a large extent defined and distinct objects. Dominant species belonging to the larger groups within each class tend to give birth to new and dominant forms; so that each large group tends to become still larger, and at the same time more divergent in character. But, as all groups can not thus go on increasing in size, for the world would not hold them, the more dominant groups beat the less dominant. This tendency in the large groups to go on increasing in size and diverging in character, together with the inevitable contingency of much extinction, explains the arrangement of all the forms of life in groups subordinate to groups, all within a few great classes, which has prevailed throughout all time. This grand fact of the grouping of all organic beings under what is called the Natural System is utterly inexplicable on the theory of creation.

OBSCURE CHECKS TO INCREASE.

Origin of Species, page 53.

The causes which check the natural tendency of each species to increase are most obscure. Look at the most vigorous species; by as much as it swarms in numbers, by so much will it tend to increase still further. We know not exactly what the checks are even in a single instance. Nor will this surprise any one who reflects how ignorant we are on this head, even in regard to mankind, although so incomparably better known than any other animal.

Eggs or very young animals seem generally to suffer most, but this is not invariably the case. With plants there is a vast destruction of seeds, but, from some observations which I have made it appears that the seedlings suffer most from germinating in ground already thickly stocked with other plants. Seedlings, also, are destroyed in vast numbers by various enemies; for instance, on a piece of ground three feet long and two wide, dug and cleared, and where there could be no choking from other plants, I marked all the seedlings of our native weeds as they came up, and out of 357 no less than 295 were destroyed, chiefly by slugs and insects. If turf which has long been mown, and the case would be the same with turf closely browsed by quadrupeds, be let to grow, the more vigorous plants gradually kill the less vigorous, though fully grown plants; thus out of twenty species growing on a little plot of mown turf (three feet by four) nine species perished, from the other species being allowed to grow up freely.

The amount of food for each species, of course, gives the extreme limit to which each can increase; but very frequently it is not the obtaining food, but the serving as prey to other animals, which determines the average number of a species. Thus, there seems to be little doubt that the stock of partridges, grouse, and hares on any large estate depends chiefly on the destruction of vermin. If not one head of game were shot during the next twenty years in England, and, at the same time, if no vermin were destroyed, there would, in all probability, be less game than at present, although hundreds of thousands of game animals are now annually shot. On the other hand, in some cases, as with the elephant, none are destroyed by beasts of prey; for even the tiger in India most rarely dares to attack a young elephant protected by its dam.

CLIMATE AS A CHECK TO INCREASE.

Page 54. Climate plays an important part in determining the average numbers of a species, and periodical seasons of extreme cold or drought seem to be the most effective of all checks. I estimated (chiefly from the greatly reduced numbers of nests in the spring) that the winter of 1854–'55 destroyed four fifths of the birds in my own grounds; and this is a tremendous destruction, when we remember that ten per cent is an extraordinarily severe mortality from epidemics with man. The action of climate seems at first sight to be quite independent of the struggle for existence; but, in so far as climate chiefly acts in reducing food, it brings on the most severe struggle between the individuals, whether of the same or of distinct species, which subsist on the same kind of food. Even when climate—for instance, extreme cold—acts directly, it will be the least vigorous individuals, or those which have got least food through the advancing winter, which will suffer most. When we travel from south to north, or from a damp region to a dry, we invariably see some species gradually getting rarer and rarer, and finally disappearing; and, the change of climate being conspicuous, we are tempted to attribute the whole effect to its direct action. But this is a false view: we forget that each species, even where it most abounds, is constantly suffering enormous destruction at some period of its life, from enemies or from competitors for the same place and food; and, if these enemies or competitors be in the least degree favored by any slight change of climate, they will increase in numbers; and, as each area is already fully stocked with inhabitants, the other species must decrease. When we travel southward and see a species decreasing in numbers, we may feel sure that the cause lies quite as much in other species being favored as in this one being hurt. So it is when we travel northward, but in a somewhat lesser degree, for the number of species of all kinds, and therefore of competitors, decreases northward; hence, in going northward, or in ascending a mountain, we far oftener meet with stunted forms, due to the *directly* injurious action of climate, than we do in proceeding southward or in descending a mountain. When we reach the Arctic regions, or snow-capped summits, or absolute deserts, the struggle for life is almost exclusively with the elements.

INFLUENCE OF INSECTS IN THE STRUGGLE FOR EXISTENCE.

Page 56.

In several parts of the world insects determine the existence of cattle. Perhaps Paraguay offers the most curious instance of this; for here neither cattle nor horses nor dogs have ever run wild, though they swarm southward and northward in a feral state; and Azara and Rengger have shown that this is caused by the greater number in Paraguay of a certain fly, which lays its eggs in the navels of these animals when first born. The increase of these flies, numerous as they are, must be habitually checked by some means, probably by other parasitic insects. Hence, if certain insectivorous birds were to decrease in Paraguay, the parasitic insects would probably increase; and this would lessen the number of the navel-frequenting flies; then cattle and horses would become feral, and this would certainly greatly alter (as indeed I have observed in parts of South America) the vegetation: this again would largely affect the insects, and this, as we have just seen in Staffordshire, the insectivorous birds, and so onward in ever-increasing circles of complexity. Not that under nature the relations will ever be as simple as this. Battle within battle must be continually recurring with varying success; and yet in the long run the forces are so nicely balanced that the face of Nature remains for long periods of time uniform, though assuredly the merest trifle would give the victory to one organic being over another. Nevertheless, so profound is our ignorance, and so high our presumption, that we marvel when we hear of the extinction of an organic being; and, as we do not see the cause, we invoke cataclysms to desolate the world, or invent laws on the duration of the forms of life!

Page 57. Nearly all our orchidaccous plants absolutely require the visits of insects to remove their pollen-masses and thus to fertilize them. I find from experiments that humble-bees are almost indispensable to the fertilization of the heart's-ease (*Viola tricolor*), for other bees do not visit this flower. I have also found that the visits of bees are necessary for the fertilization of some kinds of clover: for instance, 20 heads of Dutch clover (*Trifolium repens*) yielded 2,290 seeds, but 20 other heads protected from bees produced not one. Again, 100 heads of red clover (*T. pratense*) produced 2,700 seeds, but the same number of protected heads produced not a single seed. Humble-bees alone visit red clover, as other bees can not reach the nectar. It has been suggested that moths may fertilize the clovers; but I doubt whether they could do so in the case of the red clover, from their weight not being sufficient to depress the wing-petals. Hence we may infer as highly probable that, if the whole genus of humble-bees became extinct or very rare in England, the heart's-ease and red clover would become very rare, or wholly disappear. The number of humble-bees in any district depends in a great measure on the number of field-mice, which destroy their combs and nests; and Colonel Newman, who has long attended to the habits of humble-bees, believes that "more than two thirds of them are thus destroyed all over England." Now, the number of mice is largely dependent, as every one knows, on the number of cats; and Colonel Newman says, "Near villages and small towns I have found the nests of humble-bees more numerous than elsewhere, which I attribute to the number of cats that destroy the mice." Hence it is quite credible that the presence of a feline animal in large numbers in a district might determine, through the intervention first of mice and then of bees, the frequency of certain flowers in that district!

NO SUCH THING AS CHANCE IN THE RESULT OF THE STRUGGLE.

Page 58. When we look at the plants and bushes clothing an entangled bank, we are tempted to attribute their proportional numbers and kinds to what we call chance. But how false a view is this! Every one has heard that, when an American forest is cut down, a very different vegetation springs up; but it has been observed that ancient Indian ruins in the Southern United States, which must formerly have been cleared of trees, now display the same beautiful diversity and proportion of kinds as in the surrounding virgin forest. What a struggle must have gone on during long centuries between the several kinds of trees, each annually scattering its seeds by the thousand; what war between insect and insect—between insects, snails, and other animals with birds and beasts of prey—all striving to increase, all feeding on each other, or on the trees, their seeds and seedlings, or on the other plants which first clothed the ground and thus checked the growth of the trees! Throw up a handful of feathers, and all fall to the ground according to definite laws; but how simple is the problem where each shall fall compared to that of the action and reaction of the innumerable plants and animals which have determined, in the course of centuries, the proportional numbers and kinds of trees now growing on the old Indian ruins!

Page 61. It is good thus to try in imagination to give to any one species an advantage over another. Probably in no single instance should we know what to do. This ought to convince us of our ignorance on the mutual relations of all organic beings—a conviction as necessary as it is difficult to acquire. All that we can do is to keep steadily in mind that each organic being is striving to increase in a geometrical ratio; that each at some period of its life, during some season of the year, during each generation or at intervals, has to struggle for life and to suffer great destruction. When we reflect on this struggle, we may console ourselves with the full belief that the war of nature is not incessant, that no fear is felt, that death is generally prompt, and that the vigorous, the healthy, and the happy survive and multiply.

V.

NATURAL SELECTION: OR, THE SURVIVAL OF THE FITTEST.

Variation of Animals and Plants under Domestication, vol. i, page 6.

THE preservation, during the battle for life, of varieties which possess any advantage in structure, constitution, or instinct, I have called Natural Selection; and Mr. Herbert Spencer has well expressed the same idêa by the Survival of the Fittest. The term "natural selection" is in some respects a bad one, as it seems to imply conscious choice; but this will be disregarded after a little familiarity. No one objects to chemists speaking of "elective affinity"; and certainly an acid has no more choice in combining with a base than the conditions of life have in determining whether or not a new form be selected or preserved. The term is so far a good one as it brings into connection the production of domestic races by man's power of selection and the natural preservation of varieties and species in a state of nature. For brevity sake I sometimes speak of natural selection as an intelligent power; in the same way as astronomers speak of the attraction of gravity as ruling the movements of the planets, or as agriculturists speak of man making domestic races by his power of selection. In the one case, as in the other, selcction does nothing without variability, and this depends in some manner on the action of the surrounding circumstances in the organism. I have, also, often personified the word Nature; for I have found it difficult to avoid this ambiguity; but I mean by nature only the aggregate action and product of many natural laws, and by laws only the ascertained sequence of events.

.AN INVENTED HYPOTHESIS.

Animals and Plants, vol.i, page 9.

In scientific investigations it is permitted to invent any hypothesis, and if it explains various large and independent classes of facts it rises to the rank of a well-grounded theory. The undulations of the ether and even its existence are hypothetical, yet every one now admits the undulatory theory of light. The principle of natural selection may be looked at as a mere hypothesis, but rendered in some degree probable by what we positively know of the variability of organic beings in a state of nature—by what we positively know of the struggle for existence, and the consequent almost inevitable preservation of favorable variations—and from the analogical formation of domestic races. Now, this hypothesis may be tested—and this seems to me the only fair and legitimate manner of considering the whole question — by trying whether it explains several large and independent classes of facts; such as the geological succession of organic beings, their distribution in past and present times, and their mutual affinities and homologies. If the principle of natural selection does explain these and other large bodies of facts, it ought to be received. On the ordinary view of each species having been independently created, we gain no scientific explanation of any one of these facts. We can only say that it has so pleased the Creator to command that the past and present inhabitants of the world should appear in a certain order and in certain areas; that he has impressed on them the most extraordinary resemblances, and has classed them in groups subordinate to groups. But by such statements we gain no new knowledge; we do not connect together facts and laws; we explain nothing.

Page 12. These facts have as yet received no explanation on the theory of independent creation; they can not be grouped together under one point of view, but each has to be considered as an ultimate fact. As the first origin of life on this earth, as well as the continued life of each individual, is at present quite beyond the scope of science, I do not wish to lay much stress on the greater simplicity of the view of a few forms or of only one form having been originally created, instead of innumerable miraculous creations having been necessary at innumerable periods; though this more simple view accords well with Maupertuis's philosophical axiom of "least action."

HOW FAR THE THEORY MAY BE EXTENDED.

Page 13. In considering how far the theory of natural selection may be extended—that is, in determining from how many progenitors the inhabitants of the world have descended—we may conclude that at least all the members of the same class have descended from a single ancestor. A number of organic beings are included in the same class, because they present, independently of their habits of life, the same fundamental type of structure, and because they graduate into each other. Moreover, members of the same class can in most cases be shown to be closely alike at an early embryonic age.

These facts can be explained on the belief of their descent from a common form; therefore it may be safely admitted that all the members of the same class are descended from one progenitor. But as the members of quite distinct classes have something in common in structure and much in common in constitution, analogy would lead us one step further, and to infer as probable that all living creatures are descended from a single prototype.

Descent of Man, part I., page 61.

Thus a large yet undefined extension may safely be given to the direct and indirect results of natural selection; but I now admit, after reading the essay by Nägeli on plants, and the remarks by various authors with respect to animals, more especially those recently made by Professor Broca, that in the earlier editions of my "Origin of Species" I perhaps attributed too much to the action of natural selection or the survival of the fittest. I have altered the fifth edition of the "Origin" so as to confine my remarks to adaptive changes of structure; but I am convinced, from the light gained during even the last few years, that very many structures which now appear to us useless will hereafter be proved to be useful, and will therefore come within the range of natural selection. Nevertheless, I did not formerly consider sufficiently the existence of structures, which, as far as we can at present judge, are neither beneficial nor injurious; and this I believe to be one of the greatest oversights as yet detected in my work. I may be permitted to say, as some excuse, that I had two distinct objects in view: firstly, to show that species had not been separately created; and, secondly, that natural selection had been the chief agent of change, though largely aided by the inherited effects of habit, and slightly by the direct action of the surrounding conditions. I was not, however, able to annul the influence of my former belief, then almost universal, that each species had been purposely created; and this led to my tacit assumption that every detail of structure, excepting rudiments, was of some special, though unrecognized, service. Any one with this assumption in his mind would naturally extend too far the action of natural selection, either during past or present times. Some of those who admit the principle of evolution, but reject natural selection, seem to forget, when criticising my book, that I had the above two objects in view; hence if I have erred in giving to natural selection great power, which I am very far from admitting, or in having exaggerated its power, which is in itself probable, I have at least, as I hope, done good service in aiding to overthrow the dogma of separate creations.

IS THERE ANY LIMIT TO WHAT SELECTION CAN EFFECT?

Animals and Plants, vol. ii, page 228.

The foregoing discussion naturally leads to the question, What is the limit to the possible amount of variation in any part or quality, and, consequently, is there any limit to what selection can effect? Will a race-horse ever be reared fleeter than Eclipse? Can our prize cattle and sheep be still further improved? Will a gooseberry ever weigh more than that produced by "London" in 1852? Will the beet-root in France yield a greater percentage of sugar? Will future varieties of wheat and other grain produce heavier crops than our present varieties? These questions can not be positively answered; but it is certain that we ought to be cautious in answering them by a negative. In some lines of variation the limit has probably been reached.

Youatt believes that the reduction of bone in some of our sheep has already been carried so far that it entails great delicacy of constitution.

Page 229. No doubt there is a limit beyond which the organization can not be modified compatibly with health or life. The extreme degree of fleetness, for instance, of which a terrestrial animal is capable, may have been acquired by our present race-horses; but, as Mr. Wallace has well remarked, the question that interests us "is not whether indefinite and unlimited change in any or all directions is possible, but whether such differences as do occur in nature could have been produced by the accumulation of varieties by selection." And in the case of our domestic productions, there can be no doubt that many parts of the organization, to which man has attended, have been thus modified to a greater degree than the corresponding parts in the natural species of the same genera or even families. We see this in the form and size of our light and heavy dogs or horses, in the beak and many other characters of our pigeons, in the size and quality of many fruits, in comparison with the species belonging to the same natural groups.

HAS ORGANIZATION ADVANCED?

Origin of Species, page 308. The problem whether organization on the whole has advanced is in many ways excessively intricate. The geological record, at all times imperfect, does not extend far enough back to show with unmistakable clearness that within the known history of the world organization has largely advanced. Even at the present day, looking to members of the same class, naturalists are not unanimous which forms ought to be ranked as highest: thus, some look at the selaceans or sharks, from their approach in some important points of structure to reptiles, as the highest fish; others look at the teleosteans as the highest. The ganoids stand intermediate between the selaceans and teleosteans; the latter at the present day are largely preponderant in number; but formerly selaceans and ganoids alone existed; and in this case, according to the standard of highness chosen, so will it be said that fishes have advanced or retrograded in organization. To attempt to compare members of distinct types in the scale of highness seems hopeless; who will decide whether a cuttlefish be higher than a bee—that insect which the great Von Baer believed to be "in fact more highly organized than a fish, although upon another type"? In the complex struggle for life it is quite credible that crustaceans, not very high in their own class, might beat cephalopods, the highest mollusks; and such crustaceans, though not highly developed, would stand very high in the scale of invertebrate animals, if judged by the most decisive of all trials—the law of battle. Besides these inherent difficulties in deciding which forms are the most advanced in organization, we ought not solely to compare the highest members of a class at any two periods—though undoubtedly this is one and perhaps the most important element in striking a balance—but we ought to compare all the members, high and low, at the two periods. At an ancient epoch the highest and lowest molluscoidal animals, namely, cephalopods and brachiopods, swarmed in numbers; at the present time both groups are greatly reduced, while others, intermediate in organization, have largely increased; consequently some naturalists maintain that mollusks were formerly more highly developed than at present; but a stronger case can be made out on the opposite side, by considering the vast reduction of brachiopods, and the fact that our existing cephalopods, though few in number, are more highly organized than their ancient representatives. We ought also to compare the relative proportional numbers at any two periods of the high and low classes throughout the world; if, for instance, at the present day fifty thousand kinds of vertebrate animals exist, and if we knew that at some former period only ten thousand kinds existed, we ought to look at this increase in number in the highest class, which implies a great displacement of lower forms, as a decided advance in the organization of the world. We thus see how hopelessly difficult it is to compare with perfect fairness, under such extremely complex relations, the standard of organization of the imperfectly-known faunas of successive periods.

Origin of Species, page 121.

There may truly be said to be a constant struggle going on between, on the one hand, the tendency to reversion to a less perfect state, as well as an innate tendency to new variations, and, on the other hand, the power of steady selection to keep the breed true. In the long run selection gains the day, and we do not expect to fail so completely as to breed bird as coarse as a common tumbler-pigeon from a good short-faced strain. But, as long as selection is rapidly going on, much variability in the parts undergoing modification may always be expected.

A HIGHER WORKMANSHIP THAN MAN'S.

Origin of Species, page 65.

As man can produce, and certainly has produced, a great result by his methodical and unconscious means of selection, what may not natural selection affect? Man can act only on external and visible characters: Nature, if I may be allowed to personify the natural preservation or survival of the fittest, cares nothing for appearances, except in so far as they are useful to any being. She can act on every internal organ, on every shade of constitutional difference, on the whole machinery of life. Man selects only for his own good: Nature only for that of the being which she tends. Every selected character is fully exercised by her, as is implied by the fact of their selection. Man keeps the natives of many climates in the same country; he seldom exercises each selected character in some peculiar and fitting manner; he feeds a long and a short beaked pigeon on the same food; he does not exercise a long-backed or long-legged quadruped in any peculiar manner; he exposes sheep with long and short wool to the same climate. He does not allow the most vigorous males to struggle for the females. He does not rigidly destroy all inferior animals, but protects during each varying season, as far as lies in his power, all his productions. He often begins his selection by some half-monstrous form; or at least by some modification prominent enough to catch the eye or to be plainly useful to him. Under nature, the slightest differences of structure or constitution may well turn the nicely-balanced scale in the struggle for life, and so be preserved. How fleeting are the wishes and efforts of man! how short his time! and consequently how poor will be his results, compared with those accumulated by Nature during whole geological periods! Can we wonder, then, that Nature's productions should be far "truer" in character than man's productions; that they should be infinitely better adapted to the most complex conditions of life, and should plainly bear the stamp of far higher workmanship?

It may metaphorically be said that natural selection is daily and hourly scrutinizing, throughout the world, the slightest variations: rejecting those that are bad, preserving and adding up all that are good; silently and insensibly working, *whenever and wherever opportunity offers*, at the improvement of each organic being in relation to its organic and inorganic conditions of life. We see nothing of these slow changes in progress, until the hand of Time has marked the lapse of ages, and then so imperfect is our view into long-past geological ages that we see only that the forms of life are now different from what they formerly were.

Page 66.

Although natural selection can act only through and for the good of each being, yet characters and structures, which we are apt to consider as of very trifling importance, may thus be acted on. When we see leaf-eating insects green and bark-feeders mottled-gray, the Alpine ptarmigan white in winter, the red-grouse the color of heather, we must believe that these tints are of service to these birds and insects in preserving them from danger. Grouse, if not destroyed at some period of their lives, would increase in countless numbers; they are known to suffer largely from birds of prey; and hawks are guided by eye-sight to their prey—so much so, that on parts of the Continent persons are warned not to keep white pigeons, as being the most liable to destruction. Hence natural selection might be effective in giving the proper color to each kind of grouse, and in keeping that color, when once acquired, true and constant. Nor ought we to think that the occasional destruction of an animal of any particular color would produce little effect: we should remember how essential it is in a flock of white sheep to destroy a lamb with the faintest trace of black.

WHY HABITS AND STRUCTURE ARE NOT IN AGREEMENT.

Origin of Species, page 142.

He who believes that each being has been created as we now see it must occasionally have felt surprise when he has met with an animal having habits and structure not in agreement. What can be plainer than that the webbed feet of ducks and geese are formed for swimming? Yet there are upland geese with webbed feet which rarely go near the water; and no one except Audubon has seen the frigate-bird, which has all its four toes webbed, alight on the surface of the ocean. On the other hand, grebes and coots are eminently aquatic, although their toes are only bordered by membrane. What seems plainer than that the long toes, not furnished with membrane, of the *Grallatores*, are formed for walking over swamps and floating plants?—the water-hen and land-rail are members of this order, yet the first is nearly as aquatic as the coot, and the second nearly as terrestrial as the quail or partridge. In such cases, and many others could be given, habits have changed without a corresponding change of structure. The webbed feet of the upland goose may be said to have become almost rudimentary in function, though not in structure. In the frigate-bird, the deeply-scooped membrane between the toes shows that structure has begun to change.

He who believes in separate and innumerable acts of creation may say that in these cases it has pleased the Creator to cause a being of one type to take the place of one belonging to another type; but this seems to me only restating the fact in dignified language. He who believes in the struggle for existence and in the principle of natural selection, will acknowledge that every organic being is constantly endeavoring to increase in numbers; and that if any one being varies ever so little, either in habits or structure, and thus gains an advantage over some other inhabitant of the same country, it will seize on the place of that inhabitant, however different that may be from its own place. Hence it will cause him no surprise that there should be geese and frigate-birds with webbed feet, living on the dry land and rarely alighting on the water; that there should be long-toed corn-crakes, living in meadows instead of in swamps; that there should be woodpeckers where hardly a tree grows; that there should be diving thrushes and diving *Hymenoptera*, and petrels with the habits of auks.

NO MODIFICATION IN ONE SPECIES DESIGNED FOR THE GOOD OF ANOTHER.

Origin of Species, page 162.

Natural selection can not possibly produce any modification in a species exclusively for the good of another species; though throughout nature one species incessantly takes advantage of, and profits by, the structures of others. But natural selection can and does often produce structures for the direct injury of other animals, as we see in the fang of the adder, and in the ovipositor of the ichneumon, by which its eggs are deposited in the living bodies of other insects. If it could be proved that any part of the structure of any one species had been formed for the exclusive good of another species, it would annihilate my theory, for such could not have been produced through natural selection. Although many statements may be found in works on natural history to this effect, I can not find even one which seems to me of any weight. It is admitted that the rattlesnake has a poison-fang for its own defense, and for the destruction of its prey; but some authors suppose that at the same time it is furnished with a rattle for its own injury, namely, to warn its prey. I would almost as soon believe that the cat curls the end of its tail when preparing to spring, in order to warn the doomed mouse. It is a much more probable view that the rattlesnake uses its rattle, the cobra expands its frill, and the puff-adder swells while hissing so loudly and harshly, in order to alarm the many birds and beasts which are known to attack even the most venomous species. Snakes act on the same principle which makes the hen ruffle her feathers and expand her wings when a dog approaches her chickens; but I have not space here to enlarge on the many ways by which animals endeavor to frighten away their enemies.

Natural selection will never produce in a being any structure more injurious than beneficial to that being, for natural selection acts solely by and for the good of each. No organ will be formed, as Paley has remarked, for the purpose of causing pain or for doing an injury to its possessor. If a fair balance be struck between the good and evil caused by each part, each will be found on the whole advantageous. After the lapse of time, under changing conditions of life, if any part comes to be injurious, it will be modified; or, if it be not so, the being will become extinct as myriads have become extinct.

Natural selection tends only to make each organic being as perfect as, or slightly more perfect than, the other inhabitants of the same country with which it comes into competition. And we see that this is the standard of perfection attained under nature. The endemic productions of New Zealand, for instance, are perfect one compared with another; but they are now rapidly yielding before the advancing legions of plants and animals introduced from Europe. Natural selection will not produce absolute perfection, nor do we always meet, as far as we can judge, with this high standard under nature. The correction for the aberration of light is said by Müller not to be perfect even in that most perfect organ, the human eye.

Page 67. Natural selection will modify the structure of the young in relation to the parent, and of the parent in relation to the young. In social animals it will adapt the structure of each individual for the benefit of the whole community, if the community profits by the selected change. What natural selection can not do is, to modify the structure of one species, without giving it any advantage, for the good of another species; and, though statements to this effect may be found in works of natural history, I can not find one case which will bear investigation. A structure used only once in an animal's life, if of high importance to it, might be modified to any extent by natural selection; for instance, the great jaws possessed by certain insects, used exclusively for opening the cocoon, or the hard tip to the beak of unhatched birds, used for breaking the egg. It has been asserted that, of the best short-beaked tumbler-pigeons, a greater number perish in the egg than are able to get out of it, so that fanciers assist in the act of hatching. Now, if Nature had to make the beak of a full-grown pigeon very short for the bird's own advantage, the process of modification would be very slow, and there would be simultaneously the most rigorous selection of all the young birds within the egg, which had the most powerful and hardest beaks, for all with weak beaks would inevitably perish;

or, more delicate and more easily broken shells might be selected, the thickness of the shell being known to vary like every other structure.

ILLUSTRATIONS OF THE ACTION OF NATURAL SELECTION.

Origin of Species, page 70.

In order to make it clear how, as I believe, natural selection acts, I must beg permission to give one or two imaginary illustrations. Let us take the case of a wolf, which preys on various animals, securing some by craft, some by strength, and some by fleetness; and let us suppose that the fleetest prey, a deer for instance, had from any change in the country increased in numbers, or that other prey had decreased in numbers, during that season of the year when the wolf was hardest pressed for food. Under such circumstances the swiftest and slimmest wolves would have the best chance of surviving, and so be preserved or selected—provided always that they retained strength to master their prey at this or some other period of the year, when they were compelled to prey on other animals. I can see no more reason to doubt that this would be the result, than that man should be able to improve the fleetness of his greyhounds by careful and methodical selection, or by that kind of unconscious selection which follows from each man trying to keep the best dogs without any thought of modifying the breed. I may add that, according to Mr. Pierce, there are two varieties of the wolf inhabiting the Catskill Mountains in the United States, one with a light greyhound-like form, which pursues deer, and the other more bulky, with shorter legs, which more frequently attacks the shepherd's flocks.

Page 73. Certain plants excrete sweet juice, apparently for the sake of eliminating something injurious from the sap: this is effected, for instance, by glands at the base of the stipules in some *Leguminosæ*, and at the backs of the leaves of the common laurel. This juice, though small in quantity, is greedily sought by insects; but their visits do not in any way benefit the plant. Now, let us suppose that the juice or nectar was excreted from the inside of the flowers of a certain number of plants of any species. Insects in seeking the nectar would get dusted with pollen, and would often transport it from one flower to another. The flowers of two distinct individuals of the same species would thus get crossed; and the act of crossing, as can be fully proved, gives rise to vigorous seedlings, which consequently would have the best chance of flourishing and surviving. The plants which produced flowers with the largest glands or nectaries, excreting most nectar, would oftenest be visited by insects, and would oftenest be crossed; and so in the long run would gain the upper hand and form a local variety. The flowers, also, which had their stamens and pistils placed, in relation to the size and habits of the particular insect which visited them, so as to favor in any degree the transportal of the pollen, would likewise be favored. We might have taken the case of insects visiting flowers for the sake of collecting pollen instead of nectar; and, as pollen is formed for the sole purpose of fertilization, its destruction appears to be a simple loss to the plant; yet if a little pollen were carried, at first occasionally and then habitually, by the pollen-devouring insects from flower to flower, and a cross thus effected, although nine tenths of the pollen were destroyed, it might still be a great gain to the plant to be thus robbed; and the individuals which produced more and more pollen, and had larger anthers, would be selected.

When our plant, by the above process long continued, had been rendered highly attractive to insects, they would, unintentionally on their part, regularly carry pollen from flower to flower.

DIVERGENCE OF CHARACTER.

Page 86. According to my view, varieties are species in the process of formation, or are, as I have called them, incipient species. How, then, does the lesser difference between varieties become augmented into the greater difference between species? That this does habitually happen, we must infer from most of the innumerable species throughout nature presenting well-marked differences; whereas varieties, the supposed prototypes and parents of future well-marked species, present slight and ill-defined differences. Mere chance, as we may call it, might cause one variety to differ in some character from its parents, and the offspring of this variety again to differ from its parent in the very same character and in a greater degree; but this alone would never account for so habitual and large a degree of difference as that between the species of the same genus.

As has always been my practice, I have sought light on this head from our domestic productions. We shall here find something analogous. It will be admitted that the production of races so different as short-horn and Hereford cattle, race and cart horses, the several breeds of pigeons, etc., could never have been effected by the mere chance accumulation of similar variations during many successive generations. In practice, a fancier is, for instance, struck by a pigeon having a slightly shorter beak; another fancier is struck by a pigeon having a rather longer beak; and, on the acknowledged principle that "fanciers do not and will not admire a medium standard, but like extremes," they both go on (as has actually occurred with the sub-breeds of the tumbler-pigeon) choosing and breeding from birds with longer and longer beaks, or with shorter and shorter beaks. Again, we may suppose that, at an early period of history, the men of one nation or district required swifter horses, while those of another required stronger and bulkier horses. The early differences would be very slight; but, in the course of time, from the continued selection of swifter horses in the one case, and of stronger ones in the other, the differences would become greater, and would be noted as forming two sub-breeds. Ultimately, after the lapse of centuries, these sub-breeds would become converted into two well-established and distinct breeds. As the differences became greater, the inferior animals with intermediate characters, being neither very swift nor very strong, would not have been used for breeding, and will thus have tended to disappear. Here, then, we see in man's productions the action of what may be called the principle of divergence, causing differences, at first barely appreciable, steadily to increase, and the breeds to diverge in character, both from each other and from their common parent.

But how, it may be asked, can any analogous principle apply in natnre? I believe it can and does apply most efficiently (though it was a long time before I saw how), from the simple circumstance that the more diversified the descendants from any one species become in structure, constitution, and habits, by so much will they be better enabled to seize on many and widely diversified places in the polity of nature, and so be enabled to increase in numbers.

Page 89. The advantage of diversification of structure in the inhabitants of the same region is, in fact, the same as that of the physiological division of labor in the organs of the same individual body—a subject so well elucidated by Milne-Edwards. No physiologist doubts that a stomach adapted to digest vegetable matter alone, or flesh alone, draws most nutriment from these substances. So in the general economy of any land, the more widely and perfectly the animals and plants are diversified for different habits of life, so will a greater number of individuals be capable of there supporting themselves. A set of animals, with their organization but little diversified, could hardly compete with a set more perfectly diversified in structure. It may be doubted, for instance, whether the Australian marsupials, which are divided into groups differing but little from each other, and feebly representing, as Mr. Waterhouse and others have remarked, our carnivorons, ruminant, and rodent mammals, could successfully compete with these well-developed orders. In the Australian mammals, we see the process of diversification in an early and incomplete stage of development.

EVOLUTION OF THE HUMAN EYE.

Origin of Species, page 143. To suppose that the eye with all its inimitable contrivances for adjusting the focus to different distances, for admitting different amounts of light, and for the correction of spherical and chromatic aberration, could have been formed by natural selection, seems, I freely confess, absurd in the highest degree. When it was first said that the sun stood still and the world turned round, the common sense of mankind declared the doctrine false; but the old saying of *Vox populi vox Dei*, as every philosopher knows, can not be trusted in science.

Page 145.

Within the highest division of the animal kingdom, namely, the *Vertebrata*, we can start from an eye so simple that it consists, as in the lancelet, of a little sac of transparent skin, furnished with a nerve and lined with pigment, but destitute of any other apparatus. In fishes and reptiles, as Owen has remarked, "the range of gradations of dioptric structures is very great." It is a significant fact that even in man, according to the high authority of Virchow, the beautiful crystalline lens is formed in the embryo by an accumulation of epidermic cells, lying in a sac-like fold of the skin; and the vitreous body is formed from embryonic subcutaneous tissue. To arrive, however, at a just conclusion regarding the formation of the eye, with all its marvelous yet not absolutely perfect characters, it is indispensable that the reason should conquer the imagination; but I have felt the difficulty far too keenly to be surprised at others hesitating to extend the principle of natural selection to so startling a length.

It is scarcely possible to avoid comparing the eye with 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 spaces filled with fluid, and 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, represented by natural selection or the survival of the fittest, always intently watching each slight alteration in the transparent layers; and carefully preserving each which, under varied circumstances, in any way or in any degree, tends to produce a distincter image. We must suppose each new state of the instrument to be multiplied by the million; each to be preserved until a better one is produced, and then the old ones to be all 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 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?

VI.

GEOGRAPHICAL DISTRIBUTION OF ORGANIC BEINGS.

Origin of Species, page 320.

WE are thus brought to the question which has been largely discussed by naturalists, namely, whether species have been created at one or more points of the earth's surface. Undoubtedly there are many cases of extreme difficulty in understanding how the same species could possibly have migrated from some one point to the several distant and isolated points where now found. Nevertheless the simplicity of the view that each species was first produced within a single region captivates the mind. He who rejects it rejects the *vera causa* of ordinary generation with subsequent migration, and calls in the agency of a miracle. It is universally admitted that in most cases the area inhabited by a species is continuous; and that, when a plant or animal inhabits two points so distant from each other, or with an interval of such a nature, that the space could not have been easily passed over by migration, the fact is given as something remarkable and exceptional. The incapacity of migrating across a wide sea is more clear in the case of terrestrial mammals than perhaps with any other organic beings; and, accordingly, we find no inexplicable instances of the same mammals inhabiting distant points of the world. No geologist feels any difficulty in Great Britain possessing the same quadrupeds with the rest of Europe, for they were no doubt once united. But, if the same species can be produced at two separate points, why do we not find a single mammal common to Europe and Australia or South America? The conditions of life are nearly the same, so that a multitude of European animals and plants have become naturalized in America and Australia; and some of the aboriginal plants are identically the same at these distant points of the northern and southern hemispheres. The answer, as I believe, is, that mammals have not been able to migrate, whereas some plants, from their varied means of dispersal, have migrated across the wide and broken interspaces. The great and striking influence of barriers of all kinds is intelligible only on the view that the great majority of species have been produced on one side, and have not been able to migrate to the opposite side. Some few families, many sub-families, very many genera, and a still greater number of sections of genera, are confined to a single region: and it has been observed by several naturalists that the most natural genera, or those genera in which the species are most closely related to each other, are generally confined to the same country, or, if they have a wide range, that their range is continuous. What a strange anomaly it would be, if a directly opposite rule were to prevail, when we go down one step lower in the series, namely, to the individuals of the same species, and these had not been, at least at first, confined to some one region!

Hence it seems to me, as it has to many other naturalists, that the view of each species having been produced in one area alone, and having subsequently migrated from that area as far as its powers of migration and subsistence under past and present conditions permitted, is the most probable. Undoubtedly many cases occur, in which we can not explain how the same species could have passed from one point to the other. But the geographical and climatal changes, which have certainly occurred within recent geological times, must have rendered discontinuous the formerly continuous range of many species. So that we are reduced to consider whether the exceptions to continuity of range are so numerous and of so grave a nature that we ought to give up the belief, rendered probable by general considerations, that each species has been produced within one area, and has migrated thence as far as it could.

ISOLATED CONTINENTS NEVER WERE UNITED.

Origin of Species, page 324.

Whenever it is fully admitted, as it will some day be, that each species has proceeded from a single birthplace, and when in the course of time we know something definite about the means of distribution, we shall be enabled to speculate with security on the former extension of the land. But I do not believe that it will ever be proved that within the recent period most of our continents which now stand quite separate have been continuously, or almost continuously, united with each other, and with the many existing oceanic islands. Several facts in distribution, such as the great difference in the marine faunas on the opposite sides of almost every continent, the close relation of the tertiary inhabitants of several lands and even seas to their present inhabitants, the degree of affinity between the mammals inhabiting islands with those of the nearest continent, being in part determined (as we shall hereafter see) by the depth of the intervening ocean, these and other such facts are opposed to the admission of such prodigious geographical revolutions within the recent period as are necessary on the view advanced by Forbes and admitted by his followers. The nature and relative proportions of the inhabitants of oceanic islands are likewise opposed to the belief of their former continuity with continents. Nor does the almost universally volcanic composition of such islands favor the admission that they are the wrecks of sunken continents; if they had originally existed as continental mountain-ranges, some at least of the islands would have been formed, like other mountain-summits, of granite, metamorphic schists, old fossiliferous and other rocks, instead of consisting of mere piles of volcanic matter.

MEANS OF DISPERSAL.

Page 326. Living birds can hardly fail to be highly effective agents in the transportation of seeds. I could give many facts showing how frequently birds of many kinds are blown by gales to vast distances across the ocean. We may safely assume that under such circumstances their rate of flight would often be thirty-five miles an hour; and some authors have given a far higher estimate. I have never seen an instance of nutritious seeds passing through the intestines of a bird; but hard seeds of fruit pass uninjured through even the digestive organs of a turkey. In the course of two months I picked up in my garden twelve kinds of seeds out of the excrement of small birds, and these seemed perfect, and some of them, which were tried, germinated. But the following fact is more important: the crops of birds do not secrete gastric juice, and do not, as I know by trial, injure in the least the germination of seeds; now, after a bird has found and devoured a large supply of food, it is positively asserted that all the grains do not pass into the gizzard for twelve or even eighteen hours. A bird in this interval might easily be blown to the distance of five hundred miles, and hawks are known to look out for tired birds, and the contents of their torn crops might thus readily get scattered. Some hawks and owls bolt their prey whole, and, after an interval of from twelve to twenty hours, disgorge pellets, which, as I know from experiments made in the Zoölogical Gardens, include seeds capable of germination. Some seeds of the oat, wheat, millet, canary, hemp, clover, and beet germinated after having been from twelve to twenty-one hours in the stomachs of different birds of prey; and two seeds of beet grew after having been thus retained for two days and fourteen hours. Fresh-water fish, I find, eat seeds of many land and water plants: fish are frequently devoured by birds, and thus the seeds might be transported from place to place. I forced many kinds of seeds into the stomachs of dead fish, and then gave their bodies to fishing-eagles, storks, and pelicans; these birds, after an interval of many hours, either rejected the seeds in pellets or passed them in their excrement; and several of these seeds retained the power of germination. Certain seeds, however, were always killed by this process.

Locusts are sometimes blown to great distances from the land; I myself caught one three hundred and seventy miles from the coast of Africa, and have heard of others caught at greater distances.

Page 328.

As icebergs are known to be sometimes loaded with earth and stones, and have even carried brushwood, bones, and the nest of a land-bird, it can hardly be doubted that they must occasionally, as suggested by Lyell, have transported seeds from one part to another of the Arctic and Antarctic regions, and during the Glacial period from one part of the now temperate regions to another. In the Azores, from the large number of plants common to Europe, in comparison with the species on the other islands of the Atlantic, which stand nearer to the mainland, and (as remarked by Mr. H. C. Watson) from their somewhat northern character in comparison with the latitude, I suspected that these islands had been partly stocked by ice-borne seeds during the Glacial epoch.

THESE MEANS OF TRANSPORT NOT ACCIDENTAL.

Page 329. These means of transport are sometimes called accidental, but this is not strictly correct; the currents of the sea are not accidental, nor is the direction of prevalent gales of wind. It should be observed that scarcely any means of transport would carry seeds for very great distances: for seeds do not retain their vitality when exposed for a great length of time to the action of sea-water; nor could they be long carried in the crops or intestines of birds. These means, however, would suffice for occasional transport across tracts of sea some hundred miles in breadth, or from island to island, or from a continent to a neighboring island, but not from one distant continent to another. The floras of distant continents would not by such means become mingled; but would remain as distinct as they now are. The currents, from their course, would never bring seeds from North America to Britain, though they might and do bring seeds from the West Indies to our western shores, where, if not killed by their very long immersion in salt-water, they could not endure our climate. Almost every year, one or two land-birds are blown across the whole Atlantic

Ocean, from North America to the western shores of Ireland and England; but seeds could be transported by these rare wanderers only by one means, namely, by dirt adhering to their feet or beaks, which is in itself a rare accident. Even in this case, how small would be the chance of a seed falling on favorable soil and coming to maturity! But it would be a great error to argue that, because a well-stocked island, like Great Britain, has not, as far as is known (and it would be very difficult to prove this), received within the last few centuries, through occasional means of transport, immigrants from Europe or any other continent, a poorly-stocked island, though standing more remote from the mainland, would not receive colonists by similar means. Out of a hundred kinds of seeds or animals transported to an island, even if far less well-stocked than Britain, perhaps not more than one would be so well fitted to its new home as to become naturalized. But this is no valid argument against what would be effected by occasional means of transport, during the long lapse of geological time, while the island was being upheaved, and before it had become fully stocked with inhabitants. On almost bare land, with few or no destructive insects or birds living there, nearly every seed which chanced to arrive, if fitted for the climate, would germinate and survive.

DISPERSAL DURING THE GLACIAL PERIOD.

Page 434. The Glacial period is defined "as a period of great cold and of enormous extension of ice upon the surface of the earth. It is believed that glacial periods have occurred repeatedly during the geological history of the earth, but the term is generally applied to the close of the Tertiary epoch, when nearly the whole of Europe was subjected to an Arctic climate."

Origin of Species, page 330.

The identity of many plants and animals, on mountain-summits, separated from each other by hundreds of miles of lowlands, where Alpine species could not possibly exist, is one of the most striking cases known of the same species living at distant points, without the apparent possibility of their having migrated from one point to the other. It is indeed a remarkable fact to see so many plants of the same species living on the snowy regions of the Alps or Pyrenees, and in the extreme northern parts of Europe; but it is far more remarkable that the plants on the White Mountains, in the United States of America, are all the same with those of Labrador, and nearly all the same, as we hear from Asa Gray, with those on the loftiest mountains of Europe. Even as long ago as 1747 snch facts led Gmelin to conclude that the same species must have been independently created at many distinct points; and we might have remained in this same belief, had not Agassiz and others called vivid attention to the Glacial period, which, as we shall immediately see, affords a simple explanation of these facts. We have evidence of almost every conceivable kind, organic and inorganic, that, within a very recent geological period, Central Europe and North America suffered under an Arctic climate. The ruins of a house burned by fire do not tell their tale more plainly than do the mountains of Scotland and Wales, with their scored flanks, polished surfaces, and perched bowlders, of the icy streams with which their valleys were lately filled. So greatly has the climate of Europe changed, that in Northern Italy gigantic moraines, left by old glaciers, are now clothed by the vine and maize. Throughout a large part of the United States erratic bowlders and scored rocks plainly reveal a former cold period.

The former influence of the glacial climate on the distribution of the inhabitants of Europe, as explained by Edward Forbes, is substantially as follows. But we shall follow the changes more readily by supposing a new glacial period slowly to come on, and then pass away, as formerly occurred. As the cold came on, and as each more southern zone became fitted for the inhabitants of the north, these would take the places of the former inhabitants of the temperate regions. The latter, at the same time, would travel farther and farther southward, unless they were stopped by barriers, in which case they would perish. The mountains would become covered with snow and ice, and their former Alpine inhabitants would descend to the plains. By the time that the cold had reached its maximum, we should have an Arctic fauna and flora, covering the central parts of Europe, as far south as the Alps and Pyrenees, and even stretching into Spain. The now temperate regions of the United States would likewise be covered by Arctic plants and animals, and these would be nearly the same with those of Europe; for the present circumpolar inhabitants, which we suppose to have everywhere traveled southward, are remarkably uniform round the world.

As the warmth returned, the Arctic forms would retreat northward, closely followed up in their retreat by the productions of the more temperate regions. And, as the snow melted from the bases of the mountains, the Arctic forms would seize on the cleared and thawed ground, always ascending, as the warmth increased and the snow still further disappeared, higher and higher, while their brethren were pursuing their northern journey. Hence, when the warmth had fully returned, the same species, which had lately lived together on the European and North American lowlands, would again be found in the

Arctic regions of the Old and New Worlds, and on many isolated mountain-summits far distant from each other.

Thus we can understand the identity of many plants at points so immensely remote as the mountains of the United States and those of Europe.

THE THEORY OF CREATION INADEQUATE.

Page 334. As on the land, so in the waters of the sea, a slow southern migration of a marine fauna, which, during the Pliocene or even a somewhat earlier period, was nearly uniform along the continuous shores of the Polar Circle, will account, on the theory of modification, for many closely allied forms now living in marine areas completely sundered. Thus, I think, we can understand the presence of some closely allied, still existing and extinct tertiary forms on the eastern and western shores of temperate North America; and the still more striking fact of many closely allied crustaceans (as described in Dana's admirable work), some fish and other marine animals, inhabiting the Mediterranean and the seas of Japan —these two areas being now completely separated by the breadth of a whole continent and by wide spaces of ocean.

These cases of close relationship in species either now or formerly inhabiting the seas on the eastern and western shores of North America, the Mediterranean and Japan, and the temperate lands of North America and Europe, are inexplicable on the theory of creation. We can not maintain that such species have been created alike, in correspondence with the nearly similar physical conditions of the areas; for, if we compare, for instance, certain parts of South America with parts of South Africa or Australia, we see countries closely similar in all their physical conditions, with their inhabitants utterly dissimilar.

CAUSES OF A GLACIAL CLIMATE.

Page 336.

Mr. Croll, in a series of admirable memoirs, has attempted to show that a glacial condition of climate is the result of various physical causes, brought into operation by an increase in the eccentricity of the earth's orbit. All these causes tend toward the same end; but the most powerful appears to be the indirect influence of the eccentricity of the orbit upon oceanic currents. According to Mr. Croll, cold periods regularly recur every ten to fifteen thousand years; and these at long intervals are extremely severe, owing to certain contingencies, of which the most important, as Sir C. Lyell has shown, is the relative position of the land and water. Mr. Croll believes that the last great Glacial period occurred about two hundred and forty thousand years ago, and endured with slight alterations of climate for about one hundred and sixty thousand years. With respect to more ancient Glacial periods, several geologists are convinced from direct evidence that such occurred during the Miocene and Eocene formations, not to mention still more ancient formations. But the most important result for us, arrived at by Mr. Croll, is that, whenever the northern hemisphere passes through a cold period, the temperature of the southern hemisphere is actually raised, with the winters rendered much milder, chiefly through changes in the direction of the ocean-currents. So conversely it will be with the northern hemisphere, while the southern passes through a glacial period. This conclusion throws so much light on geographical distribution that I am strongly inclined to trust in it.

DIFFICULTIES NOT YET REMOVED.

Page 341. I am far from supposing that all the difficulties in regard to the distribution and affinities of the identical and allied species, which now live so widely separated in the north and south, and sometimes on the intermediate mountain-ranges, are removed on the views above given. The exact lines of migration can not be indicated. We can not say why certain species and not others have migrated; why certain species have been modified and have given rise to new forms, while others have remained unaltered. We can not hope to explain such facts, until we can say why one species and not another becomes naturalized by man's agency in a foreign land; why one species ranges twice or thrice as far, and is twice or thrice as common, as another species within their own homes.

Various special difficulties also remain to be solved; for instance, the occurrence, as shown by Dr. Hooker, of the same plants at points so enormously remote as Kerguelen Land, New Zealand, and Fuegia; but icebergs, as suggested by Lyell, may have been concerned in their dispersal. The existence at these and other distant points of the southern hemisphere of species which, though distinct, belong to genera exclusively confined to the south, is a more remarkable case. Some of these species are so distinct that we can not suppose that there has been time since the commencement of the last Glacial period for their migration and subsequent modification to the necessary degree. The facts seem to indicate that distinct species belonging to the same genera have migrated in radiating lines from a common center; and I am inclined to look in the southern, as in the northern hemisphere, to a former and warmer period, before the commencement of the last Glacial period, when the Antarctic lands, now covered with ice, supported a highly peculiar and isolated flora. It may be suspected that, before this flora was exterminated during the last Glacial epoch, a few forms had been already widely dispersed to various points of the southern hemisphere by occasional means of transport, and by the aid, as halting-places, of now sunken islands. Thus the southern shores of America, Australia, and New Zealand, may have become slightly tinted by the same peculiar forms of life.

IDENTITY OF THE SPECIES OF ISLANDS WITH THOSE OF THE MAINLAND EXPLAINED ONLY BY THIS THEORY.

Origin of Species, page 353.

The most striking and important fact for us is the affinity of the species which inhabit islands to those of the nearest mainland, without being actually the same. Numerous instances could be given. The Galapagos Archipelago, situated under the equator, lies at the distance of between five hundred and six hundred miles from the shores of South America. Here almost every product of the land and of the water bears the unmistakable stamp of the American Continent. There are twenty-six land-birds; of these, twenty-one or perhaps twenty-three are ranked as distinct species, and would commonly be assumed to have been here created; yet the close affinity of most of these birds to American species is manifest in every character, in their habits, gestures, and tones of voice. So it is with the other animals, and with a large proportion of the plants, as shown by Dr. Hooker in his admirable Flora of this archipelago. The naturalist, looking at the inhabitants of these volcanic islands in the Pacific, distant several hundred miles from the continent, feels that he is standing on American land. Why should this be so? why should the species which are supposed to have been created in the Galapagos Archipelago, and nowhere else, bear so plainly the stamp of affinity to those created in America? There is nothing in the conditions of life, in the geological nature of the islands, in their height or climate, or in the proportions in which the several classes are associated together, which closely resembles the conditions of the South American coast; in fact, there is a considerable dissimilarity in all these respects. On the other hand, there is a considerable degree of resemblance in the volcanic nature of the soil, in the climate, height, and size of the islands, between the Galapagos and Cape de Verd Archipelagos; but what an entire and absolute difference in their inhabitants! The inhabitants of the Cape de Verd Islands are related to those of Africa, like those of the Galapagos to America. Facts such as these admit of no sort of explanation on the ordinary view of independent creation; whereas, on the view here maintained, it is obvious that the Galapagos Islands would be likely to receive colonists from America, whether by occasional means of transport or (though I do not believe in this doctrine) by formerly continuous land, and the Cape de Verd Islands from Africa; such colonists would be liable to modification, the principle of inheritance still betraying their original birthplace.

Many analogous facts could be given: indeed, it is an almost universal rule that the endemic productions of islands are related to those of the nearest continent, or of the nearest large island. The exceptions are few, and most of them can be explained. Thus, although Kerguelen Land stands nearer to Africa than to America, the plants are related, and that very closely, as we know from Dr. Hooker's account, to those of America: but, on the view that this island has been mainly stocked by seeds brought with earth and stones on icebergs, drifted by the prevailing currents, this anomaly disappears. New Zealand in its endemic plants is much more closely related to Australia, the nearest mainland, than to any other region: and this is what might have been expected; but it is also plainly related to South America, which, although the next nearest continent, is so enormously remote that the fact becomes an anomaly. But this difficulty partially disappears on the view that New Zealand, South America, and the other southern lands have been stocked in part from a nearly intermediate though distant point, namely, from the Antarctic islands, when they were clothed with vegetation, during a warmer tertiary period, before the commencement of the last Glacial period. The affinity, which, though feeble, I am assured by Dr. Hooker is real, between the flora of the southwestern corner of Australia and of the Cape of Good Hope, is a far more remarkable case; but this affinity is confined to the plants, and will, no doubt, some day be explained.

VII.

EVIDENCE OF THE DESCENT OF MAN FROM SOME LOWER FORM.

The Descent of Man, page 5.

He who wishes to decide whether man is the modified descendant of some pre-existing form would probably first inquire whether man varies, however slightly, in bodily structure and in mental faculties; and, if so, whether the variations are transmitted to his offspring in accordance with the laws which prevail with the lower animals. Again, are the variations the result, as far as our ignorance permits us to judge, of the same general causes, and are they governed by the same general laws, as in the case of other organisms; for instance, by correlation, the inherited effects of use and disuse, etc.? Is man subject to similar malconformations, the result of arrested development, of reduplication of parts, etc., and does he display in any of his anomalies reversion to some former and ancient type of structure? It might also naturally be inquired whether man, like so many other animals, has given rise to varieties and sub-races, differing but slightly from each other, or to races differing so much that they must be classed as doubtful species. How are such races distributed over the world; and how, when crossed, do they react on each other in the first and succeeding generations? And so with many other points.

The inquirer would next come to the important point whether man tends to increase at so rapid a rate as to lead to occasional severe struggles for existence; and consequently to beneficial variations, whether in body or mind, being preserved, and injurious ones eliminated. Do the races or species of men, whichever term may be applied, encroach on and replace one another, so that some finally become extinct? We shall see that all these questions, as indeed is obvious in respect to most of them, must be answered in the affirmative, in the same manner as with the lower animals.

POINTS OF CORRESPONDENCE BETWEEN MAN AND THE OTHER ANIMALS.

The Descent of Man, page 6.

It is notorious that man is constructed on the same general type or model as other mammals. All the bones in his skeleton can be compared with corresponding bones in a monkey, bat, or seal. So it is with his muscles, nerves, blood-vessels, and internal viscera. The brain, the most important of all the organs, follows the same law, as shown by Huxley and other anatomists. Bischoff, who is a hostile witness, admits that every chief fissure and fold in the brain of man has its analogy in that of the orang; but he adds that at no period of development do their brains perfectly agree; nor could perfect agreement be expected, for otherwise their mental powers would have been the same.

Man is liable to receive from the lower animals, and to communicate to them, certain diseases, as hydrophobia, variola, the glanders, syphilis, cholera, herpes, etc.; and this fact proves the close similarity of their tissues and blood, both in minute structure and composition, far more plainly than does their comparison under the best microscope, or by the aid of the best chemical analysis. Monkeys are liable to many of the same non-contagious diseases as we are; thus Rengger, who carefully observed for a long time the *Cebus Azaræ* in its native land, found it liable to catarrh, with the usual symptoms, and which, when often recurrent, led to consumption. These monkeys suffered also from apoplexy, inflammation of the bowels, and cataract in the eye. The younger ones when shedding their milk-teeth often died from fever. Medicines produced the same effect on them as on us. Many kinds of monkeys have a strong taste for tea, coffee, and spirituous liquors: they will also, as I have myself seen, smoke tobacco with pleasure. Brehm asserts that the natives of Northeastern Africa catch the wild baboons by exposing vessels with strong beer, by which they are made drunk. He has seen some of these animals, which he kept in confinement, in this state; and he gives a laughable account of their behavior and strange grimaces. On the following morning they were very cross and dismal; they held their aching heads with both hands, and wore a most pitiable expression: when beer or wine was offered them, they turned away with disgust, but relished the juice of lemons. An American monkey, an Ateles, after getting drunk on brandy, would never touch it again, and thus was wiser than many men. These trifling facts prove how similar the nerves of taste must be in monkeys and man, and how similarly their whole nervous system is affected.

Man is infested with internal parasites, sometimes causing fatal effects; and is plagued by external parasites, all of which belong to the same genera or families as those infesting other mammals, and in the case of scabies to the same species. Man is subject, like other mammals, birds, and even insects, to that mysterious law which causes certain normal processes, such as gestation, as well as the maturation and duration of various diseases, to follow lunar periods. His wounds are repaired by the same process of healing ; and the stumps left after the amputation of his limbs, especially during an early embryonic period, occasionally possess some power of regeneration, as in the lowest animals.

Page 9.

Man is developed from an ovule, about the 125th of an inch in diameter, which differs in no respect from the ovules of other animals. The embryo itself at a very early period can hardly be distinguished from that of other members of the vertebrate kingdom. At this period the arteries run in arch-like branches, as if to carry the blood to branchiæ which are not present in the higher vertebrata, though the slits on the side of the neck still remain, marking their former position. At a somewhat later period, when the extremities are developed, "the feet of lizards and mammals," as the illustrious Von Baer remarks, "the wings and feet of birds, no less than the hands and feet of man, all arise from the same fundamental form." It is, says Professor Huxley, "quite in the later stages of development that the young human being presents marked differences from the young ape, while the latter departs as much from the dog in its developments as the man does. Startling as this last assertion may appear to be, it is demonstrably true."

THE FACTS OF EMBRYOLOGY AND THE THEORY OF DEVELOPMENT.

Origin of Species, page 386.

This is one of the most important subjects (embryology) in the whole round of natural history. The metamorphoses of insects, with which every one is familiar, are generally effected abruptly by a few stages; but the transformations are in reality numerous and gradual, though concealed. A certain ephemerous insect (*Chlöeon*), during its development, molts, as shown by Sir J. Lubbock, above twenty times, and each time undergoes a certain amount of change; and in this case we see the act of metamorphosis performed in a primary and gradual manner. Many insects, and especially certain crustaceans, show us what wonderful changes of structure can be effected during development. Such changes, however, reach their climax in the so-called alternate generations of some of the lower animals. It is, for instance, an astonishing fact that a delicate branching coralline, studded with polypi and attached to a submarine rock, should produce, first by budding and then by transverse division, a host of huge floating jelly-fishes; and that these should produce eggs, from which are hatched swimming animalcules, which attach themselves to rocks, and become developed into branching corallines; and so on in an endless cycle. The belief in the essential identity of the process of alternate generation and of ordinary metamorphosis has been greatly strengthened by Wagner's discovery of the larva or maggot of a fly, namely, the *Cecidomyia*, producing asexually other larvæ, and these others, which finally are developed into mature males and females, propagating their kind in the ordinary manner by eggs.

Page 387. It has been already stated that various parts in the same individual, which are exactly alike during an early embryonic period, become widely different and serve for widely different purposes in the adult state. So, again, it has been shown that generally the embryos of the most distinct species belonging to the same class are closely similar, but become, when fully developed, widely dissimilar. A better proof of this latter fact can not be given than the statement by Von Baer that "the embryos of mammalia, of birds, lizards, and snakes, probably also of chelonia, are in their earliest states exceedingly like one another, both as a whole and in the mode of development of their parts; so much so, in fact, that we can often distinguish the embryos only by their size, In my possession are two little embryos in spirit, whose names I have omitted to attach, and at present I am quite unable to say to what class they belong. They may be lizards or small birds, or very young mammalia, so complete is the similarity in the mode of formation of the head and trunk in these animals. The extremities, however, are still absent in these embryos. But, even if they had existed in the earliest stage of their development, we should learn nothing, for the feet of lizards and mammals, the wings and feet of birds, no less than the hands and feet of man, all arise from the same fundamental form." The larvæ of most crustaceans, at corresponding stages of development, closely resemble each other, however different the adults may become; and so it is with very many other animals. A trace of the law of embryonic resemblance occasionally lasts till a rather late age: thus birds of the same genus, and of allied genera, often resemble each other in their immature plumage; as we see in the spotted feathers in the young of the thrush group. In the cat tribe, most of the species when adult are striped or spotted in lines; and stripes or spots can be plainly distinguished in the whelp of the lion and the puma. We occasionally though rarely see something of the same kind in plants; thus the first leaves of the ulex or furze, and the first leaves of the phyllodineous acacias, are pinnate or divided like the ordinary leaves of the *Leguminosæ*.

TWO PRINCIPLES THAT EXPLAIN THE FACTS.

Page 390. How, then, can we explain these several facts in embryology—namely, the very general, though not universal, difference in structure between the embryo and the adult; the various parts in the same individual embryo, which ultimate become very unlike and serve for diverse purposes, being at an early period of growth alike; the common, but not invariable, resemblance between the embryos or larvæ of the most distinct species in the same class; the embryo often retaining, while within the egg or womb, structures which are of no service to it, either at that or at a later period of life; on the other hand, larvæ, which have to provide for their own wants, being perfectly adapted to the surrounding conditions; and, lastly, the fact of certain larvæ standing higher in the scale of organization than the mature animal into which they are developed? I believe that all these facts can be explained as follows:

It is commonly assumed, perhaps from monstrosities affecting the embryo at a very early period, that slight variations or individual differences necessarily appear at an equally early period. We have little evidence on this head, but what we have certainly points the other way; for it is notorious that breeders of cattle, horses, and various fancy animals, can not positively tell, until some time after birth, what will be the merits or demerits of their young animals. We see this plainly in our own children; we can not tell whether a child will be tall or short, or what its precise features will be. The question is not, at what period of life each variation may have been caused, but at what period the effects are displayed. The cause may have acted, and I believe often has acted, on one or both parents before the act of generation. It deserves notice that it is of no importance to a very young animal, as long as it remains in its mother's womb or in the egg, or as long as it is nourished and protected by its parent, whether most of its characters are acquired a little earlier or later in life. It would not signify, for instance, to a bird which obtained its food by having a much-curved beak whether or not while young it possessed a beak of this shape, as long as it was fed by its parents.

I have stated in the first chapter that at whatever age a variation first appears in the parent, it tends to reappear at a corresponding age in the offspring. Certain variations can only appear at corresponding ages; for instance, peculiarities in the caterpillar, cocoon, or imago states of the silk-moth; or, again, in the full-grown horns of cattle. But variations, which, for all that we can see, might have first appeared either earlier or later in life, likewise tend to reappear at a corresponding age in the offspring and parent. I am far from meaning that this is invariably the case, and I could give several exceptional cases of variations (taking the word in the largest sense) which have supervened at an earlier age in the child than in the parent.

These two principles, namely, that slight variations generally appear at a not very early period of life, and are inherited at a corresponding not early period, explain, as I believe, all the above specified leading facts in embryology.

EMBRYOLOGY AGAINST ABRUPT CHANGES.

Origin of Species, page 203.

Unless we admit transformations as prodigious as those advocated by Mr. Mivart, such as the sudden development of the wings of birds or bats, or the sudden conversion of a Hipparion into a horse, hardly any light is thrown by the belief in abrupt modifications on the deficiency of connecting links in our geological formations. But against the belief in such abrupt changes embryology enters a strong protest. It is notorious that the wings of birds and bats, and the legs of horses or other quadrupeds, are undistinguishable at an early embryonic period, and that they become differentiated by insensibly fine steps. Embryological resemblances of all kinds can be accounted for, as we shall hereafter see, by the progenitors of our existing species having varied after early youth, and having transmitted their newly acquired characters to their offspring at a corresponding age. The embryo is thus left almost unaffected, and serves as a record of the past condition of the species. Hence it is that existing species during the early stages of their development so often resemble ancient and extinct forms belonging to the same class. On this view of the meaning of embryological resemblances, and indeed on any view, it is incredible that an animal should have undergone such momentous and abrupt transformations as those above indicated, and yet should not bear even a trace in its embryonic condition of any sudden modification, every detail in its structure being developed by insensibly fine steps.

He who believes that some ancient form was transformed suddenly through an internal force or tendency into, for instance, one furnished with wings, will be almost compelled to assume, in opposition to all analogy, that many individuals varied simultaneously. It can not be denied that such abrupt and great changes of structure are widely different from those which most species apparently have undergone. He will further be compelled to believe that many structures beautifully adapted to all the other parts of the same creature and to the surrounding conditions, have been suddenly produced; and of such complex and wonderful coadaptations he will not be able to assign a shadow of an explanation. He will be forced to admit that these great and sudden transformations have left no trace of their action on the embryo. To admit all this is, as it seems to me, to enter into the realms of miracle, and to leave those of science.

RUDIMENTARY ORGANS ONLY TO BE EXPLAINED ON THE THEORY OF DEVELOPMENT.

Descent of Man, page 11.

Not one of the higher animals can be named which does not bear some part in a rudimentary condition; and man forms no exception to the rule. Rudimentary organs must be distinguished from those that are nascent, though in some cases the distinction is not easy. The former are either absolutely useless, such as the mammæ of male quadrupeds, or the incisor teeth of ruminants which never cut through the gums; or they are of such slight service to their present possessors that we can hardly suppose that they were developed under the conditions which now exist. Organs in this latter state are not strictly rudimentary, but they are tending in this direction. Nascent organs, on the other hand, though not fully developed, are of high service to their possessors, and are capable of further development. Rudimentary organs are eminently variable; and this is partly intelligible, as they are useless, or nearly useless, and consequently are no longer subjected to natural selection. They often become wholly suppressed. When this occurs, they are nevertheless liable to occasional reappearance through reversion—a circumstance well worthy of attention.

Page 12. Rudiments of various muscles have been observed in many parts of the human body; and not a few muscles which are regularly present in some of the lower animals can occasionally be detected in man in a greatly reduced condition. Every one must have noticed the power which many animals, especially horses, possess of moving or twitching their skin; and this is effected by the *panniculus carnosus.* Remnants of this muscle in an efficient state are found in various parts of our bodies: for instance, the muscle on the forehead, by which the eyebrows are raised.

Page 13. Some few persons have the power of contracting the superficial muscles on their scalps; and these muscles are in a variable and partially rudimentary condition. M. A. de Candolle has communicated to me a curious instance of the long-continued persistence or inheritance of this power, as well as of its unusual development. He knows a family in which one member, the present head of the family, could, when a youth, pitch several heavy books from his head by the movement of the scalp alone; and he won wagers by performing this feat. His father, uncle, grandfather, and his three children possess the same power to the same unusual degree. This family became divided eight generations ago into two branches; so that the head of the above-mentioned branch is cousin in the seventh degree to the head of the other branch. This distant cousin resides in another part of France; and, on being asked whether he possessed the same faculty, immediately exhibited his power. This case offers a good illustration how persistent may be the transmission of an absolutely useless faculty, probably derived from our remote semi-human progenitors, since many monkeys have, and frequently use, the power of largely moving their scalps up and down.

Page 23. It is well known that in the males of all mammals, including man, rudimentary mammæ exist. These in several instances have become well developed, and have yielded a copious supply of milk. Their essential identity in the two sexes is likewise shown by their occasional sympathetic enlargement in both during an attack of the measles.

"NO OTHER EXPLANATION HAS EVER BEEN GIVEN."

Page 24. The homological construction of the whole frame in the members of the same class is intelligible, if we admit their descent from a common progenitor, together with their subsequent adaptation to diversified conditions. On any other view, the similarity of pattern between the hand of a man or monkey, the foot of a horse, the flipper of a seal, the wing of a bat, etc., is utterly inexplicable. It is no scientific explanation to assert that they have all been formed on the same ideal plan. With respect to development, we can clearly understand, on the principle of variations supervening at a rather late embryonic period, and being inherited at a corresponding period, how it is that the embryos of wonderfully different forms should still retain, more or less perfectly, the structure of their common progenitor. No other explanation has ever been given of the marvelous fact that the embryos of a man, dog, seal, bat, reptile, etc., can at first hardly be distinguished from each other. In order to understand the existence of rudimentary organs, we have only to suppose that a former progenitor possessed the parts in question in a perfect state, and that under changed habits of life they became greatly reduced, either from simple disuse or through the natural selection of those individuals which were least encumbered with a superfluous part, aided by the other means previously indicated.

Thus we can understand how it has come to pass that man and all other vertebrate animals have been constructed on the same general model, why they pass through the same early stages of development, and why they retain certain rudiments in common. Consequently we ought frankly to admit their community of descent; to take any other view is to admit that our own structure, and that of all the animals around us, is a mere snare laid to entrap our judgment. This conclusion is greatly strengthened, if we look to the members of the whole animal series, and consider the evidence derived from their affinities or classification, their geographical distribution, and geological succession. It is only our natural prejudice and that arrogance which made our forefathers declare that they were descended from demi-gods which leads us to demur to this conclusion. But the time will before long come when it will be thought wonderful that naturalists, who were well acquainted with the comparative structure and development of man and other mammals, should have believed that each was the work of a separate act of creation.

UNITY OF TYPE EXPLAINED BY RELATIONSHIP.

Origin of Species, page 382.

We have seen that the members of the same class, independently of their habits of life, resemble each other in the general plan of their organization. This resemblance is often expressed by the term "unity of type"; or by saying that the several parts and organs in the different species of the class are homologous. The whole subject is included under the general term of Morphology. This is one of the most interesting departments of natural history, and may almost be said to be its very soul. What can be more curious than that the hand of a man, formed for grasping, that of a mole for digging, the leg of the horse, the paddle of the porpoise, and the wing of the bat, should all be constructed on the same pattern, and should include similar bones, in the same relative positions? How curious it is, to give a subordinate though striking instance, that the hind-feet of the kangaroo, which are so well fitted for bounding over the open plains, those of the climbing, leaf-eating koala, equally well fitted for grasping the branches of trees, those of the ground-dwelling, insect or root eating, bandicoots, and those of some other Australian marsupials, should all be constructed on the same extraordinary type, namely, with the bones of the second and third digits extremely slender and enveloped within the same skin, so that they appear like a single toe furnished with two claws! Notwithstanding this similarity of pattern, it is obvious that the hind-feet of these several animals are used for as widely different purposes as it is possible to conceive. The case is rendered all the more striking by the American opossums, which follow nearly the same habits of life as some of their Australian relatives, having feet constructed on the ordinary plan. Professor Flower, from whom these statements are taken, remarks in conclusion, "We may call this conformity to type, without getting much nearer to an explanation of the phenomenon"; and he then adds, "but is it not powerfully suggestive of true relationship, of inheritance from a common ancestor?"

INEXPLICABLE ON THE ORDINARY VIEW OF CREATION.

Page 384. How inexplicable are the cases of serial homologies on the ordinary view of creation! Why should the brain be inclosed in a box composed of such numerous and such extraordinarily shaped pieces of bone, apparently representing vertebræ? As Owen has remarked, the benefit derived from the yielding of the separate pieces in the act of parturition by mammals will by no means explain the same construction in the skulls of birds and reptiles. Why should similar bones have been created to form the wing and the leg of a bat, nsed as they are for such totally different purposes, namely, flying and walking? Why should one crustacean, which has an extremely complex mouth formed of many parts, consequently always have fewer legs; or conversely, those with many legs have simpler mouths? Why should the sepals, petals, stamens, and pistils, in each flower, though fitted for such distinct purposes, be all constructed on the same pattern?

On the theory of natural selection, we can, to a certain extent, answer these questions. We need not here consider how the bodies of some animals first became divided into a series of segments, or how they became divided into right and left sides, with corresponding organs, for such questions are almost beyond investigation. It is, however, probable that some serial structures are the result of cells multiplying by division, entailing the multiplication of the parts developed from such cells. It must suffice for our purpose to bear in mind that an indefinite repetition of the same part or organ is the common characteristic, as Owen has remarked, of all low or little specialized forms; therefore the unknown progenitor of the Vertebrata probably possessed many vertebræ; the unknown progenitor of the Articulata, many segments; and the unknown progenitor of flowering plants, many leaves arranged in one or more spires. We have also formerly seen that parts many times repeated are eminently liable to vary, not only in number, but in form. Consequently such parts being already present in considerable numbers, and being highly variable, would naturally afford the materials for adaptation to the most different purposes; yet they would generally retain, through the force of inheritance, plain traces of their original or fundamental resemblance. They would retain this resemblance all the more, as the variations, which afforded the basis for their subsequent modification through natural selection, would tend from the first to be similar, the parts being at an early stage of growth alike, and being subjected to nearly the same conditions. Such parts, whether more or less modified, unless their common origin became wholly obscured, would be serially homologous.

DESCENT WITH MODIFICATION THE ONLY EXPLANATION.

Origin of Species, page 400.

In works on natural history, rudimentary organs are generally said to have been created "for the sake of symmetry," or in order "to complete the scheme of Nature." But this is not an explanation, merely a restatement of the fact. Nor is it consistent with itself: thus the boa-constrictor has rudiments of hind-limbs and of a pelvis, and if it be said that these bones have been retained "to complete the scheme of Nature," why, as Professor Weismann asks, have they not been retained by other snakes, which do not possess even a vestige of these same bones? What would be thought of an astronomer who maintained that the satellites revolve in elliptic courses round their planets "for the sake of symmetry," because the planets thus revolve round the sun? An eminent physiologist accounts for the presence of rudimentary organs, by supposing that they serve to excrete matter in excess, or matter injurious to the system; but can we suppose that the minute papilla, which often represents the pistil in male flowers, and which is formed of mere cellular tissue, can thus act? Can we suppose that rudimentary teeth, which are subsequently absorbed, are beneficial to the rapidly growing embryonic calf by removing matter so precious as phosphate of lime? When a man's fingers have been amputated, imperfect nails have been known to appear on the stumps, and I could as soon believe that these vestiges of nails are developed in order to excrete horny matter, as that the rudimentary nails on the fin of the manatee have been developed for this same purpose.

On the view of descent with modification, the origin of rudimentary organs is comparatively simple; and we can understand to a large extent the laws governing their imperfect development.

THE HISTORY OF LIFE ON THE THEORY OF DESCENT WITH MODIFICATION.

Origin of Species, page 424.

Organs in a rudimentary condition plainly show that an early progenitor had the organ in a fully-developed condition; and this in some cases implies an enormous amount of modification in the descendants. Throughout whole classes various structures are formed on the same pattern, and at a very early age the embryos closely resemble each other. Therefore I can not doubt that the theory of descent with modification embraces all the members of the same great class or kingdom. I believe that animals are descended from at most only four or five progenitors, and plants from an equal or lesser number.

Analogy would lead me one step further, namely, to the belief that all animals and plants are descended from some one prototype. But analogy may be a deceitful guide. Nevertheless, all living things have much in common, in their chemical composition, their cellular structure, their laws of growth, and their liability to injurious influences. We see this even in so trifling a fact as that the same poison often similarly affects plants and animals; or that the poison secreted by the gall-fly produces monstrous growths on the wild-rose or oak-tree. With all organic beings, excepting, perhaps, some of the very lowest, sexual reproduction seems to be essentially similar. With all, as far as is at present known, the germinal vesicle is the same; so that all organisms start from a common origin. If we look even to the two main divisions—namely, to the animal and vegetable kingdoms—certain low forms are so far intermediate in character that naturalists have disputed to which kingdom they should be referred. As Professor Asa Gray has remarked, "the spores and other reproductive bodies of many of the lower algæ may claim to have first a characteristically animal, and then an unequivocally vegetable existence." Therefore, on the principle of natural selection with divergence of character, it does not seem incredible that, from some such low and intermediate form, both animals and plants may have been developed; and, if we admit this, we must likewise admit that all the organic beings which have ever lived on this earth may be descended from some one primordial form. But this inference is chiefly grounded on analogy, and it is immaterial whether or not it be accepted.

Page 420. On the view of each organism with all its separate parts having been specially created, how utterly inexplicable is it that organs bearing the plain stamp of inutility, such as the teeth in the embryonic calf, or the shriveled wings under the soldered wing-covers of many beetles, should so frequently occur! Nature may be said to have taken pains to reveal her scheme of modification, by means of rudimentary organs, of embryological and homologous structures, but we are too blind to understand her meaning.

LETTERS RETAINED IN THE SPELLING BUT USELESS IN PRONUNCIATION.

Origin of Species, page 401. There remains, however, this difficulty. After an organ has ceased being used, and has become in consequence much reduced, how can it be still further reduced in size until the merest vestige is left; and how can it be finally quite obliterated? It is scarcely possible that disuse can go on producing any further effect after the organ has once been rendered functionless. Some additional explanation is here requisite which I can not give. If, for instance, it could be proved that every part of the organization tends to vary in a greater degree toward diminution than toward augmentation of size, then we should be able to understand how an organ which has become useless would be rendered, independently of the effects of disuse, rudimentary, and would at last be wholly suppressed; for the variations toward diminished size would no longer be checked by natural selection. The principle of the economy of growth, explained in a former chapter, by which the materials forming any part, if not useful to the possessor, are saved as far as is possible, will perhaps come into play in rendering a useless part rudimentary. But this principle will almost necessarily be confined to the earlier stages of the process of reduction; for we can not suppose that a minute papilla, for instance, representing in a male flower the pistil of the female flower, and formed merely of cellular tissue, could be further reduced or absorbed for the sake of economizing nutriment.

Finally, as rudimentary organs, by whatever steps they may have been degraded into their present useless condition, are the record of a former state of things, and have been retained solely through the power of inheritance, we can understand, on the genealogical view of classification, how it is that systematists, in placing organisms in their proper places in the natural system, have often found rudimentary parts as useful as, or even sometimes more useful than, parts of high physiological importance. Rudimentary organs may be compared with the letters in a word, still retained in the spelling, but become useless in the pronunciation, but which serve as a clew for its derivation. On the view of descent with modification, we may conclude that the existence of organs in a rudimentary, imperfect, and useless condition, or quite aborted, far from presenting a strange difficulty, as they assuredly do on the old doctrine of creation, might even have been anticipated in accordance with the views here explained.

MAN'S DEFICIENCY IN TAIL.

Descent of Man, page 58.

According to a popular impression, the absence of a tail is eminently distinctive of man; but, as those apes which come nearest to him are destitute of this organ, its disappearance does not relate exclusively to man. The tail often differs remarkably in length within the same genus: thus in some species of *Macacus* it is longer than the whole body, and is formed of twenty-four vertebræ; in others it consists of a scarcely visible stump, containing only three or four vertebræ. In some kinds of baboons there are twenty-five, while in the mandrill there are ten very small stunted caudal vertebræ, or, according to Cuvier, sometimes only five. The tail, whether it be long or short, almost always tapers toward the end; and this, I presume, results from the atrophy of the terminal muscles, together with their arteries and nerves, through disuse, leading to the atrophy of the terminal bones. But no explanation can at present be given of the great diversity which often occurs in its length. Here, however, we are more specially concerned with the complete external disappearance of the tail. Professor Broca has recently shown that the tail in all quadrupeds consists of two portions, generally separated abruptly from each other; the basal portion consists of vertebræ, more or less perfectly channeled and furnished with apophyses like ordinary vertebræ; whereas those of the terminal portion are not channeled, are almost smooth, and scarcely resemble true vertebræ. A tail, though not externally visible, is really present in man and the anthropomorphous apes, and is constructed on exactly the same pattern in both. In the terminal portion the vertebræ, constituting the *os coccyx*, are quite rudimentary, being much reduced in size and number. In the basal portion, the vertebræ are likewise few, are united firmly together, and are arrested in development; but they have been rendered much broader and flatter than the corresponding vertebræ in the tails of other animals; they constitute what Broca calls the accessory sacral vertebræ. These are of functional importance by supporting certain internal parts and in other ways; and their modification is directly connected with the erect or semi-erect attitude of man and the anthropomorphous apes. This conclusion is the more trustworthy, as Broca formerly held a different view, which he has now abandoned. The modification, therefore, of the basal caudal vertebræ in man and the higher apes may have been effected, directly or indirectly, through natural selection.

But what are we to say about the rudimentary and variable vertebræ of the terminal portion of the tail, forming the *os coccyx?* A notion which has often been, and will no doubt again be ridiculed, namely, that friction has had something to do with the disappearance of the external portion of the tail, is not so ridiculous as it at first appears. Dr. Anderson states that the extremely short tail of *Macacus brunneus* is formed of eleven vertebræ, including the imbedded basal ones. The extremity is tendinous and contains no vertebræ; this is succeeded by five rudimentary ones, so minute that together they are only one line and a half in length, and these are permanently bent to one side in the shape of a hook. The free part of the tail, only a little above an inch in length, includes only four more small vertebræ. This short tail is carried erect; but about a quarter of its total length is doubled on to itself to the left; and this terminal part, which includes the hook-like portion, serves "to fill up the interspace between the upper divergent portion of the callosities"; so that the animal sits on it, and thus renders it rough and callous.

POINTS OF RESEMBLANCE BETWEEN MAN AND MONKEY.

Descent of Man, page 150.

As small unimportant points of resemblance between man and the *Quadrumana* are not commonly noticed in systematic works, and as, when numerous, they clearly reveal our relationship, I will specify a few such points. The relative position of our features is manifestly the same; and the various emotions are displayed by nearly similar movements of the muscles and skin, chiefly above the eyebrows and round the mouth. Some few expressions are, indeed, almost the same, as in the weeping of certain kinds of monkeys and in the laughing noise made by others, during which the corners of the mouth are drawn backward, and the lower eyelids wrinkled. The external ears are curiously alike. In man the nose is much more prominent than in most monkeys; but we may trace the commencement of an aquiline curvature in the nose of the Hoolock Gibbon; and this in the *Semnopithecus nasica* is carried to a ridiculous extreme.

The faces of many monkeys are ornamented with beards, whiskers, or mustaches. The hair on the head grows to a great length in some species of Semnopithecus; and in the Bonnet monkey (*Macacus radiatus*) it radiates from a point on the crown, with a parting down the middle. It is commonly said that the forehead gives to man his noble and intellectual appearance; but the thick hair on the head of the Bonnet monkey terminates downward abruptly, and is succeeded by hair so short and fine that at a little distance the forehead, with the exception of the eyebrows, appears quite naked. It has been erroneously asserted that eyebrows are not present in any monkey. In the species just named the degree of nakedness of the forehead differs in different individuals; and Eschricht states that in our children the limit between the hairy scalp and the naked forehead is sometimes not well defined; so that here we seem to have a trifling case of reversion to a progenitor, in whom the forehead had not as yet become quite naked.

It is well known that the hair on our arms tends to converge from above and below to a point at the elbow. This curious arrangement, so unlike that in most of the lower mammals, is common to the gorilla, chimpanzee, orang, some species of Hylobates, and even to some few American monkeys. But in *Hylobates agilis* the hair on the fore-arm is directed downward or toward the wrist in the ordinary manner; and in *H. lar* it is nearly erect, with only a very slight forward inclination; so that in this latter species it is in a transitional state. It can hardly be doubted that with most mammals the thickness of the hair on the back and its direction are adapted to throw off the rain; even the transverse hairs on the fore-legs of a dog may serve for this end when he is coiled up asleep. Mr. Wallace, who has carefully studied the habits of the orang, remarks that the convergence of the hair toward the elbow on the arms of the orang may be explained as serving to throw off the rain, for this animal during rainy weather sits with its arms bent, and with the hands clasped round a branch or over its head. According to Livingstone, the gorilla also "sits in pelting rain with his hands over his head." If the above explanation is correct, as seems probable, the direction of the hair on our own arms offers a curious record of our former state; for no one supposes that it is now of any use in throwing off the rain; nor, in our present erect condition, is it properly directed for this purpose.

Page 152. It must not be supposed that the resemblances between man and certain apes in the above and many other points—such as in having a naked forehead, long tresses on the head, etc.—are all necessarily the result of unbroken inheritance from a common progenitor, or of subsequent reversion. Many of these resemblances are more probably due to analogous variation, which follows, as I have elsewhere attempted to show, from co-descended organisms having a similar constitution, and having been acted on by like causes inducing similar modifications. With respect to the similar direction of the hair on the fore-arms of man and certain monkeys, as this character is common to almost all the anthropomorphous apes, it may probably be attributed to inheritance; but this is not certain, as some very distinct American monkeys are thus characterized.

VARIABILITY OF MAN.

Descent of Man, page 26.

It is manifest that man is now subject to much variability. No two individuals of the same race are quite alike. We may compare millions of faces, and each will be distinct. There is an equally great amount of diversity in the proportions and dimensions of the various parts of the body, the length of the legs being one of the most variable points. Although in some quarters of the world an elongated skull, and in other quarters a short skull prevails, yet there is great diversity of shape even within the limits of the same race, as with the aborigines of America and South Australia—the latter a race "probably as pure and homogeneous in blood, customs, and language as any in existence"—and even with the inhabitants of so confined an area as the Sandwich Islands. An eminent dentist assures me that there is nearly as much diversity in the teeth as in the features. The chief arteries so frequently run in abnormal courses, that it has been found useful for surgical purposes to calculate from 1,040 corpses how often each course prevails. The muscles are eminently variable: thus those of the foot were found by Professor Turner not to be strictly alike in any two out of fifty bodies; and in some the deviations were considerable. He adds that the power of performing the appropriate movements must have been modified in accordance with the several deviations. Mr. J. Wood has recorded the occurrence of 295 muscular variations in thirty-six subjects, and in another set of the same number no less than 558 variations, those occurring on both sides of the body being only reckoned as one. In the last set, not one body out of the thirty-six was "found totally wanting in departures from the standard descriptions of the muscular system given in anatomical text-books." A single body presented the extraordinary number of twenty-five distinct abnormalities. The same muscle sometimes varies in many ways: thus Professor Macalister describes no less than twenty distinct variations in the *palmaris accessorius.*

CAUSES OF VARIABILITY IN DOMESTICATED MAN.

Descent of Man, page 28.

With respect to the causes of variability, we are in all cases very ignorant; but we can see that in man, as in the lower animals, they stand in some relation to the conditions to which each species has been exposed during several generations. Domesticated animals vary more than those in a state of nature; and this is apparently due to the diversified and changing nature of the conditions to which they have been subjected. In this respect the different races of man resemble domesticated animals, and so do the individuals of the same race, when inhabiting a very wide area, like that of America. We see the influence of diversified conditions in the more civilized nations; for the members belonging to different grades of rank, and following different occupations, present a greater range of character than do the members of barbarous nations. But the uniformity of savages has often been exaggerated, and in some cases can hardly be said to exist. It is, nevertheless, an error to speak of man, even if we look only to the conditions to which he has been exposed, as "far more domesticated" than any other animal. Some savage races, such as the Australians, are not exposed to more diversified conditions than are many species which have a wide range. In another and much more important respect, man differs widely from any strictly domesticated animal; for his breeding has never long been controlled, either by methodical or unconscious selection. No race or body of men has been so completely subjugated by other men as that certain individuals should be preserved, and thus unconsciously selected, from somehow excelling in utility to their masters. Nor have certain male and female individuals been intentionally picked out and matched, except in the well-known case of the Prussian grenadiers; and in this case man obeyed, as might have been expected, the law of methodical selection; for it is asserted that many tall men were reared in the villages inhabited by the grenadiers and their tall wives. In Sparta, also, a form of selection was followed, for it was enacted that all children should be examined shortly after birth; the well-formed and vigorous being preserved, the others left to perish.

If we consider all the races of man as forming a single species, his range is enormous; but some separate races, as the Americans and Polynesians, have very wide ranges. It is a well-known law that widely-ranging species are much more variable than species with restricted ranges; and the variability of man may with more truth be compared with that of widely-ranging species than with that of domesticated animals.

Not only does variability appear to be induced in man and the lower animals by the same general causes, but in both the same parts of the body are affected in a closely analogous manner.

ACTION OF CHANGED CONDITIONS.

Page 30. This is a most perplexing subject. It can not be denied that changed conditions produce some, and occasionally a considerable, effect on organisms of all kinds; and it seems at first probable that if sufficient time were allowed this would be the invariable result. But I have failed to obtain clear evidence in favor of this conclusion; and valid reasons may be urged on the other side, at least as far as the innumerable structures are concerned, which are adapted for special ends. There can, however, ~~be no~~ doubt that changed conditions induce an almost indefinite amount of fluctuating variability, by which the whole organization is rendered in some degree plastic.

In the United States, above one million soldiers, who served in the late war, were measured, and the States in which they were born and reared were recorded. From this astonishing number of observations it is proved that local influences of some kind act directly on stature; and we further learn that "the State where the physical growth has in great measure taken place, and the State of birth, which indicates the ancestry, seem to exert a marked influence on the stature." For instance, it is established that "residence in the Western States, during the years of growth, tends to produce increase of stature." On the other hand, it is certain that, with sailors, their life delays growth, as shown "by the great difference between the statures of soldiers and sailors at the ages of seventeen and eighteen years." Mr. B. A. Gould endeavored to ascertain the nature of the influences which thus act on stature; but he arrived only at negative results, namely, that they did not relate to climate, the elevation of the land, soil, nor even "in any controlling degree" to the abundance or the need of the comforts of life. This latter conclusion is directly opposed to that arrived at by Villermé, from the statistics of the height of the conscripts in different parts of France. When we compare the differences in stature between the Polynesian chiefs and the lower orders within the same islands, or between the inhabitants of the fertile volcanic and low barren coral islands of the same ocean, or, again, between the Fuegians on the eastern and western shores of their country, where the means of subsistence are very different, it is scarcely possible to avoid the conclusion that better food and greater comfort do influence stature. But the preceding statements show how difficult it is to arrive at any precise result. Dr. Beddoe has lately proved that, with the inhabitants of Britain, residence in towns and certain occupations have a deteriorating influence on height; and he infers that the result is to a certain extent inherited, as is likewise the case in the United States. Dr. Beddoe further believes that, wherever a "race attains its maximum of physical development, it rises highest in energy and moral vigor."

THE INHERITED EFFECTS OF THE INCREASED AND DIMINISHED USE OF PARTS.

Descent of Man, page 32.

It is well known that use strengthens the muscles in the individual, and complete disuse, or the destruction of the proper nerve, weakens them. When the eye is destroyed, the optic nerve often becomes atrophied. When an artery is tied, the lateral channels increase not only in diameter, but in the thickness and strength of their coats. When one kidney ceases to act from disease, the other increases in size, and does double work. Bones increase not only in thickness, but in length, from carrying a greater weight. Different occupations, habitually followed, lead to changed proportions in various parts of the body. Thus it was ascertained by the United States commission that the legs of the sailors employed in the late war were longer by 0·217 of an inch than those of the soldiers, though the sailors were on an average shorter men; while their arms were shorter by 1·09 of an inch, and therefore, out of proportion, shorter in relation to their lesser height. This shortness of the arms is apparently due to their greater use, and is an unexpected result; but sailors chiefly use their arms in pulling, and not in supporting weights. With sailors, the girth of the neck and the depth of the instep are greater, while the circumference of the chest, waist, and hips is less, than in soldiers.

Whether the several foregoing modifications would become hereditary, if the same habits of life were followed during many generations, is not known, but it is probable.

Page 33. In infants, long before birth, the skin on the soles of the feet is thicker than on any other part of the body; and it can hardly be doubted that this is due to the inherited effects of pressure during a a long series of generations.

It is familiar to every one that watchmakers and engravers are liable to be short-sighted, while men living much out-of-doors, and especially savages, are generally long-sighted. Short-sight and long-sight certainly tend to be inherited. The inferiority of Europeans, in comparison with savages, in eye-sight and in the other senses, is no doubt the accumulated and transmitted effect of lessened use during many generations.

Page 35. Although man may not have been much modified during the latter stages of his existence through the increased or decreased use of parts, the facts now given show that his liability in this respect has not been lost; and we positively know that the same law holds good with the lower animals. Consequently we may infer that when at a remote epoch the progenitors of man were in a transitional state, and were changing from quadrupeds into bipeds, natural selection would probably have been greatly aided by the inherited effects of the increased or diminished use of the different parts of the body.

REVERSION AS A FACTOR IN THE DEVELOPMENT OF MAN.

Descent of Man, page 40. In man, the canine teeth are perfectly efficient instruments for mastication. But their true canine character, as Owen remarks, "is indicated by the conical form of the crown, which terminates in an obtuse point, is convex outward and flat or sub-concave within, at the base of which surface there is a feeble prominence. The conical form is best expressed in the Melanian races, especially the Australian. The canine is more deeply implanted, and by a stronger fang than the incisors." Nevertheless, this tooth no longer serves man as a special weapon for tearing his enemies or prey; it may, therefore, as far as its proper function is concerned, be considered as rudimentary. In every large collection of human skulls some may be found, as

Häckel observes, with the canine teeth projecting considerably beyond the others in the same manner as in the anthropomorphous apes, but in a less degree. In these cases, open spaces between the teeth in the one jaw are left for the reception of the canines of the opposite jaw. An interspace of this kind in a Caffre skull, figured by Wagner, is surprisingly wide. Considering how few are the ancient skulls which have been examined, compared to recent skulls, it is an interesting fact that in at least three cases the canines project largely; and in the Naulette jaw they are spoken of as enormous.

Of the anthropomorphous apes the males alone have their canines fully developed; but in the female gorilla, and in a less degree in the female orang, these teeth project considerably beyond the others: therefore the fact, of which I have been assured, that women sometimes have considerably projecting canines, is no serious objection to the belief that their occasional great development in man is a case of reversion to an ape-like progenitor. He who rejects with scorn the belief that the shape of his own canines and their occasional great development in other men are due to our early forefathers having been provided with these formidable weapons, will probably reveal, by sneering, the line of his descent. For, though he no longer intends, nor has the power, to use these teeth as weapons, he will unconsciously retract his "snarling muscles" (thus named by Sir C. Bell), so as to expose them ready for action, like a dog prepared to fight."

Many muscles are occasionally developed in man, which are proper to the *Quadrumana* or other mammals. Professor Vlacovich examined forty male subjects, and found a muscle, called by him the ischio-pubic, in nineteen of them; in three others there was a ligament which represented this muscle; and in the remaining eighteen no trace of it. In only two out of thirty female subjects was this muscle developed on both sides, but in three others the rudimentary ligament was present. This muscle, therefore, appears to be much more common in the male than in the female sex; and on the belief in the descent of man from some lower form the fact is intelligible; for it has been detected in several of the lower animals, and in all of these it serves exclusively to aid the male in the act of reproduction.

Page 43.

That this unknown factor is reversion to a former state of existence may be admitted as in the highest degree probable. It is quite incredible that a man should through mere accident abnormally resemble certain apes in no less than seven of his muscles, if there had been no genetic connection between them. On the other hand, if man is descended from some ape-like creature, no valid reason can be assigned why certain muscles should not suddenly reappear after an interval of many thousand generations, in the same manner as with horses, asses, and mules, dark-colored stripes suddenly reappear on the legs and shoulders, after an interval of hundreds, or more probably of thousands, of generations.

REVERSION IN THE HUMAN FAMILY.

Animals and Plants, Vol. II, page 1.

When the child resembles either grandparent more closely than its immediate parents, our attention is not much arrested, though in truth the fact is highly remarkable; but when the child resembles some remote ancestor or some distant member in a collateral line—and in the last case we must attribute this to the descent of all the members from a common progenitor—we feel a just degree of astonishment. When one parent alone displays some newly-acquired and generally inheritable character, and the offspring do not inherit it, the cause may lie in the other parent having the power of prepotent transmission. But when both parents are similarly characterized, and the child does not, whatever the cause may be, inherit the character in question, but resembles its grandparents, we have one of the simplest cases of reversion. We continually see another and even more simple case of atavism, though not generally included under this head, namely, when the son more closely resembles his maternal than his paternal grandsire in some male attribute, as in any peculiarity in the beard of man, the horns of the bull, the hackles or comb of the cock, or, as in certain diseases necessarily confined to the male sex; for, as the mother can not possess or exhibit such male attributes, the child must inherit them, through her blood, from his maternal grandsire.

The cases of reversion may be divided into two main classes, which, however, in some instances, blend into one another; namely, first, those occurring in a variety or race which has not been crossed, but has lost by variation some character that it formerly possessed, and which afterward reappears. The second class includes all cases in which an individual with some distinguishable character, a race, or species, has at some former period been crossed, and a character derived from this cross, after having disappeared during one or several generations, suddenly reappears.

Page 21. From these facts we may perhaps infer that the degraded state of so many half-castes is in part due to reversion to a primitive and savage condition, induced by the act of crossing, even if mainly due to the unfavorable moral conditions under which they are generally reared.

PREPOTENCE IN THE TRANSMISSION OF CHARACTER.

Animals and Plants, Vol. II, page 40.

When individuals, belonging to the same family, but distinct enough to be recognized, or when two well-marked races, or two species, are crossed, the usual result, as stated in the previous chapter, is, that the offspring in the first generation are intermediate between their parents, or resemble one parent in one part and the other parent in another part. But this is by no means the invariable rule, for in many cases it is found that certain individuals, races, and species, are prepotent in transmitting their likeness. This subject has been ably discussed by Prosper Lucas, but is rendered extremely complex by the prepotency sometimes running equally in both sexes, and sometimes more strongly in one sex than in the other; it is likewise complicated by the presence of secondary sexual characters, which render the comparison of crossed breeds with their parents difficult.

It would appear that in certain families some one ancestor, and after him others in the same family, have had great power in transmitting their likeness through the male line; for we can not otherwise understand how the same features should so often be transmitted after marriages with many females, as in the case of the Austrian emperors; and so it was, according to Niebuhr, with the mental qualities of certain Roman families. The famous bull Favorite is believed to have had a prepotent influence on the short-horn race. It has also been observed with English race-horses that certain mares have generally transmitted their own character, while other mares of equally pure blood have allowed the character of the sire to prevail. A famous black greyhound, Bedlamite, as I hear from Mr. C. M. Brown, "invariably got all his puppies black, no matter what was the color of the bitch"; but then Bedlamite "had a preponderance of black in his blood, both on the sire and dam side."

NATURAL SELECTION IN THE DEVELOPMENT OF MAN.

Descent of Man, page 48.

Man in the rudest state in which he now exists is the most dominant animal that has ever appeared on this earth. He has spread more widely than any other highly organized form; and all others have yielded before him. He manifestly owes this immense superiority to his intellectual faculties, to his social habits, which lead him to aid and defend his fellows, and to his corporeal structure. The supreme importance of these characters has been proved by the final arbitrament of the battle for life. Through his powers of intellect, articulate language has been evolved; and on this his wonderful advancement has mainly depended. As Mr. Chauncey Wright remarks: "A psychological analysis of the faculty of language shows that even the smallest proficiency in it might require more brain-power than the greatest proficiency in any other direction." He has invented and is able to use various weapons, tools, traps, etc., with which he defends himself, kills or catches prey, and otherwise obtains food. He has made rafts or canoes for fishing or crossing over to neighboring fertile islands. He has discovered the art of making fire, by which hard and stringy roots can be rendered digestible, and poisonous roots or herbs innocuous. This discovery of fire, probably the greatest ever made by man, excepting language, dates from before the dawn of history. These several inventions, by which man in the rudest state has become so pre-eminent, are the direct results of the development of his powers of observation, memory, curosity, imagination, and reason.

Page 50. Archæologists are convinced that an enormous interval of time elapsed before our ancestors thought of grinding chipped flints into smooth tools. One can hardly doubt that a man-like animal who possessed a hand and arm sufficiently perfect to throw a stone with precision, or to form a flint into a rude tool, could, with sufficient practice, as far as mechanical skill alone is concerned, make almost anything which a civilized man can make. The structure of the hand in this respect may be compared with that of the vocal organs, which in the apes are used for uttering various signal-cries, or, as in one genus, musical cadences; but in man the closely similar vocal organs have become adapted through the inherited effects of use for the utterance of articulate language.

Turning now to the nearest allies of men, and therefore to the best representatives of our early progenitors, we find that the hands of the *Quadrumana* are constructed on the same general pattern as our own, but are far less perfectly adapted for diversified uses. Their hands do not serve for locomotion so well as the feet of a dog; as may be seen in such monkeys as the chimpanzee and orang, which walk on the outer margins of the palms, or on the knuckles. Their hands, however, are admirably adapted for climbing trees. Monkeys seize thin branches or ropes, with the thumb on one side and the fingers and palm on the other, in the same manner as we do. They can thus also lift rather large objects, such as the neck of a bottle, to their mouths. Baboons turn over stones and scratch up roots with their hands. They seize nuts, insects, or other small objects with the thumb in opposition to the fingers, and no doubt they thus extract eggs and the young from the nests of birds. American monkeys beat the wild oranges on the branches until the rind is cracked, and then tear it off with the fingers of the two hands. In a wild state they break open hard fruits with stones. Other monkeys open mussel-shells with the two thumbs. With their fingers they pull out thorns and burs, and hunt for each other's parasites. They roll down stones, or throw them at their enemies; nevertheless, they are clumsy in these various actions, and, as I have myself seen, are quite unable to throw a stone with precision.

HOW MAN BECAME UPRIGHT.

Descent of Man, page 52.

If it be an advantage to man to stand firmly on his feet and to have his hands and arms free, of which, from his pre-eminent success in the battle of life, there can be no doubt, then I can see no reason why it should not have been advantageous to the progenitors of man to have become more and more erect or bipedal. They would thus have been better able to defend themselves with stones or clubs, to attack their prey, or otherwise to obtain food. The best built individuals would in the long run have succeeded best, and have survived in larger numbers. If the gorilla and a few allied forms had become extinct, it might have been argued, with great force and apparent truth, that an animal could not have been gradually converted from a quadruped into a biped, as all the individuals in an intermediate condition would have been miserably ill-fitted for progression. But we know (and this is well worthy of reflection) that the anthropomorphous apes are now actually in an intermediate condition; and no one doubts that they are on the whole well adapted for their conditions of life. Thus the gorilla runs with a sidelong, shambling gait, but more commonly progresses by resting on its bent hands. The long-armed apes occasionally use their arms like crutches, swinging their bodies forward between them, and some kinds of Hylobates, without having been taught, can walk or run upright with tolerable quickness; yet they move awkwardly, and much less securely than man. We see, in short, in existing monkeys a manner of progression intermediate between that of a quadruped and a biped; but, as an unprejudiced judge insists, the anthropomorphous apes approach in structure more nearly to the bipedal than to the quadrupedal type.

As the progenitors of man became more and more erect, with their hands and arms more and more modified for prehension and other purposes, with their feet and legs at the same time transformed for firm support and progression, endless other changes of structure would have become necessary. The pelvis would have to be broadened, the spine peculiarly curved, and the head fixed in an altered position, all which changes have been attained by man.

Page 53. The free use of the arms and hands, partly the cause and partly the result of man's erect position, appears to have led in an indirect manner to other modifications of structure. The early male forefathers of man were, as previously stated, probably furnished with great canine teeth; but, as they gradually acquired the habit of using stones, clubs, or other weapons, for fighting with their enemies or rivals, they would use their jaws and teeth less and less. In this case, the jaws, together with the teeth, would become reduced in size, as we may feel almost sure from innumerable analogous cases.

THE BRAIN ENLARGES AS THE MENTAL FACULTIES DEVELOP.

Descent of Man, page 54.

As the various mental faculties gradually developed themselves the brain would almost certainly become larger. No one, I presume, doubts that the large proportion which the size of man's brain bears to his body, compared to the same proportion in the gorilla or orang, is closely connected with his higher mental powers. We meet with closely analogous facts with insects, for in ants the cerebral ganglia are of extraordinary dimensions, and in all the *Hymenoptera* these ganglia are many times larger than in the less intelligent orders, such as beetles. On the other hand, no one supposes that the intellect of any two animals or of any two men can be accurately gauged by the cubic contents of their skulls. It is certain that there may be extraordinary mental activity with an extremely small absolute mass of nervous matter: thus the wonderfully diversified instincts, mental powers, and affections of ants are notorious, yet their cerebral ganglia are not so large as the quarter of a small pin's head. Under this point of view, the brain of an ant is one of the most marvelous atoms of matter in the world, perhaps more so than the brain of a man.

Page 55.

The gradually increasing weight of the brain and skull in man must have influenced the development of the supporting spinal column, more especially while he was becoming erect. As this change of position was being brought about, the internal pressure of the brain will also have influenced the form of the skull; for many facts show how easily the skull is thus affected. Ethnologists believe that it is modified by the kind of cradle in which infants sleep. Habitual spasms of the muscles and a cicatrix from a severe burn have permanently modified the facial bones. In young persons whose heads have become fixed either sideways or backward, owing to disease, one of the two eyes has changed its position, and the shape of the skull has been altered apparently by the pressure of the brain in a new direction. I have shown that with long-eared rabbits even so trifling a cause as the lopping forward of one ear drags forward almost every bone of the skull on that side; so that the bones on the opposite side no longer strictly correspond. Lastly, if any animal were to increase or diminish much in general size, without any change in its mental powers, or if the mental powers were to be much increased or diminished, without any great change in the size of the body, the shape of the skull would almost certainly be altered. I infer this from my observations on domestic rabbits, some kinds of which have become very much larger than the wild animal, while others have retained nearly the same size, but in both cases the brain has been much reduced relatively to the size of the body. Now, I was at first much surprised on finding that in all these rabbits the skull had become elongated or dolichocephalic; for instance, of two skulls of nearly equal breadth, the one from a wild rabbit and the other from a large domestic kind, the former was 3·15 and the latter 4·3 inches in length. One of the most marked distinctions in different races of men is that the skull in some is elongated, and in others rounded; and here the explanation suggested by the case of the rabbits may hold good; for Welcker finds that short "men incline more to brachycephaly, and tall men to dolichocephaly"; and tall men may be compared with the larger and longer-bodied rabbits, all of which have elongated skulls, or are dolichocephalic.

From these several facts we can understand, to a certain extent, the means by which the great size and more or less rounded form of the skull have been acquired by man; and these are characters eminently distinctive of him in comparison with the lower animals.

NAKEDNESS OF THE SKIN.

Descent of Man, page 56.

Another most conspicuous difference between man and the lower animals is the nakedness of the skin. Whales and porpoises (*Cetacea*), dugongs (*Sirenia*), and the hippopotamus are naked; and this may be advantageous to them for gliding through the water; nor would it be injurious to them from the loss of warmth, as the species, which inhabit the colder regions, are protected by a thick layer of blubber, serving the same purpose as the fur of seals and otters. Elephants and rhinoceroses are almost hairless; and, as certain extinct species, which formerly lived under an Arctic climate, were covered with long wool or hair, it would almost appear as if the existing species of both genera had lost their hairy covering from exposure to heat. This appears the more probable, as the elephants in India, which live on elevated and cool districts, are more hairy than those on the lowlands. May we then infer that man became divested of hair from having aboriginally inhabited some tropical land? That the hair is chiefly retained in the male sex on the chest and face, and in both sexes at the junction of all four limbs with the trunk, favors this inference—on the assumption that the hair was lost before man became erect; for the parts which now retain most hair would then have been most protected from the heat of the sun. The crown of the head, however, offers a curious exception, for at all times it must have been one of the most exposed parts, yet it is thickly clothed with hair. The fact, however, that the other members of the order of *Primates*, to which man belongs, although inhabiting various hot regions, are well clothed with hair, generally thickest on the upper surface, is opposed to the supposition that man became naked through the action of the sun.

Descent of Man, page 18.

The different races differ much in hairiness; and in the individuals of the same race the hairs are highly variable, not only in abundance, but likewise in position: thus in some Europeans the shoulders are quite naked, while in others they bear thick tufts of hair. There can be little doubt that the hairs thus scattered over the body are the rudiments of the uniform hairy coat of the lower animals. This view is rendered all the more probable, as it is known that the fine, short, and pale-colored hairs on the limbs and other parts of the body occasionally become developed into "thick-set, long, and rather coarse dark hairs," when abnormally nourished near old-standing inflamed surfaces.

I am informed by Sir James Paget that often several members of a family have a few hairs in their eyebrows much longer than the others; so that even this slight peculiarity seems to be inherited. These hairs, too, seem to have their representatives; for in the chimpanzee, and in certain species of Macacus, there are scattered hairs of considerable length rising from the naked skin above the eyes, and corresponding to our eyebrows; similar long hairs project from the hairy covering of the superciliary ridges in some baboons.

IS MAN THE MOST HELPLESS OF THE ANIMALS?

Descent of Man, page 63.

It has often been objected to such views as the foregoing, that man is one of the most helpless and defenseless creatures in the world; and that during his early and less well-developed condition he would have been still more helpless. The Duke of Argyll, for instance, insists that "the human frame has diverged from the structure of brutes, in the direction of greater physical helplessness and weakness. That is to say, it is a divergence which of all others it is most impossible to ascribe to mere natural selection." He adduces the naked and unprotected state of the body, the absence of great teeth or claws for defense, the small strength and speed of man, and his slight power of discovering food or of avoiding danger by smell. To these deficiencies there might be added one still more serious, namely, that he can not climb quickly, and so escape from enemies. The loss of hair would not have been a great injury to the inhabitants of a warm country. For we know that the unclothed Fuegians can exist under a wretched climate. When we compare the defenseless state of man with that of apes, we must remember that the great canine teeth with which the latter are provided are possessed in their full development by the males alone, and are chiefly used by them for fighting with their rivals; yet the females, which are not thus provided, manage to survive.

In regard to bodily size or strength, we do not know whether man is descended from some small species, like the chimpanzee, or from one as powerful as the gorilla; and, therefore, we can not say whether man has become larger and stronger, or smaller and weaker, than his ancestors. We should, however, bear in mind that an animal possessing great size, strength, and ferocity, and which, like the gorilla, could defend itself from all enemies, would not perhaps have become social; and this would most effectually have checked the acquirement of the higher mental qualities—such as sympathy and the love of his fellows. Hence it might have been an immense advantage to man to have sprung from some comparatively weak creature.

The small strength and speed of man, his want of natural weapons, etc., are more than counterbalanced, firstly, by his intellectual powers, through which he has formed for himself weapons, tools, etc., though still remaining in a barbarous state, and, secondly, by his social qualities, which lead him to give and receive aid from his fellow-men. No country in the world abounds in a greater degree with dangerous beasts than Southern Africa; no country presents more fearful physical hardships than the Arctic regions; yet one of the puniest of races, that of the Bushmen, maintains itself in Southern Africa, as do the dwarfed Esquimaux in the Arctic regions. The ancestors of man were, no doubt, inferior in intellect, and probably in social disposition, to the lowest existing savages; but it is quite conceivable that they might have existed, or even flourished, if they had advanced in intellect, while gradually losing their brute-like powers, such as that of climbing trees, etc. But these ancestors would not have been exposed to any special danger, even if far more helpless and defenseless than any existing savages, had they inhabited some warm continent or large island, such as Australia, New Guinea, or Borneo, which is now the home of the orang. And natural selection arising from the competition of tribe with tribe, in some such large area as one of these, together with the inherited effects of habit, would, under favorable conditions, have sufficed to raise man to his present high position in the organic scale.

VIII.

MENTAL POWERS OF MAN AND THE LOWER ANIMALS COMPARED.

Descent of Man, page 65.

No doubt the difference in this respect is enormous, even if we compare the mind of one of the lowest savages, who has no words to express any number higher than four, and who uses hardly any abstract terms for common objects or for the affections, with that of the most highly organized ape. The difference would, no doubt, still remain immense, even if one of the higher apes had been improved or civilized as much as a dog has been in comparison with its parent-form, the wolf or jackal. The Fuegians rank among the lowest barbarians; but I was continually struck with surprise how closely the three natives on board H. M. S. Beagle, who had lived some years in England, and could talk a little English, resembled us in disposition and in most of our mental faculties. If no organic being excepting man had possessed any mental power, or if his powers had been of a wholly different nature from those of the lower animals, then we should never have been able to convince ourselves that our high faculties had been gradually developed. But it can be shown that there is no fundamental difference of this kind. We must also admit that there is a much wider interval in mental power between one of the lowest fishes, as a lamprey or lancelet, and one of the higher apes than between an ape and man; yet this interval is filled up by numberless gradations.

Nor is the difference slight in moral disposition between a barbarian, such as the man described by the old navigator Byron, who dashed his child on the rocks for dropping a basket of sea-urchins, and a Howard or Clarkson; and in intellect between a savage, who uses hardly any abstract terms, and a Newton or Shakespeare. Differences of this kind between the highest men of the highest races and the lowest savages, are connected by the finest gradations. Therefore it is possible that they might pass and be developed into each other.

Page 66. In what manner the mental powers were first developed in the lowest organisms is as hopeless an inquiry as how life itself first originated. These are problems for the distant future, if they are ever to be solved by man.

FUNDAMENTAL INTUITIONS THE SAME IN MAN AND THE OTHER ANIMALS.

Page 66. As man possesses the same senses as the lower animals, his fundamental intuitions must be the same. Man has also some few instincts in common, as that of self-preservation, sexual love, the love of the mother for her new-born offspring, the desire possessed by the latter to suck, and so forth. But man, perhaps, has somewhat fewer instincts than those possessed by the animals which come next to him in the series. The orang in the Eastern islands and the chimpanzee in

Africa build platforms on which they sleep; and, as both species follow the same habit, it might be argued that this was due to instinct, but we can not feel sure that it is not the result of both animals having similar wants, and possessing similar powers of reasoning. These apes, as we may assume, avoid the many poisonous fruits of the tropics, and man has no such knowledge: but, as our domestic animals, when taken to foreign lands, and when first turned out in the spring, often eat poisonous herbs, which they afterward avoid, we can not feel sure that the apes do not learn from their own experience or from that of their parents what fruits to select. It is, however, certain, as we shall presently see, that apes have an instinctive dread of serpents, and probably of other dangerous animals.

The fewness and the comparative simplicity of the instincts in the higher animals are remarkable in contrast with those of the lower animals. Cuvier maintained that instinct and intelligence stand in an adverse ratio to each other; and some have thought that the intellectual faculties of the higher animals have been gradually developed from their instincts. But Pouchet, in an interesting essay, has shown that no such inverse ratio really exists. Those insects which possess the most wonderful instincts are certainly the most intelligent. In the vertebrate series, the least intelligent members, namely, fishes and amphibians, do not possess complex instincts; and among mammals the animal most remarkable for its instincts, namely, the beaver, is highly intelligent, as will be admitted by every one who has read Mr. Morgan's excellent work.

MAN AND THE LOWER ANIMALS EXCITED BY THE SAME EMOTIONS.

Page 69.

The fact that the lower animals are excited by the same emotions as ourselves is so well established that it will not be necessary to weary the reader by many details. Terror acts in the same manner on them as on us, causing the muscles to tremble, the heart to palpitate, the sphincters to be relaxed, and the hair to stand on end. Suspicion, the offspring of fear, is eminently characteristic of most wild animals. It is, I think, impossible to read the account given by Sir E. Tennent, of the behavior of the female elephants, used as decoys, without admitting that they intentionally practice deceit, and well know what they are about. Courage and timidity are extremely variable qualities in the individuals of the same species, as is plainly seen in our dogs. Some dogs and horses are ill-tempered, and easily turn sulky; others are good-tempered; and these qualities are certainly inherited. Every one knows how liable animals are to furious rage, and how plainly they show it. Many, and probably true, anecdotes have been published on the long-delayed and artful revenge of various animals. The accurate Rengger and Brehm state that the American and African monkeys which they kept tame certainly revenged themselves. Sir Andrew Smith, a zoölogist whose scrupulous accuracy was known to many persons, told me the following story of which he was himself an eye-witness: At the Cape of Good Hope an officer had often plagued a certain baboon, and the animal, seeing him approaching one Sunday for parade, poured water into a hole and hastily made some thick mud, which he skillfully dashed over the officer as he passed by, to the amusement of many by-standers. For long afterward the baboon rejoiced and triumphed whenever he saw his victim.

Page 70.

The love of a dog for his master is notorious; as an old writer quaintly says, "A dog is the only thing on this earth that luvs you more than he luvs himself."

In the agony of death a dog has been known to caress his master, and every one has heard of the dog suffering under vivisection, who licked the hand of the operator; this man, unless the operation was fully justified by an increase of our knowledge, or unless he had a heart of stone, must have felt remorse to the last hour of his life.

Page 71.

Most of the more complex emotions are common to the higher animals and ourselves. Every one has seen how jealous a dog is of his master's affection, if lavished on any other creature; and I have observed the same fact with monkeys. This shows that animals not only love, but have desire to be loved. Animals manifestly feel emulation. They love approbation or praise; and a dog carrying a basket for his master exhibits in a high degree self-complacency or pride. There can, I think, be no doubt that a dog feels shame, as distinct from fear, and something very like modesty when begging too often for food. A great dog scorns the snarling of a little dog, and this may be called magnanimity. Several observers have stated that monkeys certainly dislike being laughed at; and they sometimes invent imaginary offenses. In the Zoölogical Gardens I saw a baboon who always got into a furious rage when his keeper took out a letter or book and read it aloud to him; and his rage was so violent that, as I witnessed on one occasion, he bit his own leg till the blood flowed.

All animals feel *wonder*, and many exhibit *curiosity*. They sometimes suffer from this latter quality, as when the hunter plays antics and thus attracts them; I have witnessed this with deer, and so it is with the wary chamois, and with some kinds of wild-ducks. Brehm gives a curious account of the instinctive dread which his monkeys exhibited for snakes; but their curiosity was so great that they could not desist from occasionally satiating their horror in a most human fashion, by lifting up the lid of the box in which the snakes were kept. I was so much surprised at his account, that I took a stuffed and coiled-up snake into the monkey-house at the Zoölogical Gardens, and the excitement thus caused was one of the most curious spectacles which I ever beheld.

ALL ANIMALS POSSESS SOME POWER OF REASONING.

Page 75. Of all the faculties of the human mind, it will, I presume, be admitted that *reason* stands at the summit. Only a few persons now dispute that animals possess some power of reasoning. Animals may constantly be seen to pause, deliberate, and resolve. It is a significant fact that the more the habits of any particular animal are studied by a naturalist, the more he attributes to reason and the less to unlearned instincts. In future chapters we shall see that some animals extremely low in the scale apparently display a certain amount of reason. No doubt it is often difficult to distinguish between the power of reason and that of instinct. For instance, Dr. Hayes, in his work on "The Open Polar Sea," repeatedly remarks that his dogs, instead of continuing to draw the sledges in a compact body, diverged and separated when they came to thin ice, so that their weight might be more evenly distributed. This was often the first warning which the travelers received that the ice was becoming thin and dangerous. Now, did the dogs act thus from the experience of each individual, or from the example of the older and wiser dogs, or from an inherited habit, that is, from instinct? This instinct may possibly have arisen since the time, long ago, when dogs were first employed by the natives in drawing their sledges; or the Arctic wolves, the parent-stock of the Esquimau dog, may have acquired an instinct, impelling them not to attack their prey in a close pack, when on thin ice.

Page 79 Archbishop Sumner formerly maintained that man alone is capable of progressive improvement. That he is capable of incomparably greater and more rapid improvement than is any other animal, admits of no dispute; and this is mainly due to his power of speaking and handing down his acquired knowledge. With animals, looking first to the individual, every one who has had any experience in setting traps knows that young animals can be caught much more easily than old ones; and they can be much more easily approached by an enemy. Even with respect to old animals, it is impossible to catch many in the same place and in the same kind of trap, or to destroy them by the same kind of poison; yet it is improbable that all should have partaken of the poison, and impossible that all should have been caught in a trap. They must learn caution by seeing their brethren caught or poisoned.

Page 80. Our domestic dogs are descended from wolves and jackals, and though they may not have gained in cunning, and may have lost in wariness and suspicion, yet they have progressed in certain moral qualities, such as in affection, trustworthiness, temper, and probably in general intelligence.

THE POWER OF ASSOCIATION IN DOG AND SAVAGE.

Descent of Man, page 77.

The savage and the dog have often found water at a low level, and the coincidence under such circumstances has become associated in their minds. A cultivated man would perhaps make some general proposition on the subject; but from all that we know of savages it is extremely doubtful whether they would do so, and a dog certainly would not. But a savage, as well as a dog, would search in the same way, though frequently disappointed; and in both it seems to be equally an act of reason, whether or not any general proposition on the subject is consciously placed before the mind. The same would apply to the elephant and the bear making currents in the air or water. The savage would certainly neither know nor care by what law the desired movements were effected; yet his act would be guided by a rude process of reasoning, as surely as would a philosopher in his longest chain of deductions. There would no doubt be this difference between him and one of the higher animals, that he would take notice of much slighter circumstances and conditions, and would observe any connection between them after much less experience, and this would be of paramount importance. I kept a daily record of the actions of one of my infants, and when he was about eleven months old, and before he could speak a single word, I was continually struck with the greater quickness with which all sorts of objects and sounds were associated together in his mind, compared with that of the most intelligent dogs I ever knew. But the higher animals differ in exactly the same way in this power of association from those low in the scale, such as the pike, as well as in that of drawing inferences and of observation.

THE LOWER ANIMALS PROGRESS IN INTELLIGENCE.

Page 81. To maintain, independently of any direct evidence, that no animal during the course of ages has progressed in intellect or other mental faculties, is to beg the question of the evolution of species. We have seen that, according to Lartet, existing mammals belonging to several orders have larger brains than their ancient tertiary prototypes.

It has often been said that no animal uses any tool; but the chimpanzee, in a state of nature, cracks a native fruit, somewhat like a walnut, with a stone. Rengger easily taught an American monkey thus to break open hard palm-nuts; and afterward, of its own accord, it used stones to open other kinds of nuts, as well as boxes. It thus also removed the soft rind of fruit that had a disagreeable flavor. Another monkey was taught to open the lid of a large box with a stick, and afterward it used the stick as a lever to move heavy bodies; and I have myself seen a young orang put a stick into a crevice, slip his hand to the other end, and use it in the proper manner as a lever. The tamed elephants in India are well known to break off branches of trees and use them to drive away the flies; and this same act has been observed in an elephant in a state of nature.

Page 82. The Duke of Argyll remarks that the fashioning of an implement for a special purpose is absolutely peculiar to man; and he considers that this forms an immeasurable gulf between him and the brutes.

This is no doubt a very important distinction; but there appears to me much truth in Sir J. Lubbock's suggestion that, when primeval man first used flint-stones for any purpose, he would have accidentally splintered them, and would then have used the sharp fragments. From this step it would be a small one to break the flints on purpose, and not a very wide step to fashion them rudely. This latter advance, however, may have taken long ages, if we may judge by the immense interval of time which elapsed before the men of the neolithic period took to grinding and polishing their stone tools. In breaking the flints, as Sir J. Lubbock likewise remarks, sparks would have been emitted, and in grinding them heat would have been evolved; thus the two usual methods of "obtaining fire may have originated." The nature of fire would have been known in the many volcanic regions where lava occasionally flows through forests.

THE POWER OF ABSTRACTION.

Page 83. If one may judge from various articles which have been published lately, the greatest stress seems to be laid on the supposed entire absence in animals of the power of abstraction, or of forming general concepts. But when a dog sees another dog at a distance, it is often clear that he perceives that it is a dog in the abstract; for when he gets nearer his whole manner suddenly changes, if the other dog be a friend. A recent writer remarks that in all such cases it is a pure assumption to assert that the mental act is not essentially of the same nature in the animal as in man. If either refers what he perceives with his senses to a mental concept, then so do both. When I say to my terrier, in an eager voice (and I have made the trial many times), "Hi, hi, where is it?" she at once takes it as a sign that something is to be hunted, and generally first looks quickly all around, and then rushes into the nearest thicket, to scent for any game, but, finding nothing, she looks up into any neighboring tree for a squirrel. Now, do not these actions clearly show that she had in her mind a general idea or concept that some animal is to be discovered and hunted?

It may be freely admitted that no animal is self-conscious, if by this term it is implied that he reflects on such points as whence he comes or whither he will go, or what is life and death, and so forth. But how can we feel sure that an old dog with an excellent memory and some power of imagination, as shown by his dreams, never reflects on his past pleasures or pains in the chase? And this would be a form of self-consciousness. On the other hand, as Büchner has remarked, how little can the hard-worked wife of a degraded Australian savage, who uses very few abstract words, and can not count above four, exert her self-consciousness, or reflect on the nature of her own existence! It is generally admitted that the higher animals possess memory, attention, association, and even some imagination and reason. If these powers, which differ much in different animals, are capable of improvement, there seems no great improbability in more complex faculties, such as the higher forms of abstraction, and self-consciousness, etc., having been evolved through the development and combination of the simpler ones. It has been urged against the views here maintained that it is impossible to say at what point in the ascending scale animals become capable of abstraction, etc.; but who can say at what age this occurs in our young children? We see at least that such powers are developed in children by imperceptible degrees.

THE EVOLUTION OF LANGUAGE.

Page 84. This faculty (language) has justly been considered as one of the chief distinctions between man and the lower animals. But man, as a highly competent judge, Archbishop Whately, remarks, "is not the only animal that can make use of language to express what is passing in his mind, and can understand, more or less, what is so expressed by another." In Paraguay the *Cebus azaræ* when excited utters at least six distinct sounds, which excite in other monkeys similar emotions. The movements of the features and gestures of monkeys are understood by us, and they partly understand ours, as Rengger and others declare. It is a more remarkable fact that the dog, since being domesticated, has learned to bark in at least four or five distinct tones. Although barking is a new art, no doubt the wild parent-species of the dog expressed their feelings by cries of various kinds. With the domesticated dog we have the bark of eagerness, as in the chase; that of anger, as well as growling; the yelp or howl of despair, as when shut up; the baying at night; the bark of joy, as when starting on a walk with his master; and the very distinct one of demand or supplication, as when wishing for a door or window to be opened. According to Houzeau, who paid particular attention to the subject, the domestic fowl utters at least a dozen significant sounds.

The habitual use of articulate language is, however, peculiar to man; but he uses, in common with the lower animals, inarticulate cries to express his meaning, aided by gestures and the movements of the muscles of the face. This especially holds good with the more simple and vivid feelings, which are but little connected with our higher intelligence. Our cries of pain, fear, surprise, anger, together with their appropriate actions, and the murmur of a mother to her beloved child, are more expressive than any words. That which distinguishes man from the lower animals is not the understanding of articulate sounds, for, as every one knows, dogs understand many words and sentences. In this respect they are at the same stage of development as infants, between the ages of ten and twelve months, who understand many words and short sentences, but can not yet utter a single word. It is not the mere articulation which is our distinguishing character, for parrots and other birds possess this power. Nor is it the mere capacity of connecting definite sounds with definite ideas; for it is certain that some parrots, which have been taught to speak, connect unerringly words with things, and persons with events. The lower animals differ from man solely in his almost infinitely larger power of associating together the most diversified sounds and ideas; and this obviously depends on the high development of his mental powers.

As Horne Tooke, one of the founders of the noble science of philology, observes, language is an art, like brewing or baking; but writing would have been a better simile. It certainly is not a true instinct, for every language has to be learned. It differs, however, widely from all ordinary arts, for man has an instinctive tendency to speak, as we see in the babble of our young children; while no child has an instinctive tendency to brew, bake, or write. Moreover, no philologist now supposes that any language has been deliberately invented; it has been slowly and unconsciously developed by many steps. The sounds uttered by birds offer in several respects the nearest analogy to language, for all the members of the same species utter the same instinctive cries expressive of their emotions; and all the kinds which sing exert their power instinctively; but the actual song, and even the call-notes, are learned from their parents or foster-parents. These sounds, as Daines Barrington has proved, "are no more innate than language is in man." The first attempts to sing "may be compared to the imperfect endeavor in a child to babble." The young males continue practicing, or, as the bird-catchers say, "recording," for ten or eleven months. Their first essays show hardly a rudiment of the future song; but as they grow older we can perceive what they are aiming at; and at last they are said "to sing their song round." Nestlings which have learned the song of a distinct species, as with the canary-birds educated in the Tyrol, teach and transmit their new song to their offspring. The slight natural differences of song in the same species inhabiting different districts may be appositely compared, as Barrington remarks, "to provincial dialects"; and the songs of allied though distinct species may be compared with the languages of distinct races of man. I have given the foregoing details to show that an instinctive tendency to acquire an art is not peculiar to man.

With respect to the origin of articulate language, after having read on the one side the highly interesting works of Mr. Hensleigh Wedgwood, the Rev. F. Farrar, and Professor Schleicher, and the celebrated lectures of Professor Max Müller on the other side, I can not doubt that language owes its origin to the imitation and modification of various natural sounds, the voices of other animals, and man's own instinctive cries, aided by signs and gestures.

Page 87. It is, therefore, probable that the imitation of musical cries by articulate sounds may have given rise to words expressive of various complex emotions. The strong tendency in our nearest allies, the monkeys, in microcephalous idiots, and in the barbarous races of mankind, to imitate whatever they hear, deserves notice, as bearing on the subject of imitation. Since monkeys certainly understand much that is said to them by man, and, when wild, utter signal-cries of danger to their fellows; and since fowls give distinct warnings for danger on the ground, or in the sky from hawks (both, as well as a third cry, intelligible to dogs), may not some unusually wise ape-like animal have imitated the growl of a beast of prey, and thus told his fellow-monkeys the nature of the expected danger? This would have been a first step in the formation of a language.

As the voice was used more and more, the vocal organs would have been strengthened and perfected through the principle of the inherited effects of use; and this would have reacted on the power of speech.

Page 89.

The fact of the higher apes not using their vocal organs for speech no doubt depends on their intelligence not having been sufficiently advanced. The possession by them of organs, which with long-continued practice might have been used for speech, although not thus used, is paralleled by the case of many birds which possess organs fitted for singing, though they never sing. Thus, the nightingale and crow have vocal organs similarly constructed, these being used by the former for diversified song, and by the latter only for croaking.

DEVELOPMENT OF LANGUAGES AND SPECIES COMPARED.

Descent of Man, page 90.

The formation of different languages and of distinct species and the proofs that both have been developed through a gradual process are curiously parallel. But we can trace the formation of many words further back than that of species, for we can perceive how they actually arose from the imitation of various sounds. We find in distinct languages striking homologies due to community of descent, and analogies due to a similar process of formation. The manner in which certain letters or sounds change when others change is very like correlated growth. We have in both cases the reduplication of parts, the effects of long-continued use, and so forth. The frequent presence of rudiments, both in languages and in species, is still more remarkable. The letter *m* in the word *am* means *I*; so that, in the expression *I am*, a superfluous and useless rudiment has been retained. In the spelling also of words, letters often remain as the rudiments of ancient forms of pronunciation. Languages, like organic beings, can be classed in groups under groups; and they can be classed either naturally according to descent, or artificially by other characters. Dominant languages and dialects spread widely, and lead to the gradual extinction of other tongues. A language, like a species, when once extinct, never, as Sir C. Lyell remarks, reappears. The same language never has two birthplaces. Distinct languages may be crossed or blended together. We see variability in every tongue, and new words are continually cropping up; but, as there is a limit to the powers of the memory, single words, like whole languages, gradually become extinct. As Max Müller has well remarked: "A struggle for life is constantly going on among the words and grammatical forms in each language. The better, the shorter, the easier forms are constantly gaining the upper hand, and they owe their success to their own inherent virtue." To these more important causes of the survival of certain words, mere novelty and fashion may be added; for there is in the mind of man a strong love for slight changes in all things. The survival or preservation of certain favored words in the struggle for existence is natural selection.

The perfectly regular and wonderfully complex construction of the languages of many barbarous nations has often been advanced as a proof, either of the divine origin of these languages, or of the high art and former civilization of their founders. Thus F. von Schlegel writes: "In those languages which appear to be at the lowest grade of intellectual culture, we frequently observe a very high and elaborate degree of art in their grammatical structure. This is especially the case with the Basque and the Lapponian, and many of the American languages." But it is assuredly an error to speak of any language as an art, in the sense of its having been elaborately and methodically formed. Philologists now admit that conjugations, declensions, etc., originally existed as distinct words, since joined together; and, as such words express the most obvious relations between objects and persons, it is not surprising that they should have been used by the men of most races during the earliest ages. With respect to perfection, the following illustration will best show how easily we may err: a crinoid sometimes consists of no less than one hundred and fifty thousand pieces of shell, all arranged with perfect symmetry in radiating lines; but a naturalist does not consider an animal of this kind as more perfect than a bilateral one with comparatively few parts, and with none of these parts alike, excepting on the opposite sides of the body. He justly considers the differentiation and specialization of organs as the test of perfection. So with languages; the most symmetrical and complex ought not to be ranked above irregular, abbreviated, and bastardized languages.

THE SENSE OF BEAUTY.

Descent of Man, page 92.

This sense has been declared to be peculiar to man. I refer here only to the pleasure given by certain colors, forms, and sounds, and which may fairly be called a sense of the beautiful; with cultivated men such sensations are, however, intimately associated with complex ideas and trains of thought. When we behold a male bird elaborately displaying his graceful plumes or splendid colors before the female, while other birds, not thus decorated, make no such display, it is impossible to doubt that she admires the beauty of her male partner. As women everywhere deck themselves with these plumes, the beauty of such ornaments can not be disputed. As we shall see later, the nests of humming-birds and the playing passages of bower-birds are tastefully ornamented with gayly-colored objects; and this shows that they must receive some kind of pleasure from the sight of such things. With the great majority of animals, however, the taste for the beautiful is confined, as far as we can judge, to the attractions of the opposite sex. The sweet strains poured forth by many male birds during the season of love are certainly admired by the females, of which fact evidence will hereafter be given. If female birds had been incapable of appreciating the beautiful colors, the ornaments, and voices of their male partners, all the labor and anxiety exhibited by the latter in displaying their charms before the females would have been thrown away; and this it is impossible to admit. Why certain bright colors should excite pleasure can not, I presume, be explained, any more than why certain flavors and scents are agreeable; but habit has something to do with the result, for that which is at first unpleasant to our senses, ultimately becomes pleasant, and habits are inherited.

DEVELOPMENT OF THE EAR FOR MUSIC.

Descent of Man, page 568.

A critic has asked how the ears of man, and he ought to have added of other animals, could have been adapted by selection so as to distinguish musical notes. But this question shows some confusion on the subject; a noise is the sensation resulting from the co-existence of several aërial "simple vibrations" of various periods, each of which intermits so frequently that its separate existence can not be perceived. It is only in the want of continuity of such vibrations, and in their want of harmony *inter se*, that a noise differs from a musical note. Thus an ear to be capable of discriminating noises—and the high importance of this power to all animals is admitted by every one—must be sensitive to musical notes. We have evidence of this capacity even low down in the animal scale; thus crustaceans are provided with auditory hairs of different lengths, which have been seen to vibrate when the proper musical notes are struck. As stated in a previous chapter, similar observations have been made on the hairs of the antennæ of gnats. It has been positively asserted by good observers that spiders are attracted by music. It is also well known that some dogs howl when hearing particular tones. Seals apparently appreciate music, and their fondness for it "was well known to the ancients, and is often taken advantage of by the hunters at the present day."

Therefore, as far as the mere perception of musical notes is concerned, there seems no special difficulty in the case of man or of any other animal.

But if it be further asked why musical tones in a certain order and rhythm give man and other animals pleasure, we can no more give the reason than for the pleasantness of certain tastes and smells. That they do give pleasure of some kind to animals we may infer from their being produced during the season of courtship by many insects, spiders, fishes, amphibians, and birds; for, unless the females were able to appreciate such sounds and were excited or charmed by them, the persevering efforts of the males and the complex structures often possessed by them alone would be useless; and this it is impossible to believe.

IX.

DEVELOPMENT OF THE MORAL SENSE.

Descent of Man, page 97.

I FULLY subscribe to the judgment of those writers who maintain that, of all the differences between man and the lower animals, the moral sense or conscience is by far the most important. This sense, as Mackintosh remarks, "has a rightful supremacy over every other principle of human action"; it is summed up in that short but imperious word *ought*, so full of high significance. It is the most noble of all the attributes of man, leading him without a moment's hesitation to risk his life for that of a fellow-creature; or, after due deliberation, impelled simply by the deep feeling of right or duty, to sacrifice it in some great cause.

Page 111.

A moral being is one who is capable of comparing his past and future actions or motives, and of approving or disapproving of them. We have no reason to suppose that any of the lower animals have this capacity; therefore, when a Newfoundland dog drags a child out of the water, or a monkey faces danger to rescue its comrade, or takes charge of an orphan monkey, we do not call its conduct moral. But in the case of man, who alone can with certainty be ranked as a moral being, actions of a certain class are called moral.

FROM THE SOCIAL INSTINCTS TO THE MORAL SENSE.

Page 98. The following proposition seems to me in a high degree probable—namely, that any animal whatever, endowed with well-marked social instincts, the parental and filial affections being here included, would inevitably acquire a moral sense or conscience, as soon as its intellectual powers had become as well, or nearly as well, developed as in man. For, *firstly*, the social instincts lead an animal to take pleasure in the society of its fellows, to feel a certain amount of sympathy with them, and to perform various services for them. The services may be of a definite and evidently instinctive nature; or there may be only a wish and readiness, as with most of the higher social animals, to aid their fellows in certain general ways. But these feelings and services are by no means extended to all the individuals of the same species, only to those of the same association. *Secondly*, as soon as the mental faculties had become highly developed, images of all past actions and motives would be incessantly passing through the brain of each individual; and that feeling of dissatisfaction, or even misery, which invariably results, as we shall hereafter see, from any unsatisfied instinct, would arise, as often as it was perceived that the enduring and always present social instinct had yielded to some other instinct, at the time stronger, but neither enduring in its nature, nor leaving behind it a very vivid impression. It is clear that many instinctive desires, such as that of hunger, are in their nature of short duration; and, after being satisfied, are not readily or vividly recalled. *Thirdly*, after the power of language had been acquired, and the wishes of the community could be expressed, the common opinion how each member ought to act for the public good would naturally become in a paramount degree the guide to action. But it should be borne in mind that, however great weight we may attribute to public opinion, our regard for the approbation and disapprobation of our fellows depends on sympathy, which, as we shall see, forms an essential part of the social instinct, and is, indeed, its foundation-stone. *Lastly,* habit in the individual would ultimately play a very important part in guiding the conduct of each member; for the social instinct, together with sympathy, is, like any other instinct, greatly strengthened by habit, and so consequently would be obedience to the wishes and judgment of the community. These several subordinate propositions must now be discussed, and some of them at considerable length.

It may be well first to premise that I do not wish to maintain that any strictly social animal, if its intellectual faculties were to become as active and as highly developed as in man, would acquire exactly the same moral sense as ours. In the same manner as various animals have some sense of beauty, though they admire widely different objects, so they might have a sense of right and wrong, though led by it to follow widely different lines of conduct. If, for instance, to take an extreme case, men were reared under precisely the same conditions as hive-bees, there can hardly be a doubt that our unmarried females would, like the worker-bees, think it a sacred duty to kill their brothers, and mothers would strive to kill their fertile daughters; and no one would think of interfering. Nevertheless, the bee, or any other social animal, would gain in our supposed case, as it appears to me, some feeling of right or wrong, or a conscience. For each individual would have an inward sense of possessing certain stronger or more enduring instincts, and others less strong or enduring; so that there would often be a struggle as to which impulse should be followed; and satisfaction, dissatisfaction, or even misery would be felt, as past impressions were compared during their incessant passage through the mind. In this case an inward monitor would tell the animal that it would have been better to have followed the one impulse rather than the other. The one course ought to have been followed, and the other ought not; the one would have been right and the other wrong.

HUMAN SYMPATHY AMONG ANIMALS.

Page 102. Who can say what cows feel when they surround and stare intently on a dying or dead companion? Apparently, however, as Houzeau remarks, they feel no pity. That animals sometimes are far from feeling any sympathy is too certain; for they will expel a wounded animal from the herd, or gore or worry it to death. This is almost the blackest fact in natural history, unless, indeed, the explanation which has been suggested is true, that their instinct or reason leads them to expel an injured companion, lest beasts of prey, including man, should be tempted to follow the troop. In this case their conduct is not much worse than that of the North American Indians, who leave their feeble comrades to perish on the plains; or the Feejeeans, who, when their parents get old, or fall ill, bury them alive.

Page 103. Several years ago a keeper at the Zoölogical Gardens showed me some deep and scarcely healed wounds on the nape of his own neck, inflicted on him, while kneeling on the floor, by a fierce baboon. The little American monkey, who was a warm friend of this keeper, lived in the same large compartment, and was dreadfully afraid of the great baboon. Nevertheless, as soon as he saw his friend in peril, he rushed to the rescue, and by screams and bites so distracted the baboon that the man was able to escape, after, as the surgeon thought, running great risk of his life.

Besides love and sympathy, animals exhibit other qualities connected with the social instincts, which in us would be called moral; and I agree with Agassiz that dogs possess something very like a conscience.

Page 107. With mankind, selfishness, experience, and imitation, probably add, as Mr. Bain has shown, to the power of sympathy; for we are led by the hope of receiving good in return to perform acts of sympathetic kindness to others; and sympathy is much strengthened by habit. In however complex a manner this feeling may have originated, as it is one of high importance to all those animals which aid and defend one another, it will have been increased through natural selection; for those communities which included the greatest number of the most sympathetic members would flourish best and rear the greatest number of offspring.

It is, however, impossible to decide in many cases whether certain social instincts have been acquired through natural selection, or are the indirect result of other instincts and faculties, such as sympathy, reason, experience, and a tendency to imitation; or, again, whether they are simply the result of long-continued habit. So remarkable an instinct as the placing sentinels to warn the community of danger can hardly have been the indirect result of any of these faculties; it must, therefore, have been directly acquired. On the other hand, the habit followed by the males of some social animals of defending the community, and of attacking their enemies or their prey in concert, may perhaps have originated from mutual sympathy; but courage, and in most cases strength, must have been previously acquired, probably through natural selection.

THE LOVE OF APPROBATION.

Page 109. Although man has no special instincts to tell him how to aid his fellow-men, he still has the impulse, and with his improved intellectual faculties would naturally be much guided in this respect by reason and experience. Instinctive sympathy would also cause him to value highly the approbation of his fellows; for, as Mr. Bain has clearly shown, the love of praise and the strong feeling of glory, and the still stronger horror of scorn and infamy, "are due to the workings of sympathy." Consequently, man would be influenced in the highest degree by the wishes, approbation, and blame of his fellow-men, as expressed by their gestures and language. Thus the social instincts, which must have been acquired by man in a very rude state, and probably even by his early ape-like progenitors, still give the impulse to some of his best actions; but his actions are in a higher degree determined by the expressed wishes and judgment of his fellow-men, and unfortunately very often by his own strong selfish desires. But as love, sympathy, and self-command become strengthened by habit, and as the power of reasoning becomes clearer, so that man can value justly the judgments of his fellows, he will feel himself impelled, apart from any transitory pleasure or pain, to certain lines of conduct. He might then declare —not that any barbarian or uncultivated man could thus think—I am the supreme judge of my own conduct, and, in the words of Kant, I will not in my own person violate the dignity of humanity.

FELLOW-FEELING FOR OUR FELLOW-ANIMALS.

Page 123. Sympathy beyond the confines of man, that is, humanity to the lower animals, seems to be one of the latest moral acquisitions. It is apparently unfelt by savages, except toward their pets. How little the old Romans knew of it is shown by their abhorrent gladiatorial exhibitions. The very idea of humanity, as far as I could observe, was new to most of the Gauchos of the Pampas. This virtue, one of the noblest with which man is endowed, seems to arise incidentally from our sympathies becoming more tender and more widely diffused, until they are extended to all sentient beings. As soon as this virtue is honored and practiced by some few men, it spreads through instruction and example to the young, and eventually becomes incorporated in public opinion.

The highest possible stage in moral culture is when we recognize that we ought to control our thoughts, and "not even in inmost thought to think again the sins that made the past so pleasant to us." Whatever makes any bad action familiar to the mind renders its performance by so much the easier. As Marcus Aurelius long ago said: "Such as are thy habitual thoughts, such also will be the character of thy mind; for the soul is dyed by the thoughts."

Page 125. Looking to future generations, there is no cause to fear that the social instincts will grow weaker, and we may expect that virtuous habits will grow stronger, becoming perhaps fixed by inheritance. In this case the struggle between our higher and lower impulses will be less severe, and virtue will be triumphant.

DEVELOPMENT OF THE GOLDEN RULE.

Page 125. There can be no doubt that the difference between the mind of the lowest man and that of the highest animal is immense. An anthropomorphous ape, if he could take a dispassionate view of his own case, would admit that though he could form an artful plan to plunder a garden, though he could use stones for fighting or for breaking open nuts, yet that the thought of fashioning a stone into a tool was quite beyond his scope. Still less, as he would admit, could he follow out a train of metaphysical reasoning, or solve a mathematical problem, or reflect on God, or admire a grand natural scene. Some apes, however, would probably declare that they could and did admire the beauty of the colored skin and fur of their partners in marriage. They would admit that, though they could make other apes understand by cries some of their perceptions and simpler wants, the notion of expressing definite ideas by definite sounds had never crossed their minds. They might insist that they were ready to aid their fellow-apes of the same troop in many ways, to risk their lives for them, and to take charge of their orphans; but they would be forced to acknowledge that disinterested love for all living creatures, the most noble attribute of man, was quite beyond their comprehension.

Nevertheless, the difference in mind between man and the higher animals, great as it is, certainly is one of degree and not of kind. We have seen that the senses and intuitions, the various emotions and faculties, such as love, memory, attention, curiosity, imitation, reason, etc., of which man boasts, may be found in an incipient, or even sometimes in a well-developed condition, in the lower animals. They are also capable of some inherited improvement, as we see in the domestic dog compared with the wolf or jackal. If it could be proved that certain high mental powers, such as the formation of general concepts, self-consciousness, etc., were absolutely peculiar to man, which seems extremely doubtful, it is not improbable that these qualities are merely the incidental results of other highly-advanced intellectual faculties; and these again mainly the result of the continued use of a perfect language. At what age does the new-born infant possess the power of abstraction, or become self-conscious, and reflect on its own existence? We can not answer; nor can we answer in regard to the ascending organic scale. The half-art, half-instinct of language still bears the stamp of its gradual evolution. The ennobling belief in God is not universal with man; and the belief in spiritual agencies naturally follows from other mental powers. The moral sense perhaps affords the best and highest distinction between man and the lower animals; but I need say nothing on this head, as I have so lately endeavored to show that the social instincts—the prime principle of man's moral constitution—with the aid of active intellectual powers and the effects of habit, naturally lead to the golden rule, "As ye would that men should do to you, do ye to them likewise"; and this lies at the foundation of morality.

REGRET PECULIAR TO MAN, AND WHY.

Descent of Man, page 112.

Why does man regret, even though trying to banish such regret, that he has followed the one natural impulse rather than the other? and why does he further feel that he ought to regret his conduct? Man in this respect differs profoundly from the lower animals. Nevertheless we can, I think, see with some degree of clearness the reason of this difference.

Man, from the activity of his mental faculties, can not avoid reflection: past impressions and images are incessantly and clearly passing through his mind. Now, with those animals which live permanently in a body, the social instincts are ever present and persistent. Such animals are always ready to utter the danger-signal, to defend the community, and to give aid to their fellows in accordance with their habits; they feel at all times, without the stimulus of any special passion or desire, some degree of love and sympathy for them; they are unhappy if long separated from them, and always happy to be again in their company. So it is with ourselves. Even when we are quite alone, how often do we think with pleasure or pain of what others think of us—of their imagined approbation or disapprobation!—and this all follows from sympathy, a fundamental element of the social instincts. A man who possessed no trace of such instincts would be an unnatural monster. On the other hand, the desire to satisfy hunger, or any passion such as vengeance, is in its nature temporary, and can for a time be fully satisfied. Nor is it easy, perhaps hardly possible, to call up with complete vividness the feeling, for instance, of hunger; nor, indeed, as has often been remarked, of any suffering. The instinct of self-preservation is not felt except in the presence of danger; and many a coward has thought himself brave until he has met his enemy face to face. The wish for another man's property is perhaps as persistent a desire as any that can be named; but even in this case the satisfaction of actual possession is generally a weaker feeling than the desire: many a thief, if not an habitual one, after success has wondered why he stole some article.

REMORSE EXPLAINED.

Page 114. Several critics have objected that though some slight regret or repentance may be explained by the view advocated in this chapter, it is impossible thus to account for the soul-shaking feeling of remorse. But I can see little force in this objection. My critics do not define what they mean by remorse, and I can find no definition implying more than an overwhelming sense of repentance. Remorse seems to bear the same relation to repentance as rage does to anger, or agony to pain. It is far from strange that an instinct so strong and so generally admired as maternal love should, if disobeyed, lead to the deepest misery, as soon as the impression of the past cause of disobedience is weakened. Even when an action is opposed to no special instinct, merely to know that our friends and equals despise us for it is enough to cause great misery. Who can doubt that the refusal to fight a duel through fear has caused many men an agony of shame? Many a Hindoo, it is said, has been stirred to the bottom of his soul by having partaken of unclean food. Here is another case of what must, I think, be called remorse. Dr. Landor acted as a magistrate in West Australia, and relates that a native on his farm, after losing one of his wives from disease, came and said that "he was going to a distant tribe to spear a woman, to satisfy his sense of duty to his wife." I told him that if he did so I would send him to prison for life. He remained about the farm for some months, but got exceedingly thin, and complained that he could not rest or eat, that his wife's spirit was haunting him because he had not taken a life for hers. I was inexorable, and assured him that nothing should save him if he did. Nevertheless, the man disappeared for more than a year, and then returned in high condition; and his other wife told Dr. Landor that her husband had taken the life of a woman belonging to a distant tribe; but it was impossible to obtain legal evidence of the act. The breach of a rule held sacred by the tribe will thus, as it seems, give rise to the deepest feelings, and this quite apart from the social instincts, excepting in so far as the rule is grounded on the judgment of the community. How so many strange superstitions have arisen throughout the world we know not; nor can we tell how some real and great crimes, such as incest, have come to be held in an abhorrence (which is not, however, quite universal) by the lowest savages. It is even doubtful whether in some tribes incest would be looked on with greater horror than would the marriage of a man with a woman bearing the same name, though not a relation. "To violate this law is a crime which the Australians hold in the greatest abhorrence, in this agreeing exactly with certain tribes of North America. When the question is put in either district, is it worse to kill a girl of a foreign tribe, or to marry a girl of one's own, an answer just opposite to ours would be given without hesitation." We may, therefore, reject the belief, lately insisted on by some writers, that the abhorrence of incest is due to our possessing a special God-implanted conscience.

DEVELOPMENT OF SELF-CONTROL.

Page 115. Man, prompted by his conscience, will through long habit acquire such perfect self-command, that his desires and passions will at last yield instantly and without a struggle to his social sympathies and instincts, including his feeling for the judgment of his fellows. The still hungry or the still revengeful man will not think of stealing food, or of wreaking his vengeance. It is possible, or, as we shall hereafter see, even probable, that the habit of self-command may, like other habits, be inherited. Thus at last man comes to feel, through acquired and perhaps inherited habit, that it is best for him to obey his more persistent impulses. The imperious word *ought* seems merely to imply the consciousness of the existence of a rule of conduct, however it may have originated. Formerly it must have been often vehemently urged that an insulted gentleman *ought* to fight a duel. We even say that a pointer *ought* to point, and a retriever to retrieve game. If they fail to do so, they fail in their duty and act wrongly.

If any desire or instinct leading to an action opposed to the good of others still appears, when recalled to mind, as strong as, or stronger than, the social instinct, a man will feel no keen regret at having followed it; but he will be conscious that, if his conduct were known to his fellows, it would meet with their disapprobation; and few are so destitute of sympathy as not to feel discomfort when this is realized. If he has no snch sympathy, and if his desires leading to bad actions are at the time strong, and when recalled are not overmastered by the persistent social instincts and the judgment of others, then he is essentially a bad man; and the sole restraining motive left is the fear of punishment, and the conviction that in the long run it would be best for his own selfish interests to regard the good of others rather than his own.

It is obvious that every one may with an easy conscience gratify his own desires, if they do not interfere with his social instincts, that is, with the good of others; but in order to be quite free from self-reproach, or at least of anxiety, it is almost necessary for him to avoid the disapprobation, whether reasonable or not, of his fellow-men. Nor must he break through the fixed habits of his life, especially if these are supported by reason; for, if he does, he will assuredly feel dissatisfaction. He must likewise avoid the reprobation of the one God or gods in whom, according to his knowledge or superstition, he may believe; but in this case the additional fear of divine punishment often supervenes.

VARIABILITY OF CONSCIENCE.

Page 117. Suicide during former times was not generally considered as a crime, but rather, from the courage displayed, as an honorable act; and it is still practiced by some semi-civilized and savage nations without reproach, for it does not obviously concern others of the tribe. It has been recorded that an Indian thug conscientiously regretted that he had not robbed and strangled as many travelers as did his father before him. In a rude state of civilization the robbery of strangers is, indeed, generally considered as honorable.

Slavery, although in some way beneficial during ancient times, is a great crime; yet it was not so regarded until quite recently, even by the most civilized nations. And this was especially the case because the slaves belonged in general to a race different from that of their masters. As barbarians do not regard the opinion of their women, wives are commonly treated like slaves.

Page 122. How so many absurd rules of conduct, as well as so many absurd religious beliefs, have originated, we do not know; nor how it is that they have become, in all quarters of the world, so deeply impressed on the minds of men; but it is worthy of remark that a belief constantly inculcated during the early years of life, while the brain is impressible, appears to acquire almost the nature of an instinct; and the very essence of an instinct is that it is followed independently of reason. Neither can we say why certain admirable virtues, such as the love of truth, are much more highly appreciated by some savage tribes than by others; nor, again, why similar differences prevail even among highly civilized nations. Knowing how firmly fixed many strange customs and superstitions have become, we need feel no surprise that the self-regarding virtues, supported as they are by reason, should now appear to us so natural as to be thought innate, although they were not valued by man in his early condition.

Page 121. The wishes and opinions of the members of the same community, expressed at first orally, but later by writing also, either form the sole guides of our conduct, or greatly re-enforce the social instincts; such opinions, however, have sometimes a tendency directly opposed to these instincts. This latter fact is well exemplified by the *law of honor*, that is, the law of the opinion of our equals, and not of all our countrymen. The breach of this law, even when the breach is known to be strictly accordant with true morality, has caused many a man more agony than a real crime. We recognize the same influence in the burning sense of shame which most of us have felt, even after the interval of years, when calling to mind some accidental breach of a trifling, though fixed, rule of etiquette.

PROGRESS NOT AN INVARIABLE RULE.

Descent of Man, page 140.

We must remember that progress is no invariable rule. It is very difficult to say why one civilized nation rises, becomes more powerful, and spreads more widely, than another; or why the same nation progresses more quickly at one time than at another. We can only say that it depends on an increase in the actual number of the population, on the number of the men endowed with high intellectual and moral faculties, as well as on their standard of excellence. Corporeal structure appears to have little influence, except so far as vigor of body leads to vigor of mind.

It has been urged by several writers that, as high intellectual powers are advantageous to a nation, the old Greeks, who stood some grades higher in intellect than any race that has ever existed, ought, if the power of natural selection were real, to have risen still higher in the scale, increased in number, and stocked the whole of Europe. Here we have the tacit assumption, so often made with respect to corporeal structures, that there is some innate tendency toward continued development in mind and body. But development of all kinds depends on many concurrent favorable circumstances. Natural selection acts only tentatively. Individuals and races may have acquired certain indisputable advantages, and yet have perished from failing in other characters. The Greeks may have retrograded from a want of coherence between the many small states, from the small size of their whole country, from the practice of slavery, or from extreme sensuality; for they did not succumb until "they were enervated and corrupt to the very core." The Western nations of Europe, who now so immeasurably surpass their former savage progenitors, and stand at the summit of civilization, owe little or none of their superiority to direct inheritance from the old Greeks, though they owe much to the written works of that wonderful people.

Page 142. The remarkable success of the English as colonists, compared to other European nations, has been ascribed to their "daring and persistent energy"; a result which is well illustrated by comparing the progress of the Canadians of English and French extraction; but who can say how the English gained their energy? There is apparently much truth in the belief that the wonderful progress of the United States, as well as the character of the people, is the result of natural selection; for the more energetic, restless, and courageous men from all parts of Europe have emigrated during the last ten or twelve generations to that great country, and have there succeeded best.

ALL CIVILIZED NATIONS ARE THE DESCENDANTS OF BARBARIANS.

Page 144. The evidence that all civilized nations are the descendants of barbarians consists, on the one side, of clear traces of their former low condition in still-existing customs, beliefs, language, etc.; and, on the other side, of proofs that savages are independently able to raise themselves a few steps in the scale of civilization, and have actually thus risen. The evidence on the first head is extremely curious, but can not be here given: I refer to such cases as that of the art of enumeration, which, as Mr. Tylor clearly shows by reference to the words still used in some places, originated in counting the fingers, first of one hand and then of the other, and lastly of the toes. We have traces of this in our own decimal system, and in the Roman numerals, where, after the V, which is supposed to be an abbreviated picture of a human hand, we pass on to VI, etc., when the other hand no doubt was used. So again, "when we speak of threescore and ten, we are counting by the vigesimal system, each score thus ideally made standing for 20—for 'one man' as a Mexican or Carib would put it." According to a large and increasing school of philologists, every language bears the marks of its slow and gradual evolution. So it is with the art of writing, for letters are rudiments of pictorial representations. It is hardly possible to read Mr. McLennan's work and not admit that almost all civilized nations still retain traces of such rude habits as the forcible capture of wives. What ancient nation, as the same author asks, can be named that was originally monogamous? The primitive idea of justice, as shown by the law of battle and other customs of which vestiges still remain, was likewise most rude. Many existing superstitions are the remnants of former false religious beliefs. The highest form of religion—the grand idea of God hating sin and loving righteousness—was unknown during primeval times.

Turning to the other kind of evidence: Sir J. Lubbock has shown that some savages have recently improved a little in some of their simpler arts. From the extremely curious account which he gives of the weapons, tools, and arts in use among savages in various parts of the world, it can not be doubted that these have nearly all been independent discoveries, excepting perhaps the art of making fire. The Australian boomerang is a good instance of one such independent discovery. The Tahitians when first visited had advanced in many respects beyond the inhabitants of most of the other Polynesian islands. There are no just grounds for the belief that the high culture of the native Peruvians and Mexicans was derived from abroad; many native plants were there cultivated, and a few native animals domesticated. We should bear in mind that, judging from the small influence of most missionaries, a wandering crew from some semi-civilized land, if washed to the shores of America, would not have produced any marked effect on the natives, unless they had already become somewhat advanced. Looking to a very remote period in the history of the world, we find, to use Sir J. Lubbock's well-known terms, a paleolithic and neolithic period; and no one will pretend that the art of grinding rough flint tools was a borrowed one. In all parts of Europe, as far east as Greece, in Palestine, India, Japan, New Zealand, and Africa, including Egypt, flint tools have been discovered in abundance; and of their use the existing inhabitants retain no tradition. There is also indirect evidence of their former use by the Chinese and ancient Jews. Hence there can hardly be a doubt that the inhabitants of these countries, which include nearly the whole civilized world, were once in a barbarous condition. To believe that man was aboriginally civilized and then suffered utter degradation in so many regions is to take a pitiably low view of human nature. It is apparently a truer and more cheerful view that progress has been much more general than retrogression; that man has risen, though by slow and interrupted steps, from a lowly condition to the highest standard as yet attained by him in knowledge, morals, and religion.

"THE ENNOBLING BELIEF IN GOD."

Descent of Man, page 93.

There is no evidence that man was aboriginally endowed with the ennobling belief in the existence of an Omnipotent God. On the contrary, there is ample evidence, derived not from hasty travelers, but from men who have long resided with savages, that numerous races have existed, and still exist, who have no idea of one or more gods, and who have no words in their languages to express such an idea. The question is, of course, wholly distinct from that higher one, whether there exists a Creator and Ruler of the universe; and this has been answered in the affirmative by some of the highest intellects that have ever existed.

If, however, we include under the term "religion" the belief in unseen or spiritual agencies, the case is wholly different; for this belief seems to be universal with the less civilized races. Nor is it difficult to comprehend how it arose. As soon as the important faculties of the imagination—wonder and curiosity, together with some power of reasoning—had become partially developed, man would naturally crave to understand what was passing around him, and would have vaguely speculated on his own existence. As Mr. McLennan has remarked: "Some explanation of the phenomena of life a man must feign for himself; and, to judge from the universality of it, the simplest hypothesis, and the first to occur to men, seems to have been that natural phenomena are ascribable to the presence in animals, plants, and things, and in the forces of nature, of such spirits prompting to action as men are conscious they themselves possess." It is also probable, as Mr. Tylor has shown, that dreams may have first given rise to the notion of spirits; for savages do not readily distinguish between subjective and objective impressions. When a savage dreams, the figures which appear before him are believed to have come from a distance, and to stand over him; or "the soul of the dreamer goes out on its travels, and comes home with a remembrance of what it has seen." But, until the faculties of imagination, curiosity, reason, etc., had been fairly well developed in the mind of man, his dreams would not have led him to believe in spirits, any more than in the case of a dog.

The tendency in savages to imagine that natural objects and agencies are animated by spiritual or living essences is, perhaps, illustrated by a little fact which I once noticed. My dog, a full-grown and very sensible animal, was lying on the lawn during a hot and still day; but at a little distance a slight breeze occasionally moved an open parasol, which would have been wholly disregarded by the dog had any one stood near it. As it was, every time that the parasol slightly moved, the dog growled fiercely and barked. He must, I think, have reasoned to himself, in a rapid and unconscious manner, that movement, without any apparent cause, indicated the presence of some strange living agent, and that no stranger had a right to be on his territory.

The belief in spiritual agencies would easily pass into the belief in the existence of one or more gods. For savages would naturally attribute to spirits the same passions, the same love of vengeance, or simplest form of justice, and the same affections, which they themselves feel. The Fuegians appear to be in this respect in an intermediate condition, for, when the surgeon on board the Beagle shot some young ducklings as specimens, York Minster declared, in the most solemn manner, "Oh, Mr. Bynoe, much rain, much snow, blow much"; and this was evidently a retributive punishment for wasting human food. So, again, he related how, when his brother killed a "wild man," storms long raged, much rain and snow fell. Yet we could never discover that the Fuegians believed in what we should call a God, or practiced any religious rites; and Jemmy Button, with justifiable pride, stoutly maintained that there was no devil in his land. This latter assertion is the more remarkable, as with savages the belief in bad spirits is far more common than that in good ones.

The feeling of religious devotion is a highly complex one, consisting of love, complete submission to an exalted and mysterious superior, a strong sense of dependence, fear, reverence, gratitude, hope for the future, and perhaps other elements. No being could experience so complex an emotion until advanced in his intellectual and moral faculties to at least a moderately high level. Nevertheless, we see some distant approach to this state of mind in the deep love of a dog for his master, associated with complete submission, some fear, and perhaps other feelings. The behavior of a dog, when returning to his master after an absence, and, as I may add, of a monkey to his beloved keeper, is widely different from that toward their fellows. In the latter case, the transports of joy appear to be somewhat less, and the sense of equality is shown in every action. Professor Braubach goes so far as to maintain that a dog looks on his master as on a god.

The same high mental faculties which first led man to believe in unseen spiritual agencies, then in fetichism, polytheism, and ultimately in monotheism, would infallibly lead him, as long as his reasoning powers remained poorly developed, to various strange superstitions and customs. Many of these are terrible to think of—such as the sacrifice of human beings to a blood-loving god; the trial of innocent persons by the ordeal of poison or fire; witchcraft, etc.—yet it is well occasionally to reflect on these superstitions, for they show us what an infinite debt of gratitude we owe to the improvement of our reason, to science, and to our accumulated knowledge. As Sir J. Lubbock has well observed, "It is not too much to say that the horrible dread of unknown evil hangs like a thick cloud over savage life, and embitters every pleasure." These miserable and indirect consequences of our highest faculties may be compared with the incidental and occasional mistakes of the instincts of the lower animals.

X.

THE GENEALOGY OF MAN.

Descent of Man, page 146.

SOME naturalists, from being deeply impressed with the mental and spiritual powers of man, have divided the whole organic world into three kingdoms, the human, the animal, and the vegetable, thus giving to man a separate kingdom. Spiritual powers can not be compared or classed by the naturalist: but he may endeavor to show, as I have done, that the mental faculties of man and the lower animals do not differ in kind, although immensely in degree. A difference in degree, however great, does not justify us in placing man in a distinct kingdom, as will perhaps be best illustrated by comparing the mental powers of two insects, namely, a coccus or scale-insect and an ant, which undoubtedly belong to the same class. The difference is here greater than, though of a somewhat different kind from, that between man and the highest mammal. The female coccus, while young, attaches itself by its proboscis to a plant; sucks the sap, but never moves again; is fertilized and lays eggs; and this is its whole history. On the other hand, to describe the habits and mental powers of worker-ants would require, as Pierre Huber has shown, a large volume; I may, however, briefly specify a few points. Ants certainly communicate information to each other, and several unite for the same work, or for games of play. They recognize their fellow-ants after months of absence, and feel sympathy for each other. They build great edifices, keep them clean, close the doors in the evening, and post sentries. They make roads as well as tunnels under rivers, and temporary bridges over them, by clinging together. They collect food for the community, and, when an object, too large for entrance, is brought to the nest, they enlarge the door, and afterward build it up again. They store up seeds, of which they prevent the germination, and which, if damp, are brought up to the surface to dry. They keep aphides and other insects as milch-cows. They go out to battle in regular bands, and freely sacrifice their lives for the common weal. They emigrate according to a preconcerted plan. They capture slaves. They move the eggs of their aphides, as well as their own eggs and cocoons, into warm parts of the nest, in order that they may be quickly hatched; and endless similar facts could be given. On the whole, the difference in mental power between an ant and a coccus is immense; yet no one has ever dreamed of placing these insects in distinct classes, much less in distinct kingdoms. No doubt the difference is bridged over by other insects; and this is not the case with man and the higher apes. But we have every reason to believe that the breaks in the series are simply the results of many forms having become extinct.

MAN A SUB-ORDER.

Page 149. The greater number of naturalists who have taken into consideration the whole structure of man, including his mental faculties, have followed

Blumenbach and Cuvier, and have placed man in a separate order, under the title of the Bimana, and therefore on an equality with the orders of the Quadrumana, Carnivora, etc. Recently many of our best naturalists have recurred to the view first propounded by Linnæus, so remarkable for his sagacity, and have placed man in the same order with the Quadrumana, under the title of the Primates. The justice of this conclusion will be admitted: for, in the first place, we must bear in mind the comparative insignificance for classification of the great development of the brain in man, and that the strongly-marked differences between the skulls of man and the Quadrumana (lately insisted upon by Bischoff, Aeby, and others) apparently follow from their differently developed brains. In the second place, we must remember that nearly all the other and more important differences between man and the Quadrumana are manifestly adaptive in their nature, and relate chiefly to the erect position of man; such as the structure of his hand, foot, and pelvis, the curvature of his spine, and the position of his head. The family of seals offers a good illustration of the small importance of adaptive characters for classification. These animals differ from all other Carnivora in the form of their bodies and in the structure of their limbs, far more than does man from the higher apes; yet in most systems, from that of Cuvier to the most recent one by Mr. Flower, seals are ranked as a mere family in the order of the Carnivora. If man had not been his own classifier, he would never have thought of founding a separate order for his own reception.

Page 152. As far as differences in certain important points of structure are concerned, man may no doubt rightly claim the rank of a sub-order; and this rank is too low, if we look chiefly to his mental faculties. Nevertheless, from a genealogical point of view, it appears that this rank is too high, and that man ought to form merely a family, or possibly even only a sub-family. If we imagine three lines of descent proceeding from a common stock, it is quite conceivable that two of them might after the lapse of ages be so slightly changed as still to remain as species of the same genus, while the third line might become so greatly modified as to deserve to rank as a distinct sub-family, family, or even order. But in this case it is almost certain that the third line would still retain through inheritance numerous small points of resemblance with the other two. Here, then, would occur the difficulty, at present insoluble, how much weight we ought to assign in our classifications to strongly-marked differences in some few points—that is, to the amount of modification undergone—and how much to close resemblance in numerous unimportant points, as indicating the lines of descent of genealogy. To attach much weight to the few but strong differences is the most obvious and perhaps the safest course, though it appears more correct to pay great attention to the many small resemblances, as giving a truly natural classification.

In forming a judgment on this head with reference to man, we must glance at the classification of the *Simiadæ*. This family is divided by almost all naturalists into the Catarrhine group, or Old World monkeys, all of which are characterized (as their name expresses) by the peculiar structure of their nostrils, and by having four premolars in each jaw; and into the Platyrrhine group or New World monkeys (including two very distinct sub-groups), all of which are characterized by differently constructed nostrils, and by having six premolars in each jaw. Some other small differences might be mentioned. Now man unquestionably belongs in his dentition, in the structure of his nostrils, and some other respects, to the Catarrhine or Old World division; nor does he resemble the Platyrrhines more closely than the Catarrhines in any characters, excepting in a few of not much importance and apparently of an adaptive nature. It is, therefore, against all probability that some New World species should have formerly varied and produced a man-like creature, with all the distinctive characters proper to the Old World division, losing at the same time all its own distinctive characters. There can, consequently, hardly be a doubt that man is an offshoot from the Old World Simian stem, and that, under a genealogical point of view, he must be classed with the Catarrhine division.

Page 155. And, as man from a genealogical point of view belongs to the Catarrhine or Old World stock, we must conclude, however much the conclusion may revolt our pride, that our early progenitors would have been properly thus designated. But we must not fall into the error of supposing that the early progenitor of the whole Simian stock, including man, was identical with, or even closely resembled, any existing ape or monkey.

THE BIRTHPLACE OF MAN.

Page 155. We are naturally led to inquire, where was the birthplace of man at that stage of descent when our progenitors diverged from the Catarrhine stock? The fact that they belonged to this stock clearly shows that they inhabited the Old World; but not Australia nor any oceanic island, as we may infer from the laws of geographical distribution. In each great region of the world the living mammals are closely related to the extinct species of the same region. It is, therefore, probable that Africa was formerly inhabited by extinct apes closely allied to the gorilla and chimpanzee; and, as these two species are now man's nearest allies, it is somewhat more probable that our early progenitors lived on the African Continent than elsewhere. But it is useless to speculate on this subject; for two or three anthropomorphous apes, one the Dryopithecus of Lartet, nearly as large as a man, and closely allied to Hylobates, existed in Europe during the Miocene age; and since so remote a period the earth has certainly undergone many great revolutions, and there has been ample time for migration on the largest scale.

At the period and place, whenever and wherever it was, when man first lost his hairy covering, he probably inhabited a hot country; a circumstance favorable for the frugiferous diet on which, judging from analogy, he subsisted. We are far from knowing how long ago it was when man first diverged from the Catarrhine stock; but it may have occurred at an epoch as remote as the Eocene * period; for that the higher apes have diverged from the lower apes as early as the Upper Miocene period is shown by the existence of the Dryopithecus. We are also quite ignorant at how rapid a rate organisms, whether high or low in the scale, may be modified under favorable circumstances; we know, however, that some have retained the same form during an enormous lapse of time. From what we see going on under domestication, we learn that some of the co-descendants of the same species may be not at all, some a little, and some greatly changed, all within the same period. Thus it may have been with

* Eocene.—The earliest of the three divisions of the Tertiary epoch of geologists. Rocks of this age contain a small proportion of shells identical with species now living.

man, who has undergone a great amount of modification in certain characters in comparison with the higher apes.

The great break in the organic chain between man and his nearest allies, which can not be bridged over by any extinct or living species, has often been advanced as a grave objection to the belief that man is descended from some lower form; but this objection will not appear of much weight to those who, from general reasons, believe in the general principle of evolution. Breaks often occur in all parts of the series, some being wide, sharp, and defined, others less so in various degrees; as between the orang and its nearest allies—between the Tarsius and the other *Lemuridæ*—between the elephant, and in a more striking manner between the Ornithorhynchus or Echidna, and all other mammals. But these breaks depend merely on the number of related forms which have become extinct. At some future period, not very distant as measured by centuries, the civilized races of man will almost certainly exterminate, and replace, the savage races throughout the world. At the same time the anthropomorphous apes, as Professor Schaaffhausen has remarked, will no doubt be exterminated. The break between man and his nearest allies will then be wider, for it will intervene between man in a more civilized state, as we may hope, even than the Caucasian, and some ape as low as a baboon, instead of as now between the negro or Australian and the gorilla.

With respect to the absence of fossil remains, serving to connect man with his ape-like progenitors, no one will lay much stress on this fact who reads Sir C. Lyell's discussion, where he shows that in all the vertebrate classes the discovery of fossil remains has been a very slow and fortuitous process. Nor should it be forgotten that those regions which are the most likely to afford remains connecting man with some extinct ape-like creature, have not as yet been searched by geologists.

In attempting to trace the genealogy of the Mammalia, and therefore of man, lower down in the series, we become involved in greater and greater obscurity; but as a most capable judge, Mr. Parker, has remarked, we have good reason to believe that no true bird or reptile intervenes in the direct line of descent.

ORIGIN OF THE VERTEBRATA.

Page 158.

[The Vertebrata are defined as "the highest division of the animal kingdom, so called from the presence in most cases of a backbone composed of numerous joints or *vertebræ*, which constitutes the center of the skeleton and at the same time supports and protects the central parts of the nervous system."]

Every evolutionist will admit that the five great vertebrate classes, namely, mammals, birds, reptiles, amphibians, and fishes, are descended from some one prototype; for they have much in common, especially during their embryonic state. As the class of fishes is the most lowly organized, and appeared before the others, we may conclude that all the members of the vertebrate kingdom are derived from some fish-like animal. The belief that animals so distinct as a monkey, an elephant, a humming-bird, a snake, a frog, and a fish, etc., could all have sprung from the same parents, will appear monstrous to those who have not attended to the recent progress of natural history. For this belief implies the former existence of links binding closely together all these forms, now so utterly unlike.

Nevertheless, it is certain that groups of animals have existed, or do now exist, which serve to connect several of the great vertebrate classes more or less closely. We have seen that the Ornithorhynchus graduates toward reptiles ; and Professor Huxley has discovered, and is confirmed by Mr. Cope and others, that the Dinosaurians are in many important characters intermediate between certain reptiles and certain birds—the birds referred to being the ostrich-tribe (itself evidently a widely-diffused remnant of a larger group) and the Archeopteryx, that strange Secondary bird, with a long, lizard-like tail. Again, according to Professor Owen, the Ichthyosaurians—great sea-lizards furnished with paddles—present many affinities with fishes, or rather, according to Huxley, with amphibians ; a class which, including in its highest division frogs and toads, is plainly allied to the Ganoid fishes. These latter fishes swarmed during the earlier geological periods, and were constructed on what is called a generalized type, that is, they presented diversified affinities with other groups of organisms. The Lepidosiren is also so closely allied to amphibians and fishes that naturalists long disputed in which of these two classes to rank it ; it, and also some few Ganoid fishes have been preserved from utter extinction by inhabiting rivers, which are harbors of refuge, and are related to the great waters of the ocean in the same way that islands are to continents.

Lastly, one single member of the immense and diversified class of fishes, namely, the lancelet or amphioxus, is so different from all other fishes, that Häckel maintains that it ought to form a distinct class in the vertebrate kingdom. This fish is remarkable for its negative characters ; it can hardly be said to possess a brain, vertebral column, or heart, etc., so that it was classed by the older naturalists among the worms. Many years ago Professor Goodsir perceived that the lancelet presented some affinities with the Ascidians, which are invertebrate, hermaphrodite, marine creatures permanently attached to a support. They hardly appear like animals, and consist of a simple, tough, leathery sack, with two small projecting orifices. They belong to the Molluscoida of Huxley—a lower division of the great kingdom of the Mollusca; but they have recently been placed by some naturalists among the Vermes or worms. Their larvæ somewhat resemble tadpoles in shape, and have the power of swimming freely about. M. Kovalevsky has lately observed that the larvæ of Ascidians are related to the Vertebrata, in their manner of development, in the relative position of the nervous system, and in possessing a structure closely like the *chorda dorsalis* of vertebrate animals; and in this he has been since confirmed by Professor Kupffer.

Page 160. Thus, if we may rely on embryology, ever the safest guide in classification, it seems that we have at last gained a clew to the source whence the Vertebrata were derived. We should then be justified in believing that at an extremely remote period a group of animals existed, resembling in many respects the larvæ of our present Ascidians, which diverged into two great branches—the one retrograding in development and producing the present class of Ascidians, the other rising to the crown and summit of the animal kingdom by giving birth to the Vertebrata.

FROM NO BONE TO BACKBONE.

Page 164. The most ancient progenitors in the kingdom of the Vertebrata, at which we are able to obtain an obscure glance, apparently consisted of a group of marine animals, resembling the larvæ of existing Ascidians. These animals probably gave rise to a group of fishes, as lowly organized as the lancelet; and from these the Ganoids, and other fishes like the Lepidosiren, must have been developed. From such fish a very small advance would carry us on to the Amphibians. We have seen that birds and reptiles were once intimately connected together; and the Monotremata now connect mammals with reptiles in a slight degree. But no one can at present say by what line of descent the three higher and related classes, namely, mammals, birds, and reptiles, were derived from the two lower vertebrate classes, namely, amphibians and fishes. In the class of mammals the steps are not difficult to conceive which led from the ancient Monotremata to the ancient Marsupials; and from these to the early progenitors of the placental mammals. We may thus ascend to the *Lemuridæ;* and the interval is not very wide from these to the *Simiadæ.* The *Simiadæ* then branched off into two great stems, the New World and Old World monkeys; and from the latter, at a remote period, Man, the wonder and glory of the universe, proceeded.

Thus, we have given to man a pedigree of prodigious length, but not, it may be said, of noble quality. The world, it has often been remarked, appears as if it had long been preparing for the advent of man: and this, in one sense, is strictly true, for he owes his birth to a long line of progenitors. If any single link in this chain had never existed, man would not have been exactly what he now is. Unless we willfully close our eyes, we may, with our present knowledge, approximately recognize our parentage; nor need we feel ashamed of it. The most humble organism is something much higher than the inorganic dust under our feet; and no one with an unbiased mind can study any living creature, however humble, without being struck with enthusiasm at its marvelous structure and properties.

DOES MANKIND CONSIST OF SEVERAL SPECIES?

Descent of Man, page 176.

The question whether mankind consists of one or several species has of late years been much discussed by anthropologists, who are divided into the two schools of monogenists and polygenists. Those who do not admit the principle of evolution must look at species as separate creations, or as in some manner as distinct entities; and they must decide what forms of man they will consider as species by the analogy of the method commonly pursued in ranking other organic beings as species. But it is a hopeless endeavor to decide this point, until some definition of the term "species" is generally accepted; and the definition must not include an indeterminate element such as an act of creation. We might as well attempt without any definition to decide whether a certain number of houses should be called a village, town, or city. We have a practical illustration of the difficulty in the never-ending doubts whether many closely-allied mammals, birds, insects, and plants, which represent each other respectively in North America and Europe, should be ranked as species or geographical races; and the like holds true of the productions of many islands situated at some little distance from the nearest continent.

Those naturalists, on the other hand, who admit the principle of evolution, and this is now admitted by the majority of rising men, will feel no doubt that all the races of man are descended from a single primitive stock; whether or not they may think fit to designate the races as distinct species, for the sake of expressing their amount of difference. With our domestic animals, the question whether the various races have arisen from one or more species is somewhat different. Although it may be admitted that all the races, as well as all the natural species within the same genus, have sprung from the same primitive stock, yet it is a fit subject for discussion whether all the domestic races of the dog, for instance, have acquired their present amount of difference since some one species was first domesticated by man; or whether they owe some of their characters to inheritance from distinct species which had already been differentiated in a state of nature. With man no such question can arise, for he can not be said to have been domesticated at any particular period.

During an early stage in the divergence of the races of man from a common stock, the differences between the races and their number must have been small; consequently, as far as their distinguishing characters are concerned, they then had less claim to rank as distinct species than the existing so-called races. Nevertheless, so arbitrary is the term of species, that such early races would, perhaps, have been ranked by some naturalists as distinct species, if their differences, although extremely slight, had been more constant than they are at present, and had not graduated into each other.

THE RACES GRADUATE INTO EACH OTHER.

Page 174. But the most weighty of all the arguments against treating the races of man as distinct species is, that they gradnate into each other, independently, in many cases, as far as we can judge, of their having intercrossed. Man has been studied more carefully than any other animal, and yet there is the greatest possible diversity among capable judges whether he should be classed as a single species or race, or as two (Virey), as three (Jacquinot), as four (Kant), five (Blumenbach), six (Buffon), seven (Hunter), eight (Agassiz), eleven (Pickering), fifteen (Bory St. Vincent), sixteen (Desmoulins), twenty-two (Morton), sixty (Crawfurd), or as sixty-three, according to Burke. This diversity of judgment does not prove that the races ought not to be ranked as species, but it shows that they graduate into each other, and that it is hardly possible to discover clear, distinctive characters between them.

Every naturalist who has had the misfortune to undertake the description of a group of highly-varying organisms, has encountered cases (I speak after experience) precisely like that of man; and, if of a cautious disposition, he will end by uniting all the forms which graduate into each other under a single species; for he will say to himself that he has no right to give names to objects which he can not define. Cases of this kind occur in the order which includes man, namely, in certain genera of monkeys; while in other genera, as in *Cercopithecus*, most of the species can be determined with certainty. In the American genus *Cebus*, the various forms are ranked by some naturalists as species, by others as mere geographical races. Now, if numerous specimens of *Cebus* were collected from all parts of South America, and those forms which at present appear to be specifically distinct were found to graduate into each other by close steps, they would usually be ranked as mere varieties or races; and this course has been followed by most naturalists with respect to the races of man.

WAS THE FIRST MAN A SPEAKING ANIMAL?

Page 180. From the fundamental differences between certain languages, some philologists have inferred that when man first became widely diffused, he was not a speaking animal; but it may be suspected that languages, far less perfect than any now spoken, aided by gestures, might have been used, and yet have left no traces on subsequent and more highly-developed tongues. Without the use of some language, however imperfect, it appears doubtful whether man's intellect could have risen to the standard implied by his dominant position at an early period.

Whether primeval man, when he possessed but few arts, and those of the rudest kind, and when his power of language was extremely imperfect, would have deserved to be called man, must depend on the definition which we employ. In a series of forms graduating insensibly from some ape-like creature to man as he now exists, it would be impossible to fix on any definite point when the term "man" ought to be used. But this is a matter of very little importance. So, again, it is almost a matter of indifference whether the so-called races of man are thus designated, or are ranked as species or sub-species; but the latter term appears the more appropriate. Finally, we may conclude that, when the principle of evolution is generally accepted, as it surely will be before long, the dispute between the monogenists and the polygenists will die a silent and unobserved death.

THE THEORY OF A SINGLE PAIR.

One other question ought not to be passed over without notice, namely, whether, as is sometimes assumed, each sub-species or race of man has sprung from a single pair of progenitors. With our domestic animals a new race can readily be formed by carefully matching the varying offspring from a single pair, or even from a single individual possessing some new character; but most of our races have been formed, not intentionally from a selected pair, but unconsciously, by the preservation of many individuals which have varied, however slightly, in some useful or desired manner. If in one country stronger and heavier horses, and in another country lighter and fleeter ones were habitually preferred, we may feel sure that two distinct sub-breeds would be produced in the course of time, without any one pair having been separated and bred from in either country. Many races have been thus formed, and their manner of formation is closely analogous to that of natural species. We know, also, that the horses taken to the Falkland Islands have, during successive generations, become smaller and weaker, while those which have run wild on the Pampas have acquired larger and coarser heads; and such changes are manifestly due, not to any one pair, but to all the individuals having been subjected to the same conditions, aided, perhaps, by the principle of reversion. The new sub-breeds in such cases are not descended from any single pair, but from many individuals which have varied in different degrees, but in the same general manner; and we many conclude that the races of man have been similarly produced, the modifications being either the direct result of exposure to different conditions, or the indirect result of some form of selection.

CIVILIZED OUT OF EXISTENCE.

Descent of Man, page 183.

When Tasmania was first colonized the natives were roughly estimated by some at seven thousand and by others at twenty thousand. Their number was soon greatly reduced, chiefly by fighting with the English and with each other. After the famous hunt by all the colonists, when the remaining natives delivered themselves up to the government, they consisted only of one hundred and twenty individuals, who were in 1832 transported to Flinders Island. This island, situated between Tasmania and Australia, is forty miles long, and from twelve to eighteen miles broad: it seems healthy, and the natives were well treated. Nevertheless, they suffered greatly in health. In 1834 they consisted (Bonwick, p. 250) of forty-seven adult males, forty-eight adult females, and sixteen children, or in all of one hundred and eleven souls. In 1835 only one hundred were left. As they continued rapidly to decrease, and as they themselves thought that they should not perish so quickly elsewhere, they were removed in 1847 to Oyster Cove in the southern part of Tasmania. They then consisted (December 20, 1847) of fourteen men, twenty-two women, and ten children. But the change of site did no good. Disease and death still pursued them, and in 1864 one man (who died in 1869) and three elderly women alone survived. The infertility of the women is even a more remarkable fact than the liability of all to ill-health and death. At the time when only nine women were left at Oyster Cove, they told Mr. Bonwick (p. 386), that only two had ever borne children: and these two had together produced only three children!

With respect to the cause of this extraordinary state of things, Dr. Story remarks that death followed the attempts to civilize the natives. "If left to themselves to roam as they were wont and undisturbed, they would have reared more children, and there would have been less mortality." Another careful observer of the natives, Mr. Davis, remarks: "The births have been few and the deaths numerous. This may have been in a great measure owing to their change of living and food; but more so to their banishment from the mainland of Van Diemen's Land, and consequent depression of spirits" (Bonwick, pp. 388, 390).

Page 191. Although the gradual decrease and ultimate extinction of the races of man is a highly complex problem, depending on many causes which differ in different places and at different times, it is the same problem as that presented by the extinction of one of the higher animals—of the fossil horse, for instance, which disappeared from South America, soon afterward to be replaced, within the same districts, by countless troops of the Spanish horse. The New-Zealander seems conscious of this parallelism, for he compares his future fate with that of the native rat, now almost exterminated by the European rat. Though the difficulty is great to our imagination, and really great, if we wish to ascertain the precise causes and their manner of action, it ought not to be so to our reason, as long as we keep steadily in mind that the increase of each species and each race is constantly checked in various ways; so that, if any new check, even a slight one, be superadded, the race will surely decrease in number; and decreasing numbers will sooner or later lead to extinction; the end, in most cases, being promptly determined by the inroads of conquering tribes.

XI.

SEXUAL SELECTION AS AN AGENCY TO ACCOUNT FOR THE DIFFERENCES BETWEEN THE RACES OF MAN.

Descent of Man, page 198.

We have thus far been baffled in all our attempts to account for the differences between the races of man; but there remains one important agency, namely, sexual selection, which appears to have acted powerfully on man, as on many other animals. I do not intend to assert that sexual selection will account for all the differences between the races. An unexplained residuum is left, about which we can only say, in our ignorance, that as individuals are continually born with, for instance, heads a little rounder or narrower, and with noses a little longer or shorter, such slight differences might become fixed and uniform, if the unknown agencies which induced them were to act in a more constant manner, aided by long-continued intercrossing. Such variations come under the provisional class, alluded to in our second chapter, which for the want of a better term are often called spontaneous. Nor do I pretend that the effects of sexual selection can be indicated with scientific precision; but it can be shown that it would be an inexplicable fact if man had not been modified by this agency, which appears to have acted powerfully on innumerable animals. It can further be shown that the differences between the races of man, as in color, hairiness, form of features, etc., are of a kind which might have been expected to come under the influence of sexual selection.

STRUGGLE OF THE MALES FOR THE POSSESSION OF THE FEMALES.

Descent of Man, page 213.

There can be no doubt that with almost all animals, in which the sexes are separate, there is a constantly recurrent struggle between the males for the possession of the females.

Our difficulty in regard to sexual selection lies in understanding how it is that the males which conquer other males, or those which prove the most attractive to the females, leave a greater number of offspring to inherit their superiority than their beaten and less attractive rivals. Unless this result does follow, the characters which give to certain males an advantage over others could not be perfected and augmented through sexual selection. When the sexes exist in exactly equal numbers, the worst-endowed males will (except where polygamy prevails) ultimately find females, and leave as many offspring, as well fitted for their general habits of life, as the best-endowed males. From various facts and considerations, I formerly inferred that with most animals, in which secondary sexual characters are well developed, the males considerably exceeded the females in number; but this is not by any means always true. If the males were to the females as two to one, or as three to two, or even in a somewhat lower ratio, the whole affair would be simple; for the better-armed or more attractive males would leave the largest number of offspring. But, after investigating, as far as possible, the numerical proportion of the sexes, I do not believe that any great inequality in number commonly exists. In most cases sexual selection appears to have been effective in the following manner:

Let us take any species, a bird for instance, and divide the females inhabiting a district into two equal bodies, the one consisting of the more vigorous and better-nourished individuals, and the other of the less vigorous and healthy. The former, there can be little doubt, would be ready to breed in the spring before the others; and this is the opinion of Mr. Jenner Weir, who has carefully attended to the habits of birds during many years. There can also be no doubt that the most vigorous, best-nourished, and earliest breeders would on an average succeed in rearing the largest number of fine offspring. The males, as we have seen, are generally ready to breed before the females; the strongest, and with some species the best armed of the males, drive away the weaker; and the former would then unite with the more vigorous and better-nourished females, because they are the first to breed. Such vigorous pairs would surely rear a larger number of offspring than the retarded females, which would be compelled to unite with the conquered and less powerful males, supposing the sexes to be numerically equal; and this is all that is wanted to add, in the course of successive generations, to the size, strength, and courage of the males, or to improve their weapons.

COURTSHIP AMONG THE LOWER ANIMALS.

Page 214. But in very many cases the males which conquer their rivals do not obtain possession of the females, independently of the choice of the latter. The courtship of animals is by no means so simple and short an affair as might be thought. The females are most excited by, or prefer pairing with, the more ornamented males, or those which are the best songsters, or play the best antics; but it is obviously probable that they would at the same time prefer the more vigorous and lively males, and this has in some cases been confirmed by actual observation. Thus, the more vigorous females, which are the first to breed, will have the choice of many males; and, though they may not always select the strongest or best armed, they will select those which are vigorous and well armed, and in other respects the most attractive. Both sexes, therefore, of such early pairs would, as above explained, have an advantage over others in rearing offspring; and this apparently has sufficed, during a long course of generations, to add not only to the strength and fighting powers of the males, but likewise to their various ornaments or other attractions.

In the converse and much rarer case, of the males selecting particular females, it is plain that those which were the most vigorous, and had conquered others, would have the freest choice; and it is almost certain that they would select vigorous as well as attractive females. Such pairs would have an advantage in rearing offspring, more especially if the male had the power to defend the female during the pairing-season, as occurs with some of the higher animals, or aided her in providing for the young. The same principles would apply if each sex preferred and selected certain individuals of the opposite sex; supposing that they selected not only the more attractive but likewise the more vigorous individuals.

WHY THE MALE PLAYS THE MORE ACTIVE PART IN COURTING.

Page 222. We are naturally led to inquire why the male, in so many and such distinct classes, has become more eager than the female, so that he searches for her, and plays the more active part in courtship. It would be no advantage, and some loss of power, if each sex searched for the other; but why should the male almost always be the seeker? The ovules of plants after fertilization have to be nourished for a time; hence the pollen is necessarily brought to the female organs—being placed on the stigma by means of insects or the wind, or by the spontaneous movements of the stamens; and, in the *Algæ*, etc., by the locomotive power of the antherozoöids. With lowly-organized aquatic animals, permanently affixed to the same spot, and having their sexes separate, the male element is invariably brought to the female; and of this we can see the reason, for even if the ova were detached before fertilization, and did not require subsequent nourishment or protection, there would yet be greater difficulty in transporting them than the male element, because, being larger than the latter, they are produced in far smaller numbers. So that many of the lower animals are, in this respect, analogous with plants. The males of affixed and aquatic animals, having been led to emit their fertilizing element in this way, it is natural that any of their descendants, which rose in the scale and became locomotive, should retain the same habit; and they would approach the female as closely as possible, in order not to risk the loss of the fertilizing element in a long passage of it through the water. With some few of the lower animals, the females alone are fixed, and the males of these must be the seekers. But it is difficult to understand why the males of species, of which the progenitors were primordially free, should invariably have acquired the habit of approaching the females, instead of being approached by them. But, in all cases, in order that the males should seek efficiently, it would be necessary that they should be endowed with strong passions; and the acquirement of such passions would naturally follow from the more eager leaving a larger number of offspring than the less eager.

TRANSMISSION OF SEXUAL CHARACTERISTICS.

Page 232. Why certain characters should be inherited by both sexes, and other characters by one sex alone, namely, by that sex in which the character first appeared, is in most cases quite unknown. We can not even conjecture why, with certain sub-breeds of the pigeon, black striæ, though transmitted through the female, should be developed in the male alone, while every other character is equally transferred to both sexes. Why, again, with cats, the tortoise-shell color should, with rare exceptions, be developed in the female alone. The very same character, such as deficient or supernumerary digits, color-blindness, etc., may with mankind be inherited by the males alone of one family, and in another family by the females alone, though in both cases transmitted through the opposite as well as through the same sex. Although we are thus ignorant, the two following rules seem often to hold good: that variations which first appear in either sex at a late period of life tend to be developed in the same sex alone; while variations which first appear early in life in either sex tend to be developed in both sexes. I am, however, far from supposing that this is the sole determining cause.

Page 233. An excellent case for investigation is afforded by the deer family. In all the species, but one, the horns are developed only in the males, though certainly transmitted through the females, and capable of abnormal development in them. In the reindeer, on the other hand, the female is provided with horns; so that, in this species, the horns ought, according to our rule, to appear early in life, long before the two sexes are mature, and have come to differ much in constitution. In all the other species the horns ought to appear later in life, which would lead to their development in that sex alone in which they first appeared in the progenitor of the whole family. Now, in seven species, belonging to distinct sections of the family, and inhabiting different regions, in which the stags alone bear horns, I find that the horns first appear at periods varying from nine months after birth in the roebuck, to ten, twelve, or even more months in the stags of the six other and larger species. But with the reindeer the case is widely different; for, as I hear from Professor Nilsson, who kindly made special inquiries for me in Lapland, the horns appear in the young animals within four or five weeks after birth, and at the same time in both sexes. So that here we have a structure developed at a most unusually early age in one species of the family, and likewise common to both sexes in this one species alone.

Page 239. Finally, from what we have now seen of the relation which exists in many natural species and domesticated races, between the period of the development of their characters and the manner of their transmission—for example, the striking fact of the early growth of the horns in the reindeer, in which both sexes bear horns, in comparison with their much later growth in the other species in which the male alone bears horns—we may conclude that one, though not the sole cause of characters being exclusively inherited by one sex, is their development at a late age. And, secondly, that one, though apparently a less efficient cause of characters being inherited by both sexes, is their development at an early age, while the sexes differ but little in constitution. It appears, however, that some difference must exist between the sexes even during a very early embryonic period, for characters developed at this age not rarely become attached to one sex.

AN OBJECTION ANSWERED.

Descent of Man, page 495.

Several writers have objected to the whole theory of sexual selection, by assuming that with animals and savages the taste of the female for certain colors or other ornaments would not remain constant for many generations; that first one color and then another would be admired, and consequently that no permanent effect could be produced. We may admit that taste is fluctuating, but it is not quite arbitrary. It depends much on habit, as we see in mankind; and we may infer that this would hold good with birds and other animals. Even in our own dress, the general character lasts long, and the changes are to a certain extent graduated. Abundant evidence will be given in two places in a future chapter, that savages of many races have admired for many generations the same cicatrices on the skin, the same hideously perforated lips, nostrils, or ears, distorted heads, etc.; and these deformities present some analogy to the natural ornaments of various animals. Nevertheless, with savages such fashions do not endure forever, as we may infer from the differences in this respect between allied tribes on the same continent. So again the raisers of fancy animals certainly have admired for many generations and still admire the same breeds; they earnestly desire slight changes, which are considered as improvements, but any great or sudden change is looked at as the greatest blemish. With birds in a state of nature we have no reason to suppose that they would admire an entirely new style of coloration, even if great and sudden variation often occurred, which is far from being the case. We know that dovecot pigeons do not willingly associate with the variously colored fancy breeds; that albino birds do not commonly get partners in marriage; and that the black ravens of the Feroe Islands chase away their piebald brethren. But this dislike of a sudden change would not preclude their appreciating slight changes, any more than it does in the case of man. Hence with respect to taste, which depends on many elements, but partly on habit and partly on a love of novelty, there seems no improbability in animals admiring for a very long period the same general style of ornamentation or other attractions, and yet appreciating slight changes in colors, form, or sound.

DIFFERENCE BETWEEN THE SEXES CREATED BY SEXUAL SELECTION.

Page 563. There can be little doubt that the greater size and strength of man, in comparison with woman, together with his broader shoulders, more developed muscles, rugged outline of body, his greater courage and pugnacity, are all due in chief part to inheritance from his half-human male ancestors. These characters would, however, have been preserved or even augmented during the long ages of man's savagery, by the success of the strongest and boldest men, both in the general struggle for life and in their contest for wives; a success which would have insured their leaving a more numerous progeny than their less favored brethren. It is not probable that the greater strength of man was primarily acquired through the inherited effects of his having worked harder than woman for his own subsistence and that of his family; for the women in all barbarous nations are compelled to work at least as hard as the men. With civilized people the arbitrament of battle for the possession of the women has long ceased; on the other hand, the men, as a general rule, have to work harder than the women for their joint subsistence, and thus their greater strength will have been kept up.

With respect to differences of this nature between man and woman, it is probable that sexual selection has played a highly important part. I am aware that some writers doubt whether there is any such inherent difference; but this is at least probable from the analogy of the lower animals which present other secondary sexual characters. No one disputes that the bull differs in disposition from the cow, the wild-boar from the sow, the stallion from the mare, and, as is well known to the keepers of menageries, the males of the larger apes from the females. Woman seems to differ from man in mental disposition, chiefly in her greater tenderness and less selfishness; and this holds good even with savages, as shown by a well-known passage in Mungo Park's "Travels," and by statements made by many other travelers. Woman, owing to her maternal instincts, displays these qualities toward her infants in an eminent degree; therefore it is likely that she would often extend them toward her fellow-creatures. Man is the rival of other men; he delights in competition, and this leads to ambition which passes too easily into selfishness. These latter qualities seem to be his natural and unfortunate birthright. It is generally admitted that with woman the powers of intuition, of rapid perception, and perhaps of imitation, are more strongly marked than in man ; but some, at least, of these faculties are characteristic of the lower races, and therefore of a past and lower state of civilization.

The chief distinction in the intellectual powers of the two sexes is shown by man's attaining to a higher eminence, in whatever he takes up, than can woman—whether requiring deep thought, reason, or imagination, or merely the use of the senses and hands. If two lists were made of the most eminent men and women in poetry, painting, sculpture, music (inclusive both of composition and performance), history, science, and philosophy, with half a dozen names under each subject, the two lists would not bear comparison. We may also infer, from the law of the deviation from averages, so well illustrated by Mr. Galton, in his work on "Hereditary Genius," that if men are capable of a decided pre-eminence over women in many subjects, the average of mental power in man must be above that of woman.

Among the half-human progenitors of man, and among savages, there have been struggles between the males during many generations for the possession of the females. But mere bodily strength and size would do little for victory, unless associated with courage, perseverance, and determined energy. With social animals, the young males have to pass through many a contest before they win a female, and the older males have to retain their females by renewed battles. They have, also, in the case of mankind, to defend their females, as well as their young, from enemies of all kinds, and to hunt for their joint subsistence. But to avoid enemies or to attack them with success, to capture wild animals, or to fashion weapons, requires the aid of the higher mental faculties, namely, observation, reason, invention, or imagination. These various faculties will thus have been continually put to the test and selected during manhood ; they will, moreover, have been strengthened by use during this same period of life. Consequently, in accordance with the principle often alluded to, we might expect that they would at least tend to be transmitted chiefly to the male offspring at the corresponding period of manhood.

HOW WOMAN COULD BE MADE TO REACH THE STANDARD OF MAN.

Page 565. It must be borne in mind that the tendency in characters acquired by either sex late in life, to be transmitted to the same sex at the same age, and of early acquired characters to be transmitted to both sexes, are rules which, though general, do not always hold. If they always held good, we might conclude (but I here exceed my proper bounds) that the inherited effects of the early education of boys and girls would be transmitted equally to both sexes; so that the present inequality in mental power between the sexes would not be effaced by a similar course of early training ; nor can it have been caused by their dissimilar early training. In order that woman should reach the same standard as man, she ought, when nearly adult, to be trained to energy and perseverance, and to have her reason and imagination exercised to the highest point ; and then she would probably transmit these qualities chiefly to her adult daughters. All women, however, could not be thus raised, unless during many generations those who excelled in the above robust virtues were married, and produced offspring in larger numbers than other women. As before remarked of bodily strength, although men do not now fight for their wives, and this form of selection has passed away, yet during manhood they generally undergo a severe struggle in order to maintain themselves and their families; and this will tend to keep up or even increase their mental powers, and, as a consequence, the present inequality between the sexes.

"CHARACTERISTIC SELFISHNESS OF MAN."

Page 577. In most, but not all parts of the world, the men are more ornamented than the women, and often in a different manner; sometimes, though rarely, the women are hardly at all ornamented. As the women are made by savages to perform the greatest share of the work, and as they are not allowed to eat the best kinds of food, so it accords with the characteristic selfishness of man that they should not be allowed to obtain or use the finest ornaments. Lastly, it is a remarkable fact, as proved by the foregoing quotations, that the same fashions in modifying the shape of the head, in ornamenting the hair, in painting, tattooing, in perforating the nose, lips, or ears, in removing or filing the teeth, etc., now prevail, and have long prevailed, in the most distant quarters of the world. It is extremely improbable that these practices, followed by so many distinct nations, should be due to tradition from any common source. They indicate the close similarity of the mind of man, to whatever race he may belong, just as do the almost universal habits of dancing, masquerading, and making rude pictures.

NO UNIVERSAL STANDARD OF BEAUTY AMONG MANKIND.

Page 584. The senses of man and of the lower animals seem to be so constituted that brilliant colors and certain forms, as well as harmonious and rhythmical sounds, give pleasure and are called beautiful; but why this should be so we know not. It is certainly not true that there is in the mind of man any universal standard of beauty with respect to the human body. It is, however, possible that certain tastes may in the course of time become inherited, though there is no evidence in favor of this belief; and if so each race would possess its own innate ideal standard of beauty. It has been argued that ugliness consists in an approach to the structure of the lower animals, and no doubt this is partly true with the more civilized nations, in which intellect is highly appreciated; but this explanation will hardly apply to all forms of ugliness. The men of each race prefer what they are accustomed to; they can not endure any great change; but they like variety, and admire each characteristic carried to a moderate extreme. Men accustomed to a nearly oval face, to straight and regular features, and to bright colors, admire, as we Europeans know, these points when strongly developed. On the other hand, men accustomed to a broad face, with high cheekbones, a depressed nose, and a black skin, admire these peculiarities when strongly marked. No doubt characters of all kinds may be too much developed for beauty. Hence a perfect beauty, which implies many characters modified in a particular manner, will be in every race a prodigy. As the great anatomist Bichat long ago said, if every one were cast in the same mold, there would be no such thing as beauty. If all our women were to become as beautiful as the Venus de' Medici, we should for a time be charmed; but we should soon wish for variety; and, as soon as we had obtained variety, we should wish to see certain characters a little exaggerated beyond the then existing common standard.

Page 578. It is well known that with many Hottentot women the posterior part of the body projects in a wonderful manner; they are steatopygous; and Sir Andrew Smith is certain that this peculiarity is greatly admired by the men. He once saw a woman who was considered a beauty, and she was so immensely developed behind, that when seated on level ground she could not rise, and had to push herself along until she came to a slope. Some of the women in the various negro tribes have the same peculiarity; and, according to Burton, the Somal men "are said to choose their wives by ranging them in a line, and by picking her out who projects farthest *a tergo*. Nothing can be more hateful to a negro than the opposite form."

DEVELOPMENT OF THE BEARD.

Page 602. With respect to the beard in man, if we turn to our best guide, the Quadrumana, we find beards equally developed in both sexes of many species, but in some, either confined to the males, or more developed in them than in the females. From this fact and from the curious arrangement, as well as the bright colors of the hair about the head of many monkeys, it is highly probable, as before explained, that the males first acquired their beards through sexual selection as an ornament, transmitting them in most cases, equally or nearly so, to their offspring of both sexes. We know from

Eschricht that, with mankind, the female as well as the male fœtus is furnished with much hair on the face, especially round the mouth; and this indicates that we are descended from progenitors of whom both sexes are bearded. It appears therefore at first sight probable that man has retained his beard from a very early period, while woman lost her beard at the same time that her body became almost completely divested of hair. Even the color of our beards seems to have been inherited from an ape-like progenitor; for, when there is any difference in tint between the hair of the head and the beard, the latter is lighter colored in all monkeys and in man. In those Quadrumana in which the male has a larger beard than that of the female, it is fully developed only at maturity, just as with mankind; and it is possible that only the later stages of development have been retained by man. In opposition to this view of the retention of the beard from an early period, is the fact of its great variability in different races, and even within the same race; for this indicates reversion—long-lost characters being very apt to vary on reappearance.

DEVELOPMENT OF THE MARRIAGE-TIE.

Descent of Man, page 590.

Although the manner of the development of the marriage-tie is an obscure subject, as we may infer from the divergent opinions on several points between the three authors who have studied it most closely, namely, Mr. Morgan, Mr. McLennan, and Sir J. Lubbock, yet, from the foregoing and several other lines of evidence, it seems probable that the habit of marriage, in any strict sense of the word, has been gradually developed; and that almost promiscuous, or very loose, intercourse was once extremely common throughout the world. Nevertheless, from the strength of the feeling of jealousy all through the animal kingdom, as well as from the analogy of the lower animals, more particularly of those which come nearest to man, I can not believe that absolutely promiscuous intercourse prevailed in times past, shortly before man attained to his present rank in the zoölogical scale. Man, as I have attempted to show, is certainly descended from some ape-like creature. With the existing Quadrumana, as far as their habits are known, the males of some species are monogamous, but live during only a part of the year with the females; of this the orang seems to afford an instance. Several kinds, for example, some of the Indian and American monkeys, are strictly monogamous, and associate all the year round with their wives. Others are polygamous, for example, the gorilla and several American species, and each family lives separate.

Page 591. Therefore, looking far enough back in the stream of time, and judging from the social habits of man as he now exists, the most probable view is that he aboriginally lived in small communities, each with a single wife, or, if powerful, with several, whom he jealously guarded against all other men. Or he may not have been a social animal, and yet have lived with several wives, like the gorilla; for all the natives "agree that but one adult male is seen in a band; when the young male grows up, a contest takes place for mastery, and the strongest, by killing and driving out the others, establishes himself as the head of the community." The younger males, being thus expelled and wandering about, would, when at last successful in finding a partner, prevent too close interbreeding within the limits of the same family.

Although savages are now extremely licentious, and although communal marriages may formerly have largely prevailed, yet many tribes practice some form of marriage, but of a far more lax nature than that of civilized nations. Polygamy, as just stated, is almost universally followed by the leading men in every tribe. Nevertheless, there are tribes, standing almost at the bottom of the scale, which are strictly monogamous. This is the case with the Veddahs of Ceylon; they have a saying, according to Sir J. Lubbock, that "death alone can separate husband and wife." An intelligent Kandyan chief, of course a polygamist, "was perfectly scandalized at the utter barbarism of living with only one wife, and never parting until separated by death." It was, he said, "just like the Wanderoo monkeys." Whether savages who now enter into some form of marriage, either polygamous or monogamous, have retained this habit from primeval times, or whether they have returned to some form of marriage, after passing through a stage of promiscuous intercourse, I will not pretend to conjecture.

UNNATURAL SELECTION IN MARRIAGE.

Descent of Man, page 617.

Man scans with scrupulous care the character and pedigree of his horses, cattle, and dogs before he matches them; but, when he comes to his own marriage, he rarely or never takes any such care. He is impelled by nearly the same motives as the lower animals, when they are left to their own free choice, though he is in so far superior to them that he highly values mental charms and virtues. On the other hand, he is strongly attracted by mere wealth or rank. Yet he might by selection do something not only for the bodily constitution and frame of his offspring, but for their intellectual and moral qualities. Both sexes ought to refrain from marriage, if they are in any marked degree inferior in body or mind; but such hopes are Utopian, and will never be even partially realized until the laws of inheritance are thoroughly known. Every one does good service who aids toward this end. When the principles of breeding and inheritance are better understood, we shall not hear ignorant members of our Legislature rejecting with scorn a plan for ascertaining whether or not consanguineous marriages are injurious to man.

The advancement of the welfare of mankind is a most intricate problem: all ought to refrain from marriage who can not avoid abject poverty for their children; for poverty is not only a great evil, but tends to its own increase by leading to recklessness in marriage. On the other hand, as Mr. Galton has remarked, if the prudent avoid marriage, while the reckless marry, the inferior members tend to supplant the better members of society. Man, like every other animal, has no doubt advanced to his present high condition through a struggle for existence consequent on his rapid multiplication; and, if he is to advance still higher, it is to be feared that he must remain subject to a severe struggle. Otherwise he would sink into indolence, and the more gifted men would not be more successful in the battle of life than the less gifted. Hence our natural rate of increase, though leading to many and obvious evils, must not be greatly diminished by any means. There should be open competition for all men; and the most able should not be prevented by laws or customs from succeeding best, and rearing the largest number of offspring. Important as the struggle for existence has been, and even still is, yet, as far as the highest part of man's nature is concerned, there are other agencies more important. For the moral qualities are advanced, either directly or indirectly, much more through the effects of habit, the reasoning powers, instruction, religion, etc., than through natural selection; though to this latter agency may be safely attributed the social instincts which afforded the basis for the development of the moral sense.

MODIFYING INFLUENCES IN BOTH SEXES.

Page 596. With animals in a state of nature, many characters proper to the males, such as size, strength, special weapons, courage, and pugnacity, have been acquired through the law of battle. The semi-human progenitors of man, like their allies the Quadrumana, will almost certainly have been thus modified; and, as savages still fight for the possession of their women, a similar process of selection has probably gone on in a greater or less degree to the present day. Other characters proper to the males of the lower animals, such as bright colors and various ornaments, have been acquired by the more attractive males having been preferred by the females. There are, however, exceptional cases in which the males are the selectors, instead of having been the selected. We recognize such cases by the females being more highly ornamented than the males—their ornamental characters having been transmitted exclusively or chiefly to their female offspring. One such case has been described in the order to which man belongs, that of the Rhesus monkey.

Man is more powerful in body and mind than woman, and in the savage state he keeps her in a far more abject state of bondage than does the male of any other animal; therefore it is not surprising that he should have gained the power of selection. Women are everywhere conscious of the value of their own beauty; and, when they have the means, they take more delight in decorating themselves with all sorts of ornaments than do men. They borrow the plumes of male birds, with which nature has decked this sex in order to charm the females. As women have long been selected for beauty, it is not surprising that some of their successive variations should have been transmitted exclusively to the same sex; consequently that they should have transmitted beauty in a somewhat higher degree to their female than to their male offspring, and thus have become more beautiful, according to general opinion, than men. Women, however, certainly transmit most of their characters, including some beauty, to their offspring of both sexes; so that the continued preference by the men of each race for the more attractive women, according to their standard of taste, will have tended to modify in the same manner all the individuals of both sexes belonging to the race.

Page 617.

He who admits the principle of sexual selection will be led to the remarkable conclusion that the nervous system not only regulates most of the existing functions of the body, but has indirectly influenced the progressive development of various bodily structures and of certain mental qualities. Courage, pugnacity, perseverance, strength and size of body, weapons of all kinds, musical organs, both vocal and instrumental, bright colors and ornamental appendages, have all been indirectly gained by the one sex or the other, through the exertion of choice, the influence of love and jealousy, and the appreciation of the beautiful in sound, color, or form; and these powers of the mind manifestly depend on the development of the brain.

"GROUNDS THAT WILL NEVER BE SHAKEN."

Descent of Man, page 606.

Many of the views which have been advanced are highly speculative, and some no doubt will prove erroneous; but I have in every case given the reasons which have led me to one view rather than to another. It seemed worth while to try how far the principle of evolution would throw light on some of the more complex problems in the natural history of man. False facts are highly injurious to the progress of science, for they often endure long; but false views, if supported by some evidence, do little harm, for every one takes a salutary pleasure in proving their falseness; and, when this is done, one path toward error is closed and the road to truth is often at the same time opened.

The main conclusion here arrived at, and now held by many naturalists who are well competent to form a sound judgment, is that man is descended from some less highly organized form. The grounds upon which this conclusion rests will never be shaken, for the close similarity between man and the lower animals in embryonic development, as well as in innumerable points of structure and constitution, both of high and of the most trifling importance—the rudiments which he retains, and the abnormal reversions to which he is occasionally liable—are facts which can not be disputed. They have long been known, but until recently they told us nothing with respect to the origin of man. Now, when viewed by the light of our knowledge of the whole organic world, their meaning is unmistakable. The great principle of evolution stands up clear and firm, when these groups of facts are considered in connection with others, such as the mutual affinities of the members of the same group, their geographical distribution in past and present times, and their geological succession. It is incredible that all these facts should speak falsely. He who is not content to look, like a savage, at the phenomena of nature as disconnected, can not any longer believe that man is the work of a separate act of creation. He will be forced to admit that the close resemblance of the embryo of man to that, for instance, of a dog—the construction of his skull, limbs, and whole frame on the same plan with that of other mammals, independently of the uses to which the parts may be put—the occasional reappearance of various structures, for instance of several muscles, which man does not normally possess, but which are common to the Quadrumana—and a crowd of analogous facts—all point in the plainest manner to the conclusion that man is the co-descendant with other mammals of a common progenitor.

XII.

THE EXPRESSION OF THE EMOTIONS IN MAN AND OTHER ANIMALS.

The subject is treated under three Principles: the Principle of Associated Habit; the Principle of Antithesis; and the Principle of the direct action of the nervous system independent of Will and Habit.

THE PRINCIPLE OF ASSOCIATED HABIT.

Expression of the Emotions, page 29.

It is notorious how powerful is the force of habit. The most complex and difficult movements can in time be performed without the least effort or consciousness. It is not positively known how it comes that habit is so efficient in facilitating complex movements; but physiologists admit that "the conducting power of the nervous fibers increases with the frequency of their excitement." This applies to the nerves of motion and sensation, as well as to those connected with the act of thinking. That some physical change is produced in the nerve-cells or nerves which are habitually used can hardly be doubted, for otherwise it is impossible to understand how the tendency to certain acquired movements is inherited.

Page 31.

It is known to every one how difficult or even impossible it is, without repeated trials, to move the limbs in certain opposed directions which have never been practiced. Analogous cases occur with sensations, as in the common experiment of rolling a marble beneath the tips of two crossed fingers, when it feels exactly like two marbles. Every one protects himself when falling to the ground by extending his arms, and as Professor Alison has remarked, few can resist acting thus when voluntarily falling on a soft bed. A man when going out-of-doors puts on his gloves quite unconsciously; and this may seem an extremely simple operation, but he who has taught a child to put on gloves knows that this is by no means the case.

When our minds are much affected, so are the movements of our bodies.

Page 30. To those who admit the gradual evolution of species, a most striking instance of the perfection with which the most difficult consensual movements can be transmitted, is afforded by the humming-bird Sphinx-moth (*Macroglossa*); for this moth, shortly after its emergence from the cocoon, as shown by the bloom on its unruffled scales, may be seen poised stationary in the air, with its long, hair-like proboscis uncurled and inserted into the minute orifices of flowers; and no one, I believe, has ever seen this moth learning to perform its difficult task, which requires such unerring aim.

Page 32. A vulgar man often scratches his head when perplexed in mind; and I believe that he acts thus from habit, as if he experienced a slightly uncomfortable bodily sensation, namely, the itching of his head, to which he is particularly liable, and which he thus relieves. Another man rubs his eyes when perplexed, or gives a little cough when embarrassed, acting in either case as if he felt a slightly uncomfortable sensation in his eyes or windpipe.

From the continued use of the eyes, these organs are especially liable to be acted on through association under various states of the mind, although there is manifestly nothing to be seen. A man, as Gratiolet remarks, who vehemently rejects a proposition, will almost certainly shut his eyes or turn away his face; but, if he accepts the proposition, he will nod his head in affirmation and open his eyes widely. The man acts in this latter case as if he clearly saw the thing, and in the former case as if he did not, or would not, see it. I have noticed that persons in describing a horrid sight often shut their eyes momentarily and firmly, or shake their heads, as if not to see or to drive away something disagreeable; and I have caught myself, when thinking in the dark of a horrid spectacle, closing my eyes firmly.

Page 34. There are other actions which are commonly performed under certain circumstances, independently of habit, and which seem to be due to imitation or some sort of sympathy. Thus persons cutting anything with a pair of scissors may be seen to move their jaws simultaneously with the blades of the scissors. Children learning to write often twist about their tongues as their fingers move, in a ridiculous fashion. When a public singer suddenly becomes a little hoarse, many of those present may be heard, as I have been assured by a gentleman on whom I can rely, to clear their throats; but here habit probably comes into play, as we clear our own throats under similar circumstances.

Page 35. Reflex actions, in the strict sense of the term, are due to the excitement of a peripheral nerve, which transmits its influence to certain nerve-cells, and these, in their turn, excite certain muscles or glands into action; and all this may take place without any sensation or consciousness on our part, though often thus accompanied. As many reflex actions are highly expressive, the subject must here be noticed at some little length. We shall also see that some of them graduate into, and can hardly be distinguished from, actions which have arisen through habit. Coughing and sneezing are familiar instances of reflex actions.

Page 37.

The conscious wish to perform a reflex action sometimes stops or interrupts its performance, though the proper sensory nerves may be stimulated. For instance, many years ago I laid a small wager with a dozen young men that they would not sneeze if they took snuff, although they all declared that they invariably did so; accordingly, they all took a pinch, but, from wishing much to succeed, not one sneezed, though their eyes watered, and all, without exception, had to pay me the wager.

Page 42.

Dogs, when they wish to go to sleep on a carpet or other hard surface, generally turn round and round and scratch the ground with their fore-paws in a senseless manner, as if they intended to trample down the grass and scoop out a hollow, as, no doubt, their wild parents did, when they lived on open, grassy plains or in the woods.

THE PRINCIPLE OF ANTITHESIS.

Expression of the Emotions, page 50.

Certain states of the mind lead, as we have seen in the last chapter, to certain habitual movements which were primarily, or may still be, of service; and we shall find that, when a directly opposite state of mind is induced, there is a strong and involuntary tendency to the performance of movements of a directly opposite nature, though these have never been of any service.

When a dog approaches a strange dog or man in a savage or hostile frame of mind, he walks upright and very stiffly ; his head is slightly raised, or not much lowered ; the tail is held erect and quite rigid ; the hairs bristle, especially along the neck and back ; the pricked ears are directed forward, and the eyes have a fixed stare. These actions follow from the dog's intention to attack his enemy, and are thus to a large extent intelligible. As he prepares to spring with a savage growl on his enemy, the canine teeth are uncovered, and the ears are pressed close backward on the head ; but with these latter actions we are not here concerned. Let us now suppose that the dog suddenly discovers that the man whom he is approaching is not a stranger, but his master ; and let it be observed how completely and instantaneously his whole bearing is reversed. Instead of walking upright, the body sinks downward or even crouches, and is thrown into flexuous movements ; his tail, instead of being held stiff and upright, is lowered and wagged from side to side ; his hair instantly becomes smooth ; his ears are depressed and drawn backward, but not closely to the head ; and his lips hang loosely. From the drawing back of the ears, the eyelids become elongated, and the eyes no longer appear round and staring. It should be added that the animal is at such times in an excited condition from joy ; and nerve-force will be generated in excess, which naturally leads to action of some kind. Not one of the above movements, so clearly expressive of affection, are of the least direct service to the animal. They are explicable, as far as I can see, solely from being in complete opposition or antithesis to the attitude and movements which, from intelligible causes, are assumed when a dog intends to fight, and which consequently are expressive of anger.

ORIGIN OF THE PRINCIPLE OF ANTITHESIS.

Page 60.

We will now consider how the principle of antithesis in expression has arisen. With social animals, the power of intercommunication between the members of the same community—and, with other species, between the opposite sexes, as well as between the young and the old—is of the highest importance to them. This is generally effected by means of the voice, but it is certain that gestures and expressions are to a certain extent mutually intelligible. Man not only uses inarticulate cries, gestures, and expressions, but has invented articulate language ; if, indeed, the word *invented* can be applied to a process completed by innumerable steps, half-consciously made. Any one who has watched monkeys will not doubt that they perfectly understand each other's gestures and expression, and to a large extent, as Rengger asserts, those of man. An animal when going to attack another, or when afraid of another, often makes itself appear terrible, by erecting its hair, thus increasing the apparent bulk of its body, by showing its teeth, or brandishing its horns, or by uttering fierce sounds.

As the power of intercommunication is certainly of high service to many animals, there is no *a priori* improbability in the supposition that gestures manifestly of an opposite nature to those by which certain feelings are already expressed should at first have been voluntarily employed under the influence of an opposite state of feeling. The fact of the gestures being now innate would be no valid objection to the belief that they were at first intentional; for, if practiced during many generations, they would probably at last be inherited. Nevertheless, it is more than doubtful, as we shall immediately see, whether any of the cases which come under our present head of antithesis have thus originated.

With conventional signs which are not innate, such as those used by the deaf and dumb and by savages, the principle of opposition or antithesis has been partially brought into play. The Cistercian monks thought it sinful to speak, and, as they could not avoid holding some communication, they invented a gesture language, in which the principle of opposition seems to have been employed. Dr. Scott, of the Exeter Deaf and Dumb Institution, writes to me that "opposites are greatly used in teaching the deaf and dumb, who have a lively sense of them." Nevertheless I have been surprised how few unequivocal instances can be adduced. This depends partly on all the signs having commonly had some natural origin; and partly on the practice of the deaf and dumb and of savages to contract their signs as much as possible for the sake of rapidity. Hence their natural source or origin often becomes doubtful, or is completely lost; as is likewise the case with articulate language.

Page 64. When a cat, or rather when some early progenitor of the species, from feeling affectionate, first slightly arched its back, held its tail perpendicularly upward and pricked its ears, can it be believed that the animal consciously wished thus to show that its frame of mind was directly the reverse of that when, from being ready to fight or to spring on its prey, it assumed a crouching attitude, curled its tail from side to side, and depressed its ears? Even still less can I believe that my dog voluntarily put on his dejected attitude and "*hot-house face*," which formed so complete a contrast to his previous cheerful attitude and whole bearing. It can not be supposed that he knew that I should understand his expression, and that he could thus soften my heart and make me give up visiting the hot-house.

Hence, for the development of the movements which come under the present head, some other principle, distinct from the will and consciousness, must have intervened. This principle appears to be that every movement which we have voluntarily performed throughout our lives has required the action of certain muscles; and, when we have performed a directly opposite movement, an opposite set of muscles has been habitually brought into play—as in turning to the right or to the left, in pushing away or pulling an object toward us, and in lifting or lowering a weight.

THE PRINCIPLE OF THE ACTION OF THE EXCITED NERVOUS SYSTEM ON THE BODY.

Expression of the Emotions, page 66.

The most striking case, though a rare and abnormal one, which can be adduced of the direct influence of the nervous system, when strongly affected, on the body, is the loss of color in the hair, which has occasionally been observed after extreme terror or grief. One authentic instance has been recorded, in the case of a man brought out for execution in India, in which the change of color was so rapid that it was perceptible to the eye.

Another good case is that of the trembling of the muscles, which is common to man and to many, or most, of the lower animals. Trembling is of no service, often of much disservice, and can not have been at first acquired through the will, and then rendered habitual in association with any emotion. I am assured by an eminent authority that young children do not tremble, but go into convulsions, under the circumstances which would induce excessive trembling in adults. Trembling is excited in different individuals in very different degrees, and by the most diversified causes—by cold to the surface, before fever-fits, although the temperature of the body is then above the normal standard; in blood-poisoning, delirium tremens, and other diseases; by general failure of power in old age; by exhaustion after excessive fatigue; locally from severe injuries, such as burns; and, in an especial manner, by the passage of a catheter. Of all emotions, fear notoriously is the most apt to induce trembling; but so do occasionally great anger and joy. I remember once seeing a boy who had just shot his first snipe on the wing, and his hands trembled to such a degree from delight that he could not for some time reload his gun; and I have heard of an exactly similar case with an Australian savage, to whom a gun had been lent. Fine music, from the vague emotions thus excited, causes a shiver to run down the backs of some persons.

Page 69. When animals suffer from an agony of pain, they generally writhe about with frightful contortions; and those which habitually use their voices utter piercing cries or groans. Almost every muscle of the body is brought into strong action. With man the mouth may be closely compressed, or, more commonly, the lips are retracted, with the teeth clinched or ground together.

Page 75. The heart will be all the more readily affected through habitual associations, as it is not under the control of the will. A man when moderately angry, or even when enraged, may command the movements of his body, but he can not prevent his heart from beating rapidly. His chest will, perhaps, give a few heaves, and his nostrils just quiver, for the movements of respiration are only in part voluntary. In like manner, those muscles of the face which are least obedient to the will will sometimes alone betray a slight and passing emotion. The glands, again, are wholly independent of the will, and a man suffering from grief may command his features, but can not always prevent the tears from coming into his eyes. A hungry man, if tempting food is placed before him, may not show his hunger by any outward gesture, but he can not check the secretion of saliva.

Page 77. With all, or almost all, animals, even with birds, terror causes the body to tremble. The skin becomes pale, sweat breaks out, and the hair bristles.

Page 79. A physician once remarked to me, as a proof of the exciting nature of anger, that a man when excessively jaded will sometimes invent imaginary offenses, and put himself into a passion, unconsciously, for the sake of reinvigorating himself; and, since hearing this remark, I have occasionally recognized its full truth.

Page 81. Exertion stimulates the heart, and this reacts on the brain, and aids the mind to bear its heavy load.

XIII.

MEANS OF THE EXPRESSION OF THE EMOTIONS.

VOCAL ORGANS.

Expression of the Emotions, page 83.

WITH many kinds of animals, man included, the vocal organs are efficient in the highest degree as a means of expression. We have seen in the last chapter that, when the sensorium is strongly excited, the muscles of the body are generally thrown into violent action; and, as a consequence, loud sounds are uttered, however silent the animal may generally be, and although the sounds may be of no use. Hares and rabbits, for instance, never, I believe, use their vocal organs, except in the extremity of suffering; as, when a wounded hare is killed by the sportsman, or when a young rabbit is caught by a stoat. Cattle and horses suffer great pain in silence, but when this is excessive, and especially when associated with terror, they utter fearful sounds.

Page 87.

That animals utter musical notes is familiar to every one, as we may daily hear in the singing of birds. It is a more remarkable fact that an ape, one of the Gibbons, produces an exact octave of musical sounds, ascending and descending the scale by half-tones; so that this monkey, "alone of brute mammals, may be said to sing." From this fact, and from the analogy of other animals, I have been led to infer that the progenitors of man probably uttered musical tones before they had acquired the power of articulate speech; and that, consequently, when the voice is used under any strong emotion, it tends to assume, through the principle of association, a musical character.

ERECTION OF THE HAIR.

Page 96.

The enraged lion erects his mane. The bristling of the hair along the neck and back of the dog, and over the whole body of the cat, especially on the tail, is familiar to every one. With the cat it apparently occurs only under fear; with the dog, under anger and fear; but not, as far as I have observed, under abject fear, as when a dog is going to be flogged by a severe gamekeeper. If, however, the dog shows fight, as sometimes happens, up goes his hair. I have often noticed that the hair of a dog is particularly liable to rise if he is half angry and half afraid, as on beholding some object only indistinctly seen in the dusk.

Page 97.

Birds belonging to all the chief orders ruffle their feathers when angry or frightened. Every one must have seen two cocks, even quite young birds, preparing to fight with erected neck-hackles; nor can these feathers when erected serve as a means of defense, for cock-fighters have found by experience that it is advantageous to trim them. The male Ruff (*Machetes pugnax*) likewise erects its collar of feathers when fighting. When a dog approaches a common hen with her chickens, she spreads out her wings, raises her tail, ruffles all her feathers, and, looking as ferocious as possible, dashes at the intruder.

Page 105. Several kinds of snakes inflate themselves when irritated. The puff-adder (*Clotho arietans*) is remarkable in this respect; but, I believe, after carefully watching these animals, that they do not act thus for the sake of increasing their apparent bulk, but simply for inhaling a large supply of air, so as to produce their surprisingly loud, harsh, and prolonged hissing sound.

ERECTION OF THE EARS.

Page 111. The ears through their movements are highly expressive in many animals; but in some, such as man, the higher apes, and many ruminants, they fail in this respect. A slight difference in position serves to express in the plainest manner a different state of mind, as we may daily see in the dog; but we are here concerned only with the ears being drawn closely backward and pressed to the head. A savage frame of mind is thus shown, but only in the case of those animals which fight with their teeth; and the care which they take to prevent their ears being seized by their antagonists accounts for this position. Consequently, through habit and association, whenever they feel slightly savage, or pretend in their play to be savage, their ears are drawn back. That this is the true explanation may be inferred from the relation which exists in very many animals between their manner of fighting and the retraction of their ears.

All the Carnivora fight with their canine teeth, and all, as far as I have observed, draw their ears back when feeling savage.

A STARTLED HORSE.

Expressions of the Emotions, page 130.

The actions of a horse when much startled are highly expressive. One day my horse was much frightened at a drilling-machine, covered by a tarpaulin, and lying on an open field. He raised his head so high that his neck became almost perpendicular; and this he did from habit, for the machine lay on a slope below, and could not have been seen with more distinctness through the raising of the head; nor, if any sound had proceeded from it, could the sound have been more distinctly heard. His eyes and ears were directed intently forward; and I could feel through the saddle the palpitations of his heart. With red, dilated nostrils he snorted violently, and, whirling round, would have dashed off at full speed, had I not prevented him. The distention of the nostrils is not for the sake of scenting the source of danger, for, when a horse smells carefully at any object and is not alarmed, he does not dilate his nostrils. Owing to the presence of a valve in the throat, a horse when panting does not breathe through his open mouth, but through his nostrils; and these consequently have become endowed with great powers of expansion. This expansion of the nostrils, as well as the snorting, and the palpitations of the heart, are actions which have become firmly associated during a long series of generations with the emotion of terror; for terror has habitually led the horse to the most violent exertion in dashing away at full speed from the cause of danger.

MONKEY-SHINES.

Page 142.

Many years ago, in the Zoölogical Gardens, I placed a looking-glass on the floor before two young orangs, who, as far as it was known, had never before seen one. At first they gazed at their own images with the most steady surprise, and often changed their point of view. They then approached close and protruded their lips toward the image, as if to kiss it, in exactly the same manner as they had previously done toward each other, when first placed, a few days before, in the same room. They next made all sorts of grimaces, and put themselves in various attitudes before the mirror; they pressed and rubbed the surface; they placed their hands at different distances behind it; looked behind it; and finally seemed almost frightened, started a little, became cross, and refused to look any longer.

When we try to perform some little action which is difficult and requires precision, for instance, to thread a needle, we generally close our lips firmly, for the sake, I presume, of not disturbing our movements by breathing; and I noticed the same action in a young orang. The poor little creature was sick, and was amusing itself by trying to kill the flies on the window-panes with its knuckles; this was difficult as the flies buzzed about, and at each attempt the lips were firmly compressed, and at the same time slightly protruded.

WEEPING OF MAN AND BRUTE.

Expression of the Emotions, page 153.

Infants while young do not shed tears or weep, as is well known to nurses and medical men. This circumstance is not exclusively due to the lachrymal glands being as yet incapable of secreting tears. I first noticed this fact from having accidentally brushed with the cuff of my coat the open eye of one of my infants, when seventy-seven days old, causing this eye to water freely; and, though the child screamed violently, the other eye remained dry, or was only slightly suffused with tears. A similar slight effusion occurred ten days previously in both eyes during a screaming-fit. The tears did not run over the eyelids and roll down the cheeks of this child, while screaming badly, when one hundred and twenty-two days old. This first happened seventeen days later, at the age of one hundred and thirty-nine days. A few other children have been observed for me, and the period of free weeping appears to be very variable. In one case, the eyes became slightly suffused at the age of only twenty days; in another, at sixty-two days. With two other children, the tears did *not* run down the face at the ages of eighty-four and one hundred and ten days; but in a third child they did run down at the age of one hundred and four days. In one instance, as I was positively assured, tears ran down at the unusually early age of forty-two days. It would appear as if the lachrymal glands required some practice in the individual before they are easily excited into action, in somewhat the same manner as various inherited consensual movements and tastes require some exercise before they are fixed and perfected. This is all the more likely with a habit like weeping, which must have been acquired since the period when man branched off from the common progenitor of the genus *Homo* and of the non-weeping anthropomorphous apes.

Page 135. A woman, who sold a monkey to the Zoölogical Society, believed to have come from Borneo (*Macacus maurus* or *M. inornatus* of Gray), said that it often cried; and Mr. Bartlett, as well as the keeper Mr. Sutton, have repeatedly seen it, when grieved, or even when much pitied, weeping so copiously that the tears rolled down its cheeks.

Page 155. A New Zealand chief "cried like a child because the sailors spoiled his favorite cloak by powdering it with flour." I saw in Tierra del Fuego a native who had lately lost a brother, and who alternately cried with hysterical violence, and laughed heartily at anything which amused him. With the civilized nations of Europe there is also much difference in the frequency of weeping. Englishmen rarely cry, except under the pressure of the acutest grief; whereas, in some parts of the Continent, the men shed tears much more readily and freely.

The insane notoriously give way to all their emotions with little or no restraint; and I am informed by Dr. J. Crichton Browne that nothing is more characteristic of simple melancholia, even in the male sex, than a tendency to weep on the slightest occasions, or from no cause. They also weep disproportionately on the occurrence of any real cause of grief. The length of time during which some patients weep is astonishing, as well as the amount of tears which they shed.

Page 167. The Indian elephant is known sometimes to weep. Sir E. Tennent, in describing those which he saw captured and bound in Ceylon, says some "lay motionless on the ground, with no other indication of suffering than the tears which suffused their eyes and flowed incessantly." Speaking of another elephant he says: "When overpowered and made fast, his grief was most affecting; his violence sank to utter prostration, and he lay on the ground, uttering choking cries, with tears trickling down his cheeks."

THE GRIEF-MUSCLES.

Expression of the Emotions, page 180.

With respect to the eyebrows, they may occasionally be seen to assume an oblique position in persons suffering from deep dejection or anxiety; for instance, I have observed this movement in a mother while speaking about her sick son; and it is sometimes excited by quite trifling or momentary causes of real or pretended distress. The eyebrows assume this position owing to the contraction of certain muscles (namely, the orbiculars, corrugators, and pyramidals of the nose, which together tend to lower and contract the eyebrows) being partially checked by the more powerful action of the central fasciæ of the frontal muscle. These latter fasciæ, by their contraction, raise the inner ends alone of the eyebrows; and, as the corrugators at the same time draw the eyebrows together, their inner ends become puckered into a fold or lump. The eyebrows are at the same time somewhat roughened, owing to the hairs being made to project. Dr. J. Crichton Browne has also often noticed, in melancholic patients who keep their eyebrows persistently oblique, "a peculiar acute arching of the upper eyelid." The acute arching of the eyelids depends, I believe, on the inner end alone of the eyebrows being raised; for, when the whole eyebrow is elevated and arched, the upper eyelid follows in a slight degree the same movement.

But the most conspicuous result of the opposed contraction of the above-named muscles is exhibited by the peculiar furrows formed on the forehead. These muscles, when thus in conjoint yet opposed action, may be called, for the sake of brevity, the grief-muscles. When a person elevates his eyebrows by the contraction of the whole frontal muscle, transverse wrinkles extend across the whole breadth of the forehead; but, in the present case, the middle fasciæ alone are contracted; consequently, transverse furrows are formed across the middle part alone of the forehead. The skin over the exterior parts of both eyebrows is at the same time drawn downward and smoothed by the contraction of the outer portions of the orbicular muscles. The eyebrows are likewise brought together through the simultaneous contraction of the corrugators; and this latter action generates vertical furrows, separating the exterior and lowered part of the skin of the forehead from the central and raised part. The union of these vertical furrows with the central and transverse furrows produces a mark on the forehead which has been compared to a horseshoe; but the furrows more strictly form three sides of a quadrangle. They are often conspicuous on the foreheads of adult, or nearly adult, persons, when their eyebrows are made oblique; but with young children, owing to their skin not easily wrinkling, they are rarely seen, or mere traces of them can be detected.

VOLUNTARY POWER OVER THE GRIEF-MUSCLES.

Page 183. Few persons, without some practice, can voluntarily act on their grief-muscles; but, after repeated trials, a considerable number succeed, while others never can. The degree of obliquity in the eyebrows, whether assumed voluntarily or unconsciously, differs much in different persons. With some who apparently have unusually strong pyramidal muscles, the contraction of the central fasciæ of the frontal muscle, although it may be energetic, as shown by the quadrangular furrows on the forehead, does not raise the inner ends of the eyebrows, but only prevents their being so much lowered as they otherwise would have been. As far as I have been able to observe, the grief-muscles are brought into action much more frequently by children and women than by men. They are rarely acted on, at least with grown-up persons, from bodily pain, but almost exclusively from mental distress. Two persons, who, after some practice, succeeded in acting on their grief-muscles, found by looking at a mirror that, when they made their eyebrows oblique, they unintentionally at the same time depressed the corners of their mouths; and this is often the case when the expression is naturally assumed.

The power to bring the grief-muscles freely into play appears to be hereditary, like almost every other human faculty. A lady belonging to a family famous for having produced an extraordinary number of great actors and actresses, and who can herself give this expression "with singular precision," told Dr. Crichton Browne that all her family had possessed the power in a remarkable degree. The same hereditary tendency is said to have extended, as I likewise hear from Dr. Browne, to the last descendant of the family, which gave rise to Sir Walter Scott's novel of "Red Gauntlet"; but the hero is described as contracting his forehead into a horseshoe mark from any strong emotion. I have also seen a young woman whose forehead seemed almost habitually thus contracted, independently of any emotion being at the time felt.

The grief-muscles are not very frequently brought into play; and, as the action is often momentary, it easily escapes observation. Although the expression, when observed, is universally and instantly recognized as that of grief or anxiety, yet not one person out of a thousand who has never studied the subject is able to say precisely what change passes over the sufferer's face. Hence probably it is that this expression is not even alluded to, as far as I have noticed, in any work of fiction, with the exception of "Red Gauntlet" and of one other novel; and the authoress of the latter, as I am informed, belongs to the famous family of actors just alluded to; so that her attention may have been specially called to the subject.

"DOWN IN THE MOUTH."

Page 194. To say that a person "is down in the mouth" is synonymous with saying that he is out of spirits. The depression of the corners may often be seen, as already stated on the authority of Dr. Crichton Browne and Mr. Nicol, with the melancholic insane, and was well exhibited in some photographs, sent to me by the former gentleman, of patients with a strong tendency to suicide. It has been observed with men belonging to various races, namely, with Hindoos, the dark hill-tribes of India, Malays, and, as the Rev. Mr. Hagenauer informs me, with the aborigines of Australia.

When infants scream they firmly contract the muscles round their eyes, and this draws up the upper lip; and, as they have to keep their mouths widely open, the depressor muscles running to the corners are likewise brought into strong action. This generally, but not invariably, causes a slight angular bend in the lower lip on both sides, near the corners of the mouth.

Page 195. It is remarkable how small a depression of the corners of the mouth gives to the countenance an expression of low spirits or dejection, so that an extremely slight contraction of these muscles would be sufficient to betray this state of mind.

I may here mention a trifling observation, as it will serve to sum up our present subject. An old lady with a comfortable but absorbed expression sat nearly opposite to me in a railway-carriage. While I was looking at her I saw that her *depressores anguli oris* became very slightly yet decidedly contracted; but, as her countenance remained as placid as ever, I reflected how meaningless was this contraction, and how easily one might be deceived. The thought had hardly occurred to me when I saw that her eyes suddenly became suffused with tears almost to overflowing, and her whole countenance fell. There could now be no doubt that some painful recollection, perhaps that of a long-lost child, was passing through her mind. As soon as her sensorium was thus affected, certain nerve-cells from long habit instantly transmitted an order to all the respiratory muscles, and to those round the mouth, to prepare for a fit of crying. But the order was countermanded by the will, or rather by a later acquired habit, and all the muscles were obedient, excepting in a slight degree the *depressores anguli oris*. The mouth was not even opened; the respiration was not hurried; and no muscle was affected except those which draw down the corners of the mouth.

LAUGHTER.

Expression of the Emotions, page 200.

Many curious discussions have been written on the causes of laughter with grown-up persons. The subject is extremely complex. Something incongruous or unaccountable, exciting surprise and some sense of superiority in the laughter, who must be in a happy frame of mind, seems to be the commonest cause. The circumstances must not be of a momentous nature; no poor man would laugh or smile on suddenly hearing that a large fortune had been bequeathed to him.

Page 201. The imagination is sometimes said to be tickled by a ludicrous idea; and this so-called tickling of the mind is curiously analogous with that of the body. Every one knows how immoderately children laugh and how their whole bodies are convulsed when they are tickled. The anthropoid apes, as we have seen, likewise utter a reiterated sound, corresponding with our laughter, when they are tickled, especially under the armpits. I touched with a bit of paper the sole of the foot of one of my infants, when only seven days old, and it was suddenly jerked away and the toes curled about, as in an older child. Such movements, as well as laughter from being tickled, are manifestly reflex actions; and this is likewise shown by the minute unstriped muscles, which serve to erect the separate hairs on the body, contracting near a tickled surface. Yet laughter from a ludicrous idea, though involuntary, can not be called a strictly reflex action. In this case, and in that of laughter from being tickled, the mind must be in a pleasurable condition; a young child, if tickled by a strange man, would scream from fear. The touch must be light, and an idea or event, to be ludicrous, must not be of grave import. The parts of the body which are most easily tickled are those which are not commonly touched, such as the armpits or between the toes, or parts such as the soles of the feet, which are habitually touched by a broad surface; but the surface on which we sit offers a marked exception to this rule.

Page 202. The sound of laughter is produced by a deep inspiration followed by short, interrupted, spasmodic contractions of the chest, and especially of the diaphragm. Hence we hear of "laughter holding both his sides." From the shaking of the body, the head nods to and fro. The lower jaw often quivers up and down, as is likewise the case with some species of baboons, when they are much pleased.

During laughter the mouth is opened more or less widely, with the corners drawn much backward, as well as a little upward; and the upper lip is somewhat raised. The drawing back of the corners is best seen in moderate laughter, and especially in a broad smile—the latter epithet showing how the mouth is widened.

Page 208. Although we can hardly account for the shape of the mouth during laughter, which leads to wrinkles being formed beneath the eyes, nor for the peculiar reiterated sound of laughter, nor for the quivering of the jaws, nevertheless we may infer that all these effects are due to some common cause; for they are all characteristic and expressive of a pleased state of mind in various kinds of monkeys.

It is scarcely possible to point out any difference between the tear-stained face of a person after a paroxysm of excessive laughter and after a bitter crying-fit. It is probably due to the close similarity of the spasmodic movements caused by these widely different emotions that hysteric patients alternately cry and laugh with violence, and that young children sometimes pass suddenly from the one to the other state. Mr. Swinhoe informs me that he has often seen the Chinese, when suffering from deep grief, burst out into hysterical fits of laughter.

I was anxious to know whether tears are freely shed during excessive laughter by most of the races of men, and I hear from my correspondents that this is the case.

One instance was observed with the Hindoos, and they themselves said that it often occurred. So it is with the Chinese. The women of a wild tribe of Malays in the Malacca Peninsula sometimes shed tears when they laugh heartily, though this seldom occurs. With the Dyaks of Borneo it must frequently be the case, at least with the women, for I hear from the Rajah C. Brooke that it is a common expression with them to say, "We nearly made tears from laughter."

Expression of the Emotions, page 133.

Young orangs, when tickled, grin and make a chuckling sound; and Mr. Martin says that their eyes grow brighter. As soon as their laughter ceases, an expression may be detected passing over their faces, which, as Mr. Wallace remarked to me, may be called a smile. I have also noticed something of the same kind with the chimpanzee. Dr. Duchenne—and I can not quote a better authority—informs me that he kept a very tame monkey in his house for a year; and, when he gave it during meal-times some choice delicacy, he observed that the corners of its mouth were slightly raised; thus an expression of satisfaction, partaking of the nature of an incipient smile, and resembling that often seen on the face of man, could be plainly perceived in this animal.

EXPRESSION OF THE DEVOUT EMOTIONS.

Page 220.

With some sects, both past and present, religion and love have been strangely combined; and it has even been maintained, lamentable as the fact may be, that the holy kiss of love differs but little from that which a man bestows on a woman, or a woman on a man. Devotion is chiefly expressed by the face being directed toward the heavens, with the eyeballs upturned. Sir C. Bell remarks that, at the approach of sleep, or of a fainting-fit, or of death, the pupils are drawn upward and inward; and he believes that "when we are rapt in devotional feelings, and outward impressions are unheeded, the eyes are raised by an action neither taught nor acquired"; and that this is due to the same cause as in the above cases. That the eyes are upturned during sleep is, as I hear from Professor Donders, certain. With babies, while sucking their mother's breast, this movement of the eyeballs often gives to them an absurd appearance of ecstatic delight; and here it may be clearly perceived that a struggle is going on against the position naturally assumed during sleep. But Sir C. Bell's explanation of the fact, which rests on the assumption that certain muscles are more under the control of the will than others, is, as I hear from Professor Donders, incorrect. As the eyes are often turned up in prayer, without the mind being so much absorbed in thought as to approach to the unconsciousness of sleep, the movement is probably a conventional one—the result of the common belief that Heaven, the source of Divine power to which we pray, is seated above us.

A humble kneeling posture, with the hands upturned and palms joined, appears to us, from long habit, a gesture so appropriate to devotion, that it might be thought to be innate; but I have not met with any evidence to this effect with the various extra-European races of mankind. During the classical period of Roman history it does not appear, as I hear from an excellent classic, that the hands were thus joined during prayer. Mr. Hensleigh Wedgwood has apparently given the true explanation, though this implies that the attitude is one of slavish subjection. "When the suppliant kneels and holds up his hands with the palms joined, he represents a captive who proves the completeness of his submission by offering up his hands to be bound by the victor. It is the pictorial representation of the Latin *dare manus*, to signify submission." Hence it is not probable that either the uplifting of the eyes or the joining of the open hands, under the influence of devotional feelings, is an innate or a truly expressive action; and this could hardly have been expected, for it is very doubtful whether feelings such as we should now rank as devotional affected the hearts of men while they remained during past ages in an uncivilized condition.

FROWNING.

Expression of the Emotions, page 225.

We may now inquire how it is that a frown should express the perception of something difficult or disagreeable, either in thought or action. In the same way as naturalists find it advisable to trace the embryological development of an organ in order fully to understand its structure, so with the movements of expression it is advisable to follow as nearly as possible the same plan. The earliest and almost sole expression seen during the first days of infancy, and then often exhibited, is that displayed during the act of screaming; and screaming is excited, both at first and for some time afterward, by every distressing or displeasing sensation and emotion—by hunger, pain, anger, jealousy, fear, etc. At such times the muscles round the eyes are strongly contracted; and this, as I believe, explains to a large extent the act of frowning during the remainder of our lives. I repeatedly observed my own infants, from under the age of one week to that of two or three months, and found that, when a screaming-fit came on gradually, the first sign was the contraction of the corrugators, which produced a slight frown, quickly followed by the contraction of the other muscles round the eyes.

Page 226. Screaming or weeping begins to be voluntarily restrained at an early period of life, whereas frowning is hardly ever restrained at any age. It is perhaps worth notice that, with children much given to weeping, anything which perplexes their minds, and which would cause most other children merely to frown, readily makes them weep. So with certain classes of the insane, any effort of mind, however slight, which with an habitual frowner would cause a slight frown, leads to their weeping in an unrestrained manner. It is not more surprising that the habit of contracting the brows at the first perception of something distressing, although gained during infancy, should be retained during the rest of our lives, than that many other associated habits acquired at an early age should be permanently retained both by man and the lower animals. For instance, full-grown cats, when feeling warm and comfortable, often retain the habit of alternately protruding their fore-feet with extended toes, which habit they practiced for a definite purpose while sucking their mothers.

POUTING.

Page 232. With young children sulkiness is shown by pouting, or, as it is sometimes called, "making a snout." When the corners of the mouth are much depressed, the lower lip is a little everted and protruded; and this is likewise called a pout. But the pouting here referred to consists of the protrusion of both lips into a tubular form, sometimes to such an extent as to project as far as the end of the nose, if this be short. Pouting is generally accompanied by frowning, and sometimes by the utterance of a booing or whooing noise. This expression is remarkable, as almost the sole one, as far as I know, which is exhibited much more plainly during childhood, at least with Europeans, than during maturity. There is, however, some tendency to the protrusion of the lips with the adults of all races under the influence of great rage. Some children pout when they are shy, and they can then hardly be called sulky.

Page 234. Young orangs and chimpanzees protrude their lips to an extraordinary degree, when they are discontented, somewhat angry, or sulky; also when they are surprised, a little frightened, and even when slightly pleased. Their mouths are protruded apparently for the sake of making the various noises proper to these several states of mind; and its shape, as I observed with the chimpanzee, differed slightly when the cry of pleasure and that of anger were uttered. As soon as these animals become enraged, the shape of the mouth wholly changes, and the teeth are exposed. The adult orang when wounded is said to emit "a singular cry, consisting at first of high notes, which at length deepen into a low roar. While giving out the high notes he thrusts out his lips into a funnel shape, but in uttering the low notes he holds his mouth wide open." With the gorilla, the lower lip is said to be capable of great elongation. If, then, our semi-human progenitors protruded their lips when sulky or a little angered, in the same manner as do the existing anthropoid apes, it is not an anomalous, though a curious fact, that our children should exhibit, when similarly affected, a trace of the same expression, together with some tendency to utter a noise. For it is not at all unusual for animals to retain, more or less perfectly, during early youth, and subsequently to lose, characters which were aboriginally possessed by their adult progenitors, and which are still retained by distinct species, their near relations.

DECISION AT THE MOUTH.

Page 236.

No determined man probably ever had an habitually gaping mouth. Hence, also, a small and weak lower jaw, which seems to indicate that the mouth is not habitually and firmly closed, is commonly thought to be characteristic of feebleness of character. A prolonged effort of any kind, whether of body or mind, implies previous determination; and if it can be shown that the mouth is generally closed with firmness before and during a great and continued exertion of the muscular system, then, through the principle of association, the mouth would almost certainly be closed as soon as any determined resolution was taken.

ANGER.

Expression of the Emotions, page 243.

The lips are sometimes protruded during rage in a manner the meaning of which I do not understand, unless it depends on our descent from some ape-like animal. Instances have been observed, not only with Europeans, but with the Australians and Hindoos. The lips, however, are much more commonly retracted, the grinning or clinched teeth being thus exposed. This has been noticed by almost every one who has written on expression. The appearance is as if the teeth were uncovered, ready for seizing or tearing an enemy, though there may be no intention of acting in this manner. Mr. Dyson Lacy has seen this grinning expression with the Australians, when quarreling, and so has Gaika with the Caffres of South Africa. Dickens, in speaking of an atrocious murderer who had just been caught, and was surrounded by a furious mob, describes "the people as jumping up one behind another, snarling with their teeth, and making at him like wild beasts." Every one who has had much to do with young children must have seen how naturally they take to biting, when in a passion. It seems as instinctive in them as in young crocodiles, who snap their little jaws as soon as they emerge from the egg.

SNEERING.

Expression of the Emotions, page 253.

The expression here considered, whether that of a playful sneer or ferocious snarl, is one of the most curious which occurs in man. It reveals his animal descent; for no one, even if rolling on the ground in a deadly grapple with an enemy, and attempting to bite him, would try to use his canine teeth more than his other teeth. We may readily believe from our affinity to the anthropomorphous apes that our male semi-human progenitors possessed great canine teeth, and men are now occasionally born having them of unusually large size, with interspaces in the opposite jaw for their reception. We may further suspect, notwithstanding that we have no support from analogy, that our semi-human progenitors uncovered their canine teeth when prepared for battle, as we still do when feeling ferocious, or when merely sneering at or defying some one, without any intention of making a real attack with our teeth.

DISGUST.

Expression of the Emotions, page 258.

Extreme disgust is expressed by movements round the mouth identical with those preparatory to the act of vomiting. The mouth is opened widely, with the upper lip strongly retracted, which wrinkles the sides of the nose, and with the lower lip protruded and everted as much as possible. This latter movement requires the contraction of the muscles which draw downward the corners of the mouth.

It is remarkable how readily and instantly retching or actual vomiting is induced in some persons by the mere idea of having partaken of any unusual food, as of an animal which is not commonly eaten; although there is nothing in such food to cause the stomach to reject it. When vomiting results, as a reflex action, from some real cause—as from too rich food, or tainted meat, or from an emetic—it does not ensue immediately, but generally after a considerable interval of time. Therefore, to account for retching or vomiting being so quickly and easily excited by a mere idea, the suspicion arises that our progenitors must formerly have had the power (like that possessed by ruminants and some other animals) of voluntarily rejecting food which disagreed with them, or which they thought would disagree with them; and now, though this power has been lost, as far as the will is concerned, it is called into involuntary action, through the force of a formerly well-established habit, whenever the mind revolts at the idea of having partaken of any kind of food, or at anything disgusting. This suspicion receives support from the fact, of which I am assured by Mr. Sutton, that the monkeys in the Zoölogical Gardens often vomit while in perfect health, which looks as if the act were voluntary. We can see that as man is able to communicate, by language to his children and others, the knowledge of the kinds of food to be avoided, he would have little occasion to use the faculty of voluntary rejection ; so that this power would tend to be lost through disuse.

SHRUGGING THE SHOULDERS.

Expression of the Emotions, page 271.

We may now inquire why men in all parts of the world, when they feel—whether or not they wish to show this feeling—that they cannot or will not do something, or will not resist something if done by another, shrug their shoulders, at the same time often bending in their elbows, showing the palms of their hands with extended fingers, often throwing their heads a little on one side, raising their eyebrows, and opening their mouths. These states of the mind are either simply passive, or show a determination not to act. None of the above movements are of the least service. The explanation lies, I can not doubt, in the principle of unconscious antithesis. This principle here seems to come into play as clearly as in the case of a dog, who, when feeling savage, puts himself in the proper attitude for attacking and for making himself appear terrible to his enemy ; but, as soon as he feels affectionate, throws his whole body into a directly opposite attitude, though this is of no direct use to him.

Let it be observed how an indignant man who resents and will not submit to some injury holds his head erect, squares his shoulders, and expands his chest. He often clinches his fists, and puts one or both arms in the proper position for attack or defense, with the muscles of his limbs rigid. He frowns—that is, he contracts and lowers his brows—and, being determined, closes his mouth.

The actions and attitude of a helpless man are, in every one of these respects, exactly the reverse.

BLUSHING.

Expression of the Emotions, page 310.

Blushing is the most peculiar and the most human of all expressions. Monkeys redden from passion, but it would require an overwhelming amount of evidence to make us believe that any animal could blush. The reddening of the face from a blush is due to the relaxation of the muscular coats of the small arteries, by which the capillaries become filled with blood; and this depends on the proper vaso-motor center being affected. No doubt, if there be at the same time much mental agitation, the general circulation will be affected; but it is not due to the action of the heart that the net-work of minute vessels covering the face becomes, under a sense of shame, gorged with blood. We can cause laughing by tickling the skin; weeping or frowning, by a blow; trembling, from a fear of pain, and so forth; but we can not cause a blush, as Dr. Burgess remarks, by any physical means—that is, by any action on the body. It is the mind which must be affected. Blushing is not only involuntary, but the wish to restrain it, by leading to self-attention, actually increases the tendency.

Page 312.

The tendency to blush is inherited. Dr. Burgess gives the case of a family, consisting of a father, mother, and ten children, all of whom, without exception, were prone to blush to a most painful degree. The children were grown up; "and some of them were sent to travel, in order to wear away this diseased sensibility, but nothing was of the slightest avail." Even peculiarities in blushing seem to be inherited. Sir James Paget, while examining the spine of a girl, was struck at her singular manner of blushing: a big splash of red appeared first on one cheek, and then other splashes variously scattered over the face and neck. He subsequently asked the mother whether her daughter always blushed in this peculiar manner, and was answered, "Yes, she takes after me." Sir J. Paget then perceived that, by asking this question, he had caused the mother to blush; and she exhibited the same peculiarity as her daughter.

Page 318. Mr. Washington Matthews has often seen a blush on the faces of the young squaws belonging to various wild Indian tribes of North America. At the opposite extremity of the continent, in Tierra del Fuego, the natives, according to Mr. Bridges, "blush much, but chiefly in regard to women; but they certainly blush also at their own personal appearance." This latter statement agrees with what I remember of the Fuegian, Jemmy Button, who blushed when he was quizzed about the care which he took in polishing his shoes, and in otherwise adorning himself.

Page 319. Several trustworthy observers have assured me that they have seen on the faces of negroes an appearance resembling a blush, under circumstances which would have excited one in us, though their skins were of an ebony-black tint. Some describe it as blushing brown, but most say that the blackness becomes more intense.

Page 324. I will give an instance of the extreme disturbance of mind to which some sensitive men are liable. A gentleman, on whom I can rely, assured me that he had been an eye-witness of the following scene: A small dinner-party was given in honor of an extremely shy man, who, when he rose to return thanks, rehearsed the speech, which he had evidently learned by heart, in absolute silence, and did not utter a single word; but he acted as if he were speaking with much emphasis. His friends, perceiving how the case stood, loudly applauded the imaginary bursts of eloquence, whenever his gestures indicated a pause, and the man never discovered that he had remained the whole time completely silent. On the contrary, he afterward remarked to my friend, with much satisfaction, that he thought he had succeeded uncommonly well.

BLUSHING NOT NECESSARILY AN EXPRESSION OF GUILT.

Page 333.

It is not the sense of guilt, but the thought that others think or know us to be guilty, which crimsons the face. A man may feel thoroughly ashamed at having told a small falsehood, without blushing; but if he even suspects that he is detected he will instantly blush, especially if detected by one whom he reveres.

On the other hand, a man may be convinced that God witnesses all his actions, and he may feel deeply conscious of some fault and pray for forgiveness; but this will not, as a lady who is a great blusher believes, ever excite a blush. The explanation of this difference between the knowledge by God and man of our actions lies, I presume, in man's disapprobation of immoral conduct being somewhat akin in nature to his depreciation of our personal appearance, so that through association both lead to similar results; whereas the disapprobation of God brings up no such association.

Many a person has blushed intensely when accused of some crime, though completely innocent of it.

Page 334. An action may be meritorious or of an indifferent nature, but a sensitive person, if he suspects that others take a different view of it, will blush. For instance, a lady by herself may give money to a beggar without a trace of a blush, but if others are present, and she doubts whether they approve, or suspects that they think her influenced by display, she will blush. So it will be, if she offers to relieve the distress of a decayed gentlewoman, more particularly of one whom she had previously known under better circumstances, as she can not then feel sure how her conduct will be viewed. But such cases as these blend into shyness.

Page 338. The belief that blushing was *specially* designed by the Creator is opposed to the general theory of evolution, which is now so largely accepted; but it forms no part of my duty here to argue on the general question. Those who believe in design will find it difficult to account for shyness being the most frequent and efficient of all the causes of blushing, as it makes the blusher to suffer and the beholder uncomfortable, without being of the least service to either of them. They will also find it difficult to account for negroes and other dark-colored races blushing, in whom a change of color in the skin is scarcely or not at all visible.

BLUSHING ACCOUNTED FOR.

The hypothesis which appears to me the most probable, though it may at first seem rash, is that attention closely directed to any part of the body tends to interfere with the ordinary and tonic contraction of the small arteries of that part. These vessels, in consequence, become at such times more or less relaxed, and are instantly filled with arterial blood. This tendency will have been much strengthened, if frequent attention has been paid during many generations to the same part, owing to nerve-force readily flowing along accustomed channels, and by the power of inheritance. Whenever we believe that others are depreciating or even considering our personal appearance, our attention is vividly directed to the outer and visible parts of our bodies ; and of all such parts we are most sensitive about our faces, as no doubt has been the case during many past generations. Therefore, assuming for the moment that the capillary vessels can be acted on by close attention, those of the face will have become eminently susceptible. Through the force of association, the same effects will tend to follow whenever we think that others are considering or censuring our actions or character.

Page 340. It is known that the involuntary movements of the heart are affected if close attention be paid to them. Gratiolet gives the case of a man who, by continually watching and counting his own pulse, at last caused one beat out of every six to intermit. On the other hand, my father told me of a careful observer, who certainly had heart-disease and died from it, and who positively stated that his pulse was habitually irregular to an extreme degree ; yet to his great disappointment it invariably became regular as soon as my father entered the room.

Page 342. When we direct our whole attention to any one sense, its acuteness is increased; and the continued habit of close attention, as with blind people to that of hearing, and with the blind and deaf to that of touch, appears to improve the sense in question permanently. There is, also, some reason to believe, judging from the capacities of different races of man, that the effects are inherited. Turning to ordinary sensations, it is well known that pain is increased by attending to it; and Sir B. Brodie goes so far as to believe that pain may be felt in any part of the body to which attention is closely drawn.

A NEW ARGUMENT FOR A SINGLE PARENT-STOCK.

Expression of the Emotions, page 361. I have endeavored to show in considerable detail that all the chief expressions exhibited by man are the same throughout the world. This fact is interesting, as it affords a new argument in favor of the several races being descended from a single parent-stock, which must have been almost completely human in structure, and to a large extent in mind, before the period at which the races diverged from each other. No doubt similar structures adapted for the same purpose have often been independently acquired through variation and natural selection by distinct species; but this view will not explain close similarity between distinct species in a multitude of unimportant details. Now, if we bear in mind the numerous points of structure having no relation to expression, in which all the races of man closely agree, and then add to them the numerous points, some of the highest importance and many of the most trifling value, on which the movements of expression directly or indirectly depend, it seems to me improbable in the highest degree that so much similarity, or rather identity of structure, could have been acquired by independent means. Yet this must have been the case if the races of man are descended from several aboriginally distinct species. It is far more probable that the many points of close similarity in the various races are due to inheritance from a single parent-form, which had already assumed a human character.

XIV.

THE PROVISIONAL HYPOTHESIS OF PANGENESIS.

Animals and Plants under Domestication, vol. ii, page 349.

Every one would wish to explain to himself, even in an imperfect manner, how it is possible for a character possessed by some remote ancestor suddenly to reappear in the offspring; how the effects of increased or decreased use of a limb can be transmitted to the child; how the male sexual element can act not solely on the ovules, but occasionally on the mother-form; how a hybrid can be produced by the union of the cellular tissue of two plants independently of the organs of generation; how a limb can be reproduced on the exact line of amputation, with neither too much nor too little added; how the same organism may be produced by such widely different processes as budding and true seminal generation; and, lastly, how, of two allied forms, one passes in the course of its development through the most complex metamorphoses, and the other does not do so, though when mature both are alike in every detail of structure. I am aware that my view is merely a provisional hypothesis or speculation; but, until a better one be advanced, it will serve to bring together a multitude of facts which are at present left disconnected by any efficient cause. As

Whewell, the historian of the inductive sciences, remarks, "Hypotheses may often be of service to science when they involve a certain portion of incompleteness, and even of error." Under this point of view I venture to advance the hypothesis of pangenesis, which implies that every separate part of the whole organization reproduces itself. So that ovules, spermatozoa, and pollen-grains—the fertilized egg or seed, as well as buds—include and consist of a multitude of germs thrown off from each separate part or unit.

FUNCTIONAL INDEPENDENCE OF THE UNITS OF THE BODY.

Page 364. Physiologists agree that the whole organism consists of a multitude of elemental parts, which are to a great extent independent of one another. Each organ, says Claude Bernard, has its proper life, its autonomy; it can develop and reproduce itself independently of the adjoining tissues. A great German authority, Virchow, asserts still more emphatically that each system consists of an "enormous mass of minute centers of action. . . . Every element has its own special action, and, even though it derive its stimulus to activity from other parts, yet alone effects the actual performance of duties. . . . Every single epithelial and muscular fiber-cell leads a sort of parasitical existence in relation to the rest of the body. . . . Every single bone-corpuscle really possesses conditions of nutrition peculiar to itself." Each element, as Sir J. Paget remarks, lives its appointed time and then dies, and is replaced after being cast off or absorbed. I presume that no physiologist doubts that, for instance, each bone-corpuscle of the finger differs from the corresponding corpuscle in the corresponding joint of the toe; and there can hardly be a doubt that even those on the corresponding sides of the body differ, though almost identical in nature. This near approach to identity is curiously shown in many diseases in which the same exact points on the right and left sides of the body are similarly affected; thus Sir J. Paget gives a drawing of a diseased pelvis, in which the bone has grown into a most complicated pattern, but "there is not one spot or line on one side which is not represented, as exactly as it would be in a mirror, on the other.

Many facts support this view of the independent life of each minute element of the body. Virchow insists that a single bone-corpuscle or a single cell in the skin may become diseased. The spur of a cock, after being inserted into the ear of an ox, lived for eight years, and acquired a weight of three hundred and ninety-six grammes (nearly fourteen ounces) and the astonishing length of twenty-four centimetres, or about nine inches; so that the head of the ox appeared to bear three horns. The tail of a pig has been grafted into the middle of its back, and reacquired sensibility. Dr. Ollier inserted a piece of periosteum from the bone of a young dog under the skin of a rabbit, and true bone was developed. A multitude of similar facts could be given.

Page 368. What can be more wonderful than that characters, which have disappeared during scores, or hundreds, or even thousands of generations, should suddenly reappear perfectly developed, as in the case of pigeons and fowls, both when purely bred and especially when crossed; or as with the zebrine stripes on dun-colored horses, and other such cases? Many monstrosities come under this same head, as when rudimentary organs are redeveloped, or when an organ which we must believe was possessed by an early progenitor of the species, but of which not even a rudiment is left, suddenly reappears, as with the fifth stamen in some *Scrophulariaceæ*.

Page 369. In every living creature we may feel assured that a host of long-lost characters lie ready to be evolved under proper conditions. How can we make intelligible, and connect with other facts, this wonderful and common capacity of reversion—this power of calling back to life long-lost characters?

Page 386. Imperfect nails sometimes appear on the stumps of the amputated fingers of man; and it is an interesting fact that with the snake-like saurians, which present a series with more and more imperfect limbs, the terminations of the phalanges first disappear, "the nails becoming transferred to their proximal remnants, or even to parts which are not phalanges."

Page 387. Mr. Salter and Dr. Maxwell Masters have found pollen within the ovules of the passion-flower and of the rose. Buds may be developed in the most unnatural positions, as on the petal of a flower. Numerous analogous facts could be given.

I do not know how physiologists look at such facts as the foregoing. According to the doctrine of pangenesis, the gemmules of the transposed organs become developed in the wrong place, from uniting with wrong cells or aggregates of cells during their nascent state; and this would follow from a slight modification in their elective affinities.

Page 388. On any ordinary view it is unintelligible how changed conditions, whether acting on the embryo, the young or the adult, can cause inherited modifications. It is equally or even more unintelligible, on any ordinary view, how the effects of the long-continued use or disuse of a part, or of changed habits of body or mind, can be inherited. A more perplexing problem can hardly be proposed; but on our view we have only to suppose that certain cells become at last structurally modified, and that these throw off similarly modified gemmules. This may occur at any period of development, and the modification will be inherited at a corresponding period; for the modified gemmules will unite in all ordinary cases with the proper preceding cells, and will consequently be developed at the same period at which the modification first arose. With respect to mental habits or instincts, we are so profoundly ignorant of the relation between the brain and the power of thought that we do not know positively whether a fixed habit induces any change in the nervous system, though this seems highly probable; but, when such habit or other mental attribute, or insanity, is inherited, we must believe that some actual modification is transmitted; and this implies, according to our hypothesis, that gemmules derived from modified nerve-cells are transmitted to the offspring.

NECESSARY ASSUMPTIONS.

Page 369. I have now enumerated the chief facts which every one would desire to see connected by some intelligible bond. This can be done, if we make the following assumptions, and much may be advanced in favor of the chief one. The secondary assumptions can likewise be supported by various physiological considerations. It is universally admitted that the cells or units of the body increase by self-division or proliferation, retaining the same nature, and that they ultimately become converted into the various tissues and substances of the body. But besides this means of increase I assume that the units throw off minute granules which are dispersed throughout the whole system; that these, when supplied with proper nutriment, multiply by self-division, and are ultimately developed into units like those from which they were originally derived. These granules may be called gemmules. They are collected from all parts of the system to constitute the sexual elements, and their development in the next generation forms a new being; but they are likewise capable of transmission in a dormant state to future generations and may then be developed. Their development depends on their union with other partially developed or nascent cells which precede them in the regular course of growth. Why I use the term union will be seen when we discuss the direct action of pollen on the tissues of the mother-plant. Gemmules are supposed to be thrown off by every unit, not only during the adult state, but during each stage of development of every organism; but not necessarily during the continued existence of the same unit. Lastly, I assume that the gemmules in their dormant state have a mutual affinity for each other, leading to their aggregation into buds or into the sexual elements. Hence, it is not the reproductive organs or buds which generate new organisms, but the units of which each individual is composed. These assumptions constitute the provisional hypothesis which I have called pangenesis.

Page 372. But I have further to assume that the gemmules in their undeveloped state are capable of largely multiplying themselves by self-division, like independent organisms. Delpino insists that to "admit of multiplication by fissiparity in corpuscles, analogous to seeds or buds . . . is repugnant to all analogy." But this seems a strange objection, as Thuret has seen the zoöspore of an alga divide itself, and each half germinated. Haeckel divided the segmented ovum of a siphonophora into many pieces, and these were developed. Nor does the extreme minuteness of the gemmules, which can hardly differ much in nature from the lowest and simplest organisms, render it improbable that they should grow and multiply. A great authority, Dr. Beale, says that "minute yeast-cells are capable of throwing off buds or gemmules, much less than the $\frac{1}{100000}$ of an inch in diameter"; and these he thinks are capable of subdivision practically *ad infinitum.*"

A particle of small-pox matter, so minute as to be borne by the wind, must multiply itself many thousand-fold in a person thus inoculated; and so with the contagious matter of scarlet fever. It has recently been ascertained that a minute portion of the mucous discharge from an animal affected with rinderpest, if placed in the blood of a healthy ox, increases so fast that in a short space of time "the whole mass of blood, weighing many pounds, is infected, and every small particle of that blood contains enough poison to give, within less than forty-eight hours, the disease to another animal."

Page 374. The gemmules derived from each part or organ must be thoroughly dispersed throughout the whole system. We know, for instance, that even a minute fragment of a leaf of a begonia will reproduce the whole plant; and that if a fresh-water worm is chopped into small pieces, each will reproduce the whole animal. Considering also the minuteness of the gemmules and the permeability of all organic tissues, the thorough dispersion of the gemmules is not surprising. That matter may be readily transferred without the aid of vessels from part to part of the body, we have a good instance in a case recorded by Sir J. Paget of a lady, whose hair lost its color at each successive attack of neuralgia and recovered it again in the course of a few days. With plants, however, and probably with compound animals, such as corals, the gemmules do not ordinarily spread from bud to bud, but are confined to the parts developed from each separate bud; and of this fact no explanation can be given.

TWO OBJECTIONS ANSWERED.

Page 380. But we have here to encounter two objections which apply not only to the regrowth of a part, or of a bisected individual, but to fissiparous generation and budding. The first objection is that the part which is reproduced is in the same stage of development as that of the being which has been operated on or bisected; and in the case of buds, that the new beings thus produced are in the same stage as that of the budding parent. Thus a mature salamander, of which the tail has been cut off, does not reproduce a larval tail; and a crab does not reproduce a larval leg. In the case of budding it was shown in the first part of this chapter that the new being thus produced does not retrograde in development—that is, does not pass through those earlier stages which the fertilized germ has to pass through. Nevertheless, the organisms operated on or multiplying themselves by buds must, by our hypothesis, include innumerable gemmules derived from every part or unit of the earlier stages of development; and why do not such gemmules reproduce the amputated part or the whole body at a corresponding early stage of development?

The second objection, which has been insisted on by Delpino, is that the tissues, for instance, of a mature salamander or crab, of which a limb has been removed, are already differentiated and have passed through their whole course of development; and how can such tissues in accordance with our hypothesis attract and combine with the gemmules of the part which is to be reproduced? In answer to these two objections we must bear in mind the evidence which has been advanced, showing that at least in a large number of cases the power of regrowth is a localized faculty, acquired for the sake of repairing special injuries to which each particular creature is liable; and, in the case of buds or fissiparous generation, for the sake of quickly multiplying the organism at a period of life when it can be supported in large numbers. These considerations lead us to believe that in all such cases a stock of nascent cells or of partially developed gemmules are retained for this special purpose either locally or throughout the body, ready to combine with the gemmules derived from the cells which come next in due succession. If this be admitted, we have a sufficient answer to the above two objections. Anyhow, pangenesis seems to throw a considerable amount of light on the wonderful power of regrowth.

EFFECT OF MORBID ACTION.

Page 392. We have as yet spoken only of the removal of parts, when not followed by morbid action: but, when the operation is thus followed, it is certain that the deficiency is sometimes inherited. In a former chapter instances were given, as of a cow, the loss of whose horn was followed by suppuration, and her calves were destitute of a horn on the same side of their heads.

But the evidence which admits of no doubt is that given by Brown-Séquard with respect to Guinea-pigs, which, after their sciatic nerves had been divided, gnawed off their own gangrenous toes, and the toes of their offspring were deficient in at least thirteen instances on the corresponding feet. The inheritance of the lost part in several of these cases is all the more remarkable as only one parent was affected; but we know that a congenital deficiency is often transmitted from one parent alone—for instance, the offspring of hornless cattle of either sex, when crossed with perfect animals, are often hornless. How, then, in accordance with our hypothesis can we account for mutilations being sometimes strongly inherited, if they are followed by diseased action? The answer probably is that all the gemmules of the mutilated or amputated part are gradually attracted to the diseased surface during the reparative process, and are there destroyed by the morbid action.

TRANSMISSION LIMITED.

Page 396. The transmission of dormant gemmules during many successive generations is hardly in itself more improbable, as previously remarked, than the retention during many ages of rudimentary organs, or even only of a tendency to the production of a rudiment; but there is no reason to suppose that dormant gemmules can be transmitted and propagated forever. Excessively minute and numerous as they are believed to be, an infinite number, derived, during a long course of modification and descent, from each unit of each progenitor, could not be supported or nourished by the organism. But it does not seem improbable that certain gemmules, under favorable conditions, should be retained and go on multiplying for a much longer period than others. Finally, on the view here given, we certainly gain some insight into the wonderful fact that the child may depart from the type of both its parents, and resemble its grand-parents, or ancestors removed by many hundreds of generations.

Page 398. The child, strictly speaking, does not grow into the man, but includes germs which slowly and successively become developed and form the man. In the child, as well as in the adult, each part generates the same part. Inheritance must be looked at as merely a form of growth, like the self-division of a lowly-organized unicellular organism. Reversion depends on the transmission from the forefather to his descendants of dormant gemmules, which occasionally become developed under certain known or unknown conditions. Each animal and plant may be compared with a bed of soil full of seeds, some of which soon germinate, some lie dormant for a period, while others perish. When we hear it said that a man carries in his constitution the seeds of an inherited disease, there is much truth in the expression. No other attempt, as far as I am aware, has been made, imperfect as this confessedly is, to connect under one point of view these several grand classes of facts. An organic being is a microcosm—a little universe, formed of a host of self-propagating organisms, inconceivably minute and numerous as the stars in heaven.

XV.

OBJECTIONS TO THE THEORY OF DESCENT WITH MODIFICATION CONSIDERED.

Origin of Species, page 63.

SEVERAL writers have misapprehended or objected to the term Natural Selection. Some have even imagined that natural selection induces variability, whereas it implies only the preservation of such variations as arise and are beneficial to the being under its conditions of life. No one objects to agriculturists speaking of the potent effects of man's selection; and in this case the individual difference given by nature, which man for some object selects, must of necessity first occur. Others have objected that the term selection implies conscious choice in the animals which become modified; and it has even been urged that, as plants have no volition, natural selection is not applicable to them! In the literal sense of the word, no donbt, natural selection is a false term; but who ever objected to chemists speaking of the elective affinities of the various elements?—and yet an acid can not strictly be said to elect the base with which it in preference combines. It has been said that I speak of natural selection as an active power or Deity; but who objects to an author speaking of the attraction of gravity as ruling the movements of the planets? Every one knows what is meant and is implied by such metaphorical expressions; and they are almost necessary for brevity. So again it is difficult to avoid personifying the word Nature; but I mean by Nature, only the aggregate action and product of many natural laws, and by laws the sequence of events as ascertained by us. With a little familiarity such superficial objections will be forgotten.

MISREPRESENTATIONS CORRECTED.

Origin of Species, page 421.

As my conclusions have lately been much misrepresented, and it has been stated that I attribute the modification of species exclusively to natural selection, I may be permitted to remark that in the first edition of this work, and subsequently, I placed in a most conspicuous position—namely, at the close of the introduction—the following words: "I am convinced that natural selection has been the main but not the exclusive means of modification." This has been of no avail. Great is the power of steady misrepresentation; but the history of science shows that fortunately this power does not long endure.

It can hardly be supposed that a false theory would explain, in so satisfactory a manner as does the theory of natural selection, the several large classes of facts above specified. It has recently been objected that this is an unsafe method of arguing; but it is a method used in judging of the common events of life, and has often been used by the greatest natural philosophers. The undulatory theory of light has thus been arrived at; and the belief in the revolution of the earth on its own axis was until lately supported by hardly any direct evidence. It is no valid objection that science as yet throws no light on the far higher problem of the essence or origin of life. Who can explain what is the essence of the attraction of gravity? No one now objects to following out the results consequent on this unknown element of attraction; notwithstanding that Leibnitz formerly accused Newton of introducing "occult qualities and miracles into philosophy."

I see no good reason why the views given in this volume should shock the religious feelings of any one. It is satisfactory, as showing how transient such impressions are, to remember that the greatest discovery ever made by man, namely, the law of the attraction of gravity, was also attacked by Leibnitz, "as subversive of natural, and inferentially of revealed, religion." A celebrated author and divine has written to me that "he has gradually learned to see that it is just as noble a conception of the Deity to believe that he created a few original forms capable of self-development into other and needful forms, as to believe that he required a fresh act of creation to supply the voids caused by the action of his laws."

LAPSE OF TIME AND EXTENT OF AREA.

Origin of Species, page 82.

The mere lapse of time by itself does nothing, either for or against natural selection. I state this because it has been erroneously asserted that the element of time has been assumed by me to play an all-important part in modifying species, as if all the forms of life were necessarily undergoing change through some innate law. Lapse of time is only so far important, and its importance in this respect is great, that it gives a better chance of beneficial variations arising, and of their being selected, accumulated, and fixed. It likewise tends to increase the direct action of the physical conditions of life, in relation to the constitution of each organism.

If we turn to nature to test the truth of these remarks, and look at any small isolated area, such as an oceanic island, although the number of species inhabiting it is small, as we shall see in our chapter on "Geographical Distribution," yet of these species a very large proportion are endemic—that is, have been produced there, and nowhere else in the world. Hence an oceanic island at first sight seems to have been highly favorable for the production of new species. But we may thus deceive ourselves, for, to ascertain whether a small isolated area, or a large open area like a continent, has been most favorable for the production of new organic forms, we ought to make the comparison within equal times; and this we are incapable of doing.

Although isolation is of great importance in the production of new species, on the whole I am inclined to believe that largeness of area is still more important, especially for the production of species which shall prove capable of enduring for a long period, and of spreading widely. Throughout a great and open area, not only will there be a better chance of favorable variations, arising from the large number of individuals of the same species there supported, but the conditions of life are much more complex from the large number of already existing species; and if some of these many species become modified and improved, others will have to be improved in a corresponding degree, or they will be exterminated. Each new form, also, as soon as it has been much improved, will be able to spread over the open and continuous area, and will thus come into competition with many other forms. Moreover, great areas, though now continuous, will often, owing to former oscillations of level, have existed in a broken condition; so that the good effects of isolation will generally, to a certain extent, have concurred. Finally, I conclude that, although small isolated areas haye been in some respects highly favorable for the production of new species, yet that the course of modification will generally have been more rapid on large areas; and what is more important, that the new forms produced on large areas, which already have been victorious over many competitors, will be those that will spread most widely, and will give rise to the greatest number of new varieties and species. They will thus play a more important part in the changing history of the organic world.

WHY THE HIGHER FORMS HAVE NOT SUPPLANTED THE LOWER.

Origin of Species, page 98.

But it may be objected that if all organic beings thus tend to rise in the scale, how is it that throughout the world a multitude of the lowest forms still exist; and how is it that in each great class some forms are far more highly developed than others? Why have not the more highly developed forms everywhere supplanted and exterminated the lower? Lamarck, who believed in an innate and inevitable tendency toward perfection in all organic beings, seems to have felt this difficulty so strongly that he was led to suppose that new and simple forms are continually being produced by spontaneous generation. Science has not as yet proved the truth of this belief, whatever the future may reveal. On our theory the continued existence of lowly organisms offers no difficulty; for natural selection, or the survival of the fittest, does not necessarily include progressive development—it only takes advantage of such variations as arise and are beneficial to each creature under its complex relations of life. And it may be asked, What advantage, as far as we can see, would it be to an infusorian animalcule—to an intestinal worm—or even to an earth-worm, to be highly organized? If it were no advantage, these forms would be left, by natural selection, unimproved or but little improved, and might remain for indefinite ages in their present lowly condition. And geology tells us that some of the lowest forms, as the infusoria and rhizopods, have remained for an enormous period in nearly their present state. But to suppose that most of the many now existing low forms have not in the least advanced since the first dawn of life would be extremely rash; for every naturalist who has dissected some of the beings now ranked as very low in the scale must have been struck with their really wondrous and beautiful organization.

Nearly the same remarks are applicable if we look to the different grades of organization within the same great group; for instance, in the vertebrata, to the co-existence of mammals and fish—among mammalia, to the co-existence of man and the ornithorhynchus—among fishes, to the co-existence of the shark and the lancelet (Amphioxus), which latter fish in the extreme simplicity of its structure approaches the invertebrate classes. But mammals and fish hardly come into competition with each other; the advancement of the whole class of mammals, or of certain members in this class, to the highest grade would not lead to their taking the place of fishes. Physiologists believe that the brain must be bathed by warm blood to be highly active, and this requires aërial respiration; so that warm-blooded mammals when inhabiting the water lie under a disadvantage in having to come continually to the surface to breathe. With fishes, members of the shark family would not tend to supplant the lancelet; for the lancelet, as I hear from Fritz Müller, has as sole companion and competitor on the barren, sandy shore of South Brazil an anomalous annelid. The three lowest orders of mammals, namely, marsupials, edentata, and rodents, co-exist in South America in the same region with numerous monkeys, and probably interfere little with each other. Although organization, on the whole, may have advanced and be still advancing throughout the world, yet the scale will always present many degrees of perfection ; for the high advancement of certain whole classes, or of certain members of each class, does not at all necessarily lead to the extinction of those groups with which they do not enter into close competition. In some cases, as we shall hereafter see, lowly organized forms appear to have been preserved to the present day, from inhabiting confined or peculiar stations, where they have been subjected to less severe competition, and where their scanty numbers have retarded the chance of favorable variations arising.

Finally, I believe that many lowly organized forms now exist throughout the world, from various causes. In some cases variations or individual differences of a favorable nature may never have arisen for natural selection to act on and accumulate. In no case, probably, has time sufficed for the utmost possible amount of development. In some few cases there has been what we must call retrogression of organization. But the main cause lies in the fact that under very simple conditions of life a high organization would be of no service—possibly would be of actual disservice, as being of a more delicate nature, and more liable to be put out of order and injured.

Looking to the first dawn of life, when all organic beings, as we may believe, presented the simplest structure, how, it has been asked, could the first steps in the advancement or differentiation of parts have arisen ?

Page 100.

As we have no facts to guide us, speculation on the subject is almost useless. It is, however, an error to suppose that there would be no struggle for existence, and, consequently, no natural selection, until many forms had been produced: variations in a single species inhabiting an isolated station might be beneficial, and thus the whole mass of individuals might be modified, or two distinct forms might arise. But, as I remarked toward the close of the Introduction, no one ought to feel surprised at much remaining as yet unexplained on the origin of species, if we make due allowance for our profound ignorance on the mutual relations of the inhabitants of the world at the present time, and still more so during past ages.

THE AMOUNT OF LIFE MUST HAVE A LIMIT.

Origin of Species, page 101.

What, then, checks an indefinite increase in the number of species? The amount of life (I do not mean the number of specific forms) supported on an area must have a limit, depending so largely as it does on physical conditions; therefore, if an area be inhabited by very many species, each or nearly each species will be represented by few individuals; and such species will be liable to extermination from accidental fluctuations in the nature of the seasons or in the number of their enemies. The process of extermination in such cases would be rapid, whereas the production of new species must always be slow. Imagine the extreme case of as many species as individuals in England, and the first severe winter or very dry summer would exterminate thousands on thousands of species. Rare species, and each species will become rare if the number of species in any country becomes indefinitely increased, will, on the principle often explained, present within a given period few favorable variations; consequently, the process of giving birth to new specific forms would thus be retarded. When any species becomes very rare, close interbreeding will help to exterminate it; authors have thought that this comes into play in accounting for the deterioration of the aurochs in Lithuania, of red deer in Scotland, and of bears in Norway, etc. Lastly, and this I am inclined to think is the most important element, a dominant species, which has already beaten many competitors in its own home, will tend to spread and supplant many others. Alph. de Candolle has shown that those species which spread widely tend generally to spread *very* widely; consequently, they will tend to supplant and exterminate several species in several areas, and thus check the inordinate increase of specific forms throughout the world. Dr. Hooker has recently shown that in the southeast cor ner of Australia, where, apparently, there are many invaders from different quarters of the globe, the endemic Australian species have been greatly reduced in number. How much weight to attribute to these several considerations I will not pretend to say; but conjointly they must limit in each country the tendency to an indefinite augmentation of specific forms.

THE BROKEN BRANCHES OF THE TREE OF LIFE.

Origin of Species, page 104.

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 former years 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 at all times overmastered 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 young, budding twigs; and this connection 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 the other branches; so with the species which lived during long-past geological periods, very few have left living and modified descendants. From the first growth of the tree, many a limb and branch has decayed and dropped off; and these fallen 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 in a fossil state. As we here and there see a thin straggling branch springing from a fork low down in a tree, and which by some chance has been favored 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.

WHY WE DO NOT FIND TRANSITIONAL FORMS.

Origin of Species, page 134.

It may be urged that, when several closely-allied species inhabit the same territory, we surely ought to find at the present time many transitional forms.

Page 137.

I believe that species come to be tolerably well-defined objects, and do not at any one period present an inextricable chaos of varying and intermediate links: first, because new varieties are very slowly formed, for variation is a slow process, and natural selection can do nothing until favorable individual differences or variations occur, and until a place in the natural polity of the country can be better filled by some modification of some one or more of its inhabitants. And such new places will depend on slow changes of climate, or on the occasional immigration of new inhabitants, and, probably, in a still more important degree, on some of the old inhabitants becoming slowly modified, with the new forms thus produced and the old ones acting and reacting on each other. So that, in any one region and at any one time, we ought to see only a few species presenting slight modifications of structure in some degree permanent; and this assuredly we do see.

Secondly, areas now continuous must often have existed within the recent period as isolated portions, in which many forms, more especially among the classes which unite for each birth and wander much, may have separately been rendered sufficiently distinct to rank as representative species. In this case, intermediate varieties between the several representative species and their common parent must formerly have existed within each isolated portion of the land, but these links during the process of natural selection will have been supplanted and exterminated, so that they will no longer be found in a living state.

Thirdly, when two or more varieties have been formed in different portions of a strictly continuous area, intermediate varieties will, it is probable, at first have been formed in the intermediate zones, but they will generally have had a short duration. For these intermediate varieties will, from reasons already assigned (namely, from what we know of the actual distribution of closely-allied or representative species, and likewise of acknowledged varieties), exist in the intermediate zones in lesser numbers than the varieties which they tend to connect. From this cause alone the intermediate varieties will be liable to accidental extermination; and, during the process of further modification through natural selection, they will almost certainly be beaten and supplanted by the forms which they connect; for these from existing in greater numbers will, in the aggregate, present more varieties and thus be further improved through natural selection and gain further advantages.

Lastly, looking not to any one time, but to all time, if my theory be true, numberless intermediate varieties, linking closely together all the species of the same group, must assuredly have existed; but the very process of natural selection constantly tends, as has been so often remarked, to exterminate the parent-forms and the intermediate links. Consequently evidence of their former existence could be found only among fossil remains, which are preserved, as we shall attempt to show in a future chapter, in an extremely imperfect and intermittent record.

Page 283. Professor Pictet, in commenting on early transitional forms, and taking birds as an illustration, can not see how the successive modifications of the anterior limbs of a supposed prototype could possibly have been of any advantage. But look at the penguins of the Southern Ocean; have not these birds their front limbs in this precise intermediate state of "neither true arms nor true wings"? Yet these birds hold their place victoriously in the battle for life; for they exist in infinite numbers and of many kinds. I do not suppose that we here see the real transitional grades through which the wings of birds have passed; but what special difficulty is there in believing that it might profit the modified descendants of the penguin, first to become enabled to flap along the surface of the sea like the logger-headed duck, and ultimately to rise from its surface and glide through the air?

Page 289. The several difficulties here discussed, namely—that, though we find in our geological formations many links between the species which now exist and which formerly existed, we do not find infinitely numerous fine transitional forms closely joining them all together; the sudden manner in which several groups of species first appear in our European formations—the almost entire absence, as at present known, of formations rich in fossils beneath the Cambrian strata—are all undoubtedly of the most serious nature. We see this in the fact that the most eminent paleontologists, namely, Cuvier, Agassiz, Barrande, Pictet, Falconer, E. Forbes, etc., and all our greatest geologists, as Lyell, Murchison, Sedgwick, etc., have unanimously, often vehemently, maintained the immutability of species. But Sir Charles Lyell now gives the support of his high authority to the opposite side; and most geologists and paleontologists are much shaken in their former belief. Those who believe that the geological record is in any degree perfect will undoubtedly at once reject the theory. For my part, following out Lyell's metaphor, I look at the geological record as a history of the world imperfectly kept, and written in a changing dialect; of this history we possess the last volume alone, relating only to two or three countries. Of this volume, only here and there a short chapter has been preserved; and of each page, only here and there a few lines. Each word of the slowly-changing language, more or less different in the successive chapters, may represent the forms of life which are entombed in our consecutive formations, and which falsely appear to us to have been abruptly introduced. On this view, the difficulties above discussed are greatly diminished, or even disappear.

HOW COULD THE TRANSITIONAL FORM HAVE SUBSISTED?

Page 138. It has been asked by the opponents of such views as I hold, how, for instance, could a land carnivorous animal have been converted into one with aquatic habits; for how could the animal in its transitional state have subsisted? It would be easy to show that there now exist carnivorous animals presenting close intermediate grades from strictly terrestrial to aquatic habits; and, as each exists by a struggle for life, it is clear that each must be well adapted to its place in nature. Look at the *Mustela vison* of North America, which has webbed feet, and which resembles an otter in its fur, short legs, and form of tail. During the summer this animal dives for and preys on fish, but during the long winter it leaves the frozen waters, and preys, like other polecats, on mice and land animals. If a different case had been taken, and it had been asked how an insectivorous quadruped could possibly have been converted into a flying bat, the question would have been far more difficult to answer. Yet I think such difficulties have little weight.

Here, as on other occasions, I lie under a heavy disadvantage, for, out of the many striking cases which I have collected, I can give only one or two instances of transitional habits and structures in allied species; and of diversified habits, either constant or occasional, in the same species. And it seems to me that nothing less than a long list of such cases is sufficient to lessen the difficulty in any particular case like that of the bat.

WHY NATURE TAKES NO SUDDEN LEAPS.

Origin of Species, page 156.

Finally, then, although in many cases it is most difficult even to conjecture by what transitions organs have arrived at their present state, yet, considering how small the proportion of living and known forms is to the extinct and unknown, I have been astonished how rarely an organ can be named, toward which no transitional grade is known to lead. It certainly is true that new organs, appearing as if created for some special purpose, rarely or never appear in any being —as indeed is shown by that old but somewhat exaggerated canon in natural history of "Natura non facit saltum." We meet with this admission in the writings of almost every experienced naturalist; or as Milne-Edwards has well expressed it, Nature is prodigal in variety, but niggard in innovation. Why, on the theory of Creation, should there be so much variety and so little real novelty? Why should all the parts and organs of many independent beings, each supposed to have been separately created for its proper place in nature, be so commonly linked together by graduated steps? Why should not Nature take a sudden leap from structure to structure? On the theory of natural selection, we can clearly understand why she should not; for natural selection acts only by taking advantage of slight successive variations; she can never take a great and sudden leap, but must advance by short and sure though slow steps.

IMPERFECT CONTRIVANCES OF NATURE ACCOUNTED FOR.

Page 163. If our reason leads us to admire with enthusiasm a multitude of inimitable contrivances in nature, this same reason tells us, though we may easily err on both sides, that some other contrivances are less perfect. Can we consider the sting of the bee as perfect, which, when used against many kinds of enemies, can not be withdrawn, owing to the backward serratures, and thus inevitably causes the death of the insect by tearing out its viscera?

If we look at the sting of the bee, as having existed in a remote progenitor as a boring and serrated instrument like that in so many members of the same great order, and that it has since been modified but not perfected for its present purpose with the poison originally adapted for some other object, such as to produce galls, since intensified, we can perhaps understand how it is that the use of the sting should so often cause the insect's own death: for, if on the whole the power of stinging be useful to the social community, it will fulfill all the requirements of natural selection, though it may cause the death of some few members. If we admire the truly wonderful power of scent by which the males of many insects find their females, can we admire the production for this single purpose of thousands of drones, which are utterly useless to the community for any other purpose, and which are ultimately slaughtered by their industrious and sterile sisters? It may be difficult, but we ought to admire the savage instinctive hatred of the queen-bee, which urges her to destroy the young queens, her daughters, as soon as they are born, or to perish herself in the combat; for undoubtedly this is for the good of the community; and maternal love or maternal hatred, though the latter fortunately is most rare, is all the same to the inexorable principle of natural selection. If we admire the several ingenious contrivances by which orchids and many other plants are fertilized through insect agency, can we consider as equally perfect the elaboration of dense clouds of pollen by our fir-trees, so that a few granules may be wafted by chance on to the ovules?

INSTINCTS AS A DIFFICULTY.

Origin of Species, page 205.

Many instincts are so wonderful that their development will probably appear to the reader a difficulty sufficient to overthrow my whole theory. I may here premise that I have nothing to do with the origin of the mental powers, any more than I have with that of life itself. We are concerned only with the diversities of instinct and of the other mental faculties in animals of the same class.

I will not attempt any definition of instinct. It would be easy to show that several distinct mental actions are commonly embraced by this term; but every one understands what is meant when it is said that instinct impels the cuckoo to migrate and to lay her eggs in other birds' nests. An action, which we ourselves require experience to enable us to perform, when performed by an animal, more especially by a very young one, without experience, and when performed by many individuals in the same way, without their knowing for what purpose it is performed, is usually said to be instinctive. But I could show that none of these characters are universal. A little dose of judgment or reason, as Pierre Huber expresses it, often comes into play, even with animals low in the scale of nature.

Page 206. If we suppose any habitual action to become inherited—and it can be shown that this does sometimes happen—then the resemblance between what originally was a habit and an instinct becomes so close as not to be distinguished. If Mozart, iustead of playing the piano-forte at three years old with wonderfully little practice, had played a tune with no practice at all, he might truly be said to have done so instinctively. But it would be a serious error to suppose that the greater number of instincts have been acquired by habit in one generation, and then transmitted by inheritance to succeeding generations. It can be clearly shown that the most wonderful instincts with which we are acquainted, namely, those of the hive-bee and of many ants, could not possibly have been acquired by habit.

Page 208. Why, it has been asked, if instinct be variable, has it not granted to the bee "the ability to use some other material when wax was deficient"? But what other natural material could bees use? They will work, as I have seen, with wax hardened with vermilion or softened with lard. Andrew Knight observed that his bees, instead of laboriously collecting propolis, used a cement of wax and turpentine, with which he had covered decorticated trees. It has lately been shown that bees, instead of searching for pollen, will gladly use a very different substance, namely, oatmeal. Fear of any particular enemy is certainly an instinctive quality, as may be seen in nestling birds, though it is strengthened by experience, and by the sight of fear of the same enemy in other animals. The fear of man is slowly acquired, as I have elsewhere shown, by the various animals which inhabit desert islands; and we see an instance of this even in England, in the greater wildness of all our large birds in comparison with our small birds; for the large birds have been most persecuted by man. We may safely attribute the greater wildness of our large birds to this cause; for in uninhabited islands large birds are not more fearful than small; and the magpie, so wary in England, is tame in Norway, as is the hooded crow in Egypt.

SOME INSTINCTS ACQUIRED AND SOME LOST.

Page 210. It may be doubted whether any one would have thought of training a dog to point, had not some one dog naturally shown a tendency in this line; and this is known occasionally to happen, as I once saw, in a pure terrier: the act of pointing is probably, as many have thought, only the exaggerated pause of an animal preparing to spring on its prey. When the first tendency to point was once displayed, methodical selection and the inherited effects of compulsory training in each successive generation would soon complete the work; and unconscious selection is still in progress, as each man tries to procure, without intending to improve the breed, dogs which stand and hunt best. On the other hand, habit alone in some cases has sufficed; hardly any animal is more difficult to tame than the young of the wild rabbit; scarcely any animal is tamer than the young of the tame rabbit; but I can hardly suppose that domestic rabbits have often been selected for tameness alone; so that we must attribute at least the greater part of the inherited change from extreme wildness to extreme tameness to habit and long-continued close confinement.

Natural instincts are lost under domestication: a remarkable instance of this is seen in those breeds of fowls which very rarely or never become "broody," that is, never wish to sit on their eggs. Familiarity alone prevents our seeing how largely and how permanently the minds of our domestic animals have been modified. It is scarcely possible to doubt that the love of man has become instinctive in the dog. All wolves, foxes, jackals, and species of the cat genus, when kept tame, are most eager to attack poultry, sheep, and pigs; and this tendency has been found incurable in dogs which have been brought home as puppies from countries such as Tierra del Fuego and Australia, where the savages do not keep these domestic animals. How rarely, on the other hand, do our civilized dogs, even when quite young, require to be taught not to attack poultry, sheep, and pigs! No doubt they occasionally do make an attack, and are then beaten; and, if not cured, they are destroyed; so that habit and some degree of selection have probably concurred in civilizing by inheritance our dogs. On the other hand, young chickens have lost, wholly by habit, that fear of the dog and cat which no doubt was originally instinctive in them; for I am informed by Captain Hutton that the young chickens of the parent-stock, the *Gallus bankiva*, when reared in India under a hen, are at first excessively wild. So it is with young pheasants reared in England under a hen. It is not that chickens have lost all fear, but fear only of dogs and cats, for if the hen gives the danger-chuckle, they will run (more especially young turkeys) from under her, and conceal themselves in the surrounding grass or thickets; and this is evidently done for the instinctive purpose of allowing, as we see in wild ground-birds, their mother to fly away. But this instinct retained by our chickens has become useless under domestication, for the mother-hen has almost lost by disuse the power of flight.

Hence, we may conclude that, under domestication, instincts have been acquired, and natural instincts have been lost, partly by habit, and partly by man selecting and accumulating, during successive generations, peculiar mental habits and actions, which at first appeared from what we must in our ignorance call an accident.

INNUMERABLE LINKS NECESSARILY LOST.

Origin of Species, page 264.

The main cause of innumerable intermediate links not now occurring everywhere throughout nature depends on the very process of natural selection, through which new varieties continually take the places of and supplant their parent-forms. But just in proportion as this process of extermination has acted on an enormous scale, so must the number of intermediate varieties, which have formerly existed, be truly enormous. Why, then, is not every geological formation and every stratum full of such intermediate links? Geology assuredly does not reveal any such finely-graduated organic chain; and this, perhaps, is the most obvious and serious objection which can be urged against the theory. The explanation lies, as I believe, in the extreme imperfection of the geological record.

In the first place, it should always be borne in mind what sort of intermediate forms must, on the theory, have formerly existed. I have found it difficult, when looking at any two species, to avoid picturing to myself forms *directly* intermediate between them. But this is a wholly false view; we should always look for forms intermediate between each species and a common but unknown progenitor; and the progenitor will generally have differed in some respects from all its modified descendants. To give a simple illustration: the fantail and pouter pigeons are both descended from the rock-pigeon; if we possessed all the intermediate varieties which have ever existed, we should have an extremely close series between both and the rock-pigeon; but we should have no varieties directly intermediate between the fantail and pouter; none, for instance, combining a tail somewhat expanded with a crop somewhat enlarged, the characteristic features of these two breeds. These two breeds, moreover, have become so much modified, that, if we had no historical or indirect evidence regarding their origin, it would not have been possible to have determined, from a mere comparison of their structure with that of the rock-pigeon, *C. livia*, whether they had descended from this species or from some other allied form, such as *C. oenas*.

Page 265. It is just possible by the theory, that one of two living forms might have descended from the other; for instance, a horse from a tapir; and in this case *direct* intermediate links will have existed between them. But such a case would imply that one form had remained for a very long period unaltered, while its descendants had undergone a vast amount of change; and the principle of competition between organism and organism, between child and parent, will render this a very rare event; for in all cases the new and improved forms of life tend to supplant the old and unimproved forms.

By the theory of natural selection all living species have been connected with the parent-species of each genus, by differences not greater than we see between the natural and domestic varieties of the same species at the present day; and these parent-species, now generally extinct, have in their turn been similarly connected with more ancient forms; and so on backward, always converging to the common ancestor of each great class. So that the number of intermediate and transitional links, between all living and extinct species, must have been inconceivably great. But assuredly, if this theory be true, such have lived upon the earth.

PLENTY OF TIME FOR THE NECESSARY GRADATIONS.

Page 266. Independently of our not finding fossil remains of such infinitely numerous connecting links, it may be objected that time can not have sufficed for so great an amount of organic change, all changes having been effected slowly. It is hardly possible for me to recall to the reader who is not a practical geologist the facts leading the mind feebly to comprehend the lapse of time. He who can read Sir Charles Lyell's grand work on the "Principles of Geology," which the future historian will recognize as having produced a revolution in natural science, and yet does not admit how vast have been the past periods of time, may at once close this volume.

Page 269. When geologists look at large and complicated phenomena, and then at the figures representing several million years, the two produce a totally different effect on the mind, and the figures are at once pronounced too small. In regard to subaërial denudation, Mr. Croll shows, by calculating the known amount of sediment annually brought down by certain rivers, relatively to their areas of drainage, that one thousand feet of solid rock, as it became gradually disintegrated, would thus be removed from the mean level of the whole area in the course of six million years. This seems an astonishing result, and some considerations lead to the suspicion that it may be too large, but even if halved or quartered it is still very surprising. Few of us, however, know what a million really means: Mr. Croll gives the following illustration: take a narrow strip of paper, eighty-three feet four inches in length, and stretch it along the wall of a large hall; then mark off at one end the tenth of an inch. This tenth of an inch will represent one hundred years, and the entire strip a million years. But let it be borne in mind, in relation to the subject of this work, what a hundred years implies, represented as it is by a measure utterly insignificant in a hall of the above dimensions. Several eminent breeders, during a single lifetime, have so largely modified some of the higher animals, which propagate their kind much more slowly than most of the lower animals, that they have formed what well deserves to be called a new subbreed. Few men have attended with due care to any one strain for more than half a century, so that a hundred years represents the work of two breeders in succession.

Page 270. Now let us turn to our richest geological museums, and what a paltry display we behold! That our collections are imperfect is admitted by every one. The remark of that admirable paleontologist, Edward Forbes, should never be forgotten, namely, that very many fossil species are known and named from single and often broken specimens, or from a few specimens collected on some one spot. Only a small portion of the surface of the earth has been geologically explored, and no part with sufficient care, as the important discoveries made every year in Europe prove. No organism wholly soft can be preserved. Shells and bones decay and disappear when left on the bottom of the sea, where sediment is not accumulating. We probably take a quite erroneous view, when we assume that sediment is being deposited over nearly the whole bed of the sea, at a rate sufficiently quick to imbed and preserve fossil remains. Throughout an enormously large proportion of the ocean, the bright blue tint of the water bespeaks its purity. The many cases on record of a formation conformably covered, after an immense interval of time, by another and later formation, without the underlying bed having suffered in the interval any wear and tear, seem explicable only on the view of the bottom of the sea not rarely lying for ages in an unaltered condition. The remains which do become imbedded, if in sand or gravel, will, when the beds are upraised, generally be dissolved by the percolation of rain-water charged with carbonic acid. Some of the many kinds of animals which live on the beach between high and low water mark seem to be rarely preserved. For instance, the several species of the *Chthamalinæ* (a sub-family of sessile cirripeds) coat the rocks all over the world in infinite numbers: they are all strictly littoral, with the exception of a single Mediterranean species, which inhabits deep water, and this has been found fossil in Sicily, whereas not one other species has hitherto been found in any tertiary formation; yet it is known that the genus *Chthamalus* existed during the Chalk period. Lastly, many great deposits, requiring a vast length of time for their accumulation, are entirely destitute of organic remains, without our being able to assign any reason; one of the most striking instances is that of the Flysch formation, which consists of shale and sandstone, several thousand, occasionally even six thousand, feet in thickness, and extending for at least three hundred miles from Vienna to Switzerland; and, although this great mass has been most carefully searched, no fossils, except a few vegetable remains, have been found.

WIDE INTERVALS OF TIME BETWEEN THE GEOLOGICAL FORMATIONS.

Page 271. But the imperfection in the geological record largely results from another and more important cause than any of the foregoing; namely, from the several formations being separated from each other by wide intervals of time. This doctrine has been emphatically admitted by many geologists and paleontologists, who, like E. Forbes, entirely disbelieve in the change of species. When we see the formations tabulated in written works, or when we follow them in nature, it is difficult to avoid believing that they are closely consecutive. But we know, for instance, from Sir R. Murchison's great work on Russia, what wide gaps there are in that country between the superimposed formations; so it is in North America, and in many other parts of the world. The most skillful geologist, if his attention had been confined exclusively to these large territories, would never have suspected that, during the periods which were blank and barren in his own country, great piles of sediment, charged with new and peculiar forms of life, had elsewhere been accumulated. And if, in each separate territory, hardly any idea can be formed of the length of time which has elapsed between the consecutive formations, we may infer that this could nowhere be ascertained. The frequent and great changes in the mineralogical composition of consecutive formations, generally implying great changes in the geography of the surrounding lands, whence the sediment was derived, accord with the belief of vast intervals of time having elapsed between each formation.

Page 278. It is all-important to remember that naturalists have no golden rule by which to distinguish species and varieties; they grant some little variability to each species, but, when they meet with a somewhat greater amount of difference between any two forms, they rank both as species, unless they are enabled to connect them together by the closest intermediate gradations; and this, from the reasons just assigned, we can seldom hope to effect in any one geological section. Supposing B and C to be two species, and a third, A, to be found in an older and underlying bed; even if A were strictly intermediate between B and C, it would simply be ranked as a third and distinct species, unless at the same time it could be closely connected by intermediate varieties with either one or both forms. Nor should it be forgotten, as before explained, that A might be the actual progenitor of B and C, and yet would not necessarily be strictly intermediate between them in all respects. So that we might obtain the parent-species and its several modified descendants from the lower and upper beds of the same formation, and, unless we obtained numerous transitional gradations, we should not recognize their blood-relationship, and should consequently rank them as distinct species.

SUDDEN APPEARANCE OF GROUPS OF ALLIED SPECIES.

Origin of Species, page 282.

The abrupt manner in which whole groups of species suddenly appear in certain formations has been urged by several paleontologists—for instance, by Agassiz, Pictet, and Sedgwick—as a fatal objection to the belief in the transmutation of species. If numerous species, belonging to the same genera or families, have really started into life at once, the fact would be fatal to the theory of evolution through natural selection. For the development by this means of a group of forms, all of which are descended from some one progenitor, must have been an extremely slow process; and the progenitors must have lived long before their modified descendants. But we continually overrate the perfection of the geological record, and falsely infer, because certain genera or families have not been found beneath a certain stage, that they did not exist before that stage. In all cases positive paleontological evidence may be implicitly trusted; negative evidence is worthless, as experience has so often shown. We continually forget how large the world is, compared with the area over which our geological formations have been carefully examined; we forget that groups of species may elsewhere have long existed, and have slowly multiplied, before they invaded the ancient archipelagoes of Europe and the United States. We do not make due allowance for the intervals of time which have elapsed between our consecutive formations—longer, perhaps, in many cases than the time required for the accumulation of each formation. These intervals will have given time for the multiplication of species from some one parent-form; and, in the succeeding formation, such groups or species will appear as if suddenly created.

HOW LITTLE WE KNOW OF FORMER INHABITANTS OF THE WORLD.

Page 283. Even in so short an interval as that between the first and second edition of Pictet's great work on Paleontology, published in 1844–'46 and in 1853–'57, the conclusions on the first appearance and disappearance of several groups of animals have been considerably modified; and a third edition would require still further changes. I may recall the well-known fact that in geological treatises, published not many years ago, mammals were always spoken of as having abruptly come in at the commencement of the tertiary * series. And now one of the richest known accumulations of fossil mammals belongs to the middle of the secondary series; and true mammals have been discovered in the new red sandstone at nearly the commencement of this great series. Cuvier used to urge that no monkey occurred in any tertiary stratum; but now extinct species have been discovered in India, South America, and in Europe, as far back as the Miocene stage. Had it not been for the rare accident of the preservation of footsteps in the new red sandstone of the United States, who would have ventured to suppose that no less than at least thirty different bird-like animals, some of gigantic size, existed during that period? Not a fragment of bone has been discovered in these beds. Not long ago, paleontologists maintained that the whole class of birds came suddenly into existence during the Eocene period; but now we know, on the authority of Professor Owen, that a bird certainly lived during the deposition of the upper greensand; and still more recently, that strange bird, the archeopteryx, with a long, lizard-

* TERTIARY.—The latest geological epoch, immediately preceding the establishment of the present order of things.

like tail, bearing a pair of feathers on each joint, and with its wings furnished with two free claws, has been discovered in the oölitic slates of Solenhofen. Hardly any recent discovery shows more forcibly than this, how little we as yet know of the former inhabitants of the world.

THE EXTINCTION OF SPECIES INVOLVED IN MYSTERY.

Origin of Species, page 294.

The extinction of species has been involved in the most gratuitous mystery. Some authors have even supposed that as the individual has a definite length of life, so have species a definite duration. No one can have marveled more than I have done at the extinction of species. When I found in La Plata the tooth of a horse imbedded with the remains of mastodon, megatherium, toxodon, and other extinct monsters, which all co-existed with still living shells at a very late geological period, I was filled with astonishment; for, seeing that the horse, since its introduction by the Spaniards into South America, has run wild over the whole country and has increased in numbers at an unparalleled rate, I asked myself what could so recently have exterminated the former horse under conditions of life apparently so favorable. But my astonishment was groundless. Professor Owen soon perceived that the tooth, though so like that of the existing horse, belonged to an extinct species. Had this horse been still living, but in some degree rare, no naturalist would have felt the least surprise at its rarity; for rarity is the attribute of a vast number of species of all classes, in all countries. If we ask ourselves why this or that species is rare, we answer that something is unfavorable in its conditions of life; but what that something is we can hardly ever tell. On the supposition of the fossil horse still existing as a rare species, we might have felt certain, from the analogy of all other mammals, even of the slow-breeding elephant, and from the history of the naturalization of the domestic horse in South America, that under more favorable conditions it would in a very few years have stocked the whole continent. But we could not have told what the unfavorable conditions were which checked its increase, whether some one or several contingencies, and at what period of the horse's life, and in what degree, they severally acted. If the conditions had gone on, however slowly, becoming less and less favorable, we assuredly should not have perceived the fact, yet the fossil horse would certainly have become rarer and rarer, and finally extinct; —its place being seized on by some more successful competitor.

It is most difficult always to remember that the increase of every creature is constantly being checked by unperceived hostile agencies; and that these same unperceived agencies are amply sufficient to cause rarity, and finally extinction. So little is this subject understood that I have heard surprise repeatedly expressed at such great monsters as the mastodon and the more ancient dinosaurians having become extinct; as if mere bodily strength gave victory in the battle of life. Mere size, on the contrary, would in some cases determine, as has been remarked by Owen, quicker extermination from the greater amount of requisite food. Before man inhabited India or Africa, some cause must have checked the continued increase of the existing elephant. A highly capable judge, Dr. Falconer, believes that it is chiefly insects which, from incessantly harassing and weakening the elephant in India, check its increase; and this was Bruce's conclusion with respect to the African elephant in Abyssinia. It is certain that insects and blood-sucking bats determine the existence of the larger naturalized quadrupeds in several parts of South America.

Page 295. I may repeat what I published in 1845, namely, that to admit that species generally become rare before they become extinct—to feel no surprise at the rarity of a species, and yet to marvel greatly when the species ceases to exist, is much the same as to admit that sickness in the individual is the forerunner of death—to feel no surprise at sickness, but, when the sick man dies, to wonder and to suspect that he died by some deed of violence.

DEAD LINKS BETWEEN LIVING SPECIES.

Page 302. No one will deny that the Hipparion is intermediate between the existing horse and certain older ungulate forms. What a wonderful connecting link in the chain of mammals is the Typotherium from South America, as the name given to it by Professor Gervais expresses, and which can not be placed in any existing order! The Sirenia form a very distinct group of mammals, and one of the most remarkable peculiarities in the existing dugong and lamentin is the entire absence of hind limbs, without even a rudiment being left; but the extinct Halitherium had, according to Professor Flower, an ossified thigh-bone "articulated to a well-defined acetabulum in the pelvis," and it thus makes some approach to ordinary hoofed quadrupeds, to which the Sirenia are in other respects allied. The cetaceans or whales are widely different from all other mammals, but the tertiary Zeuglodon and Squalodon, which have been placed by some naturalists in an order by themselves, are considered by Professor Huxley to be undoubtedly cetaceans, "and to constitute connecting links with the aquatic carnivora."

Even the wide interval between birds and reptiles has been shown by the naturalist just quoted to be partially bridged over in the most unexpected manner, on the one hand, by the ostrich and extinct Archeopteryx, and on the other hand, by the Compsognathus, one of the dinosaurians—that group which includes the most gigantic of all terrestrial reptiles. Turning to the Invertebrata, Barrande asserts, and a higher authority could not be named, that he is every day taught that, although palæozoic animals can certainly be classed under existing groups, yet that at this ancient period the groups were not so distinctly separated from each other as they now are.

Some writers have objected to any extinct species, or group of species, being considered as intermediate between any two living species or groups of species. If by this term it is meant that an extinct form is directly intermediate in all its characters between two living forms or groups, the objection is probably valid. But in a natural classification many fossil species certainly stand between living species, and some extinct genera between living genera, even between genera belonging to distinct families. The most common case, especially with respect to very distinct groups, such as fish and reptiles, seems to be that, supposing them to be distinguished at the present day by a score of characters, the ancient members are separated by a somewhat lesser number of characters; so that the two groups formerly made a somewhat nearer approach to each other than they now do.

LIVING DESCENDANTS OF FOSSIL SPECIES.

Page 311.

It may be asked in ridicule, whether I suppose that the megatherium and other allied huge monsters, which formerly lived in South America, have left behind them the sloth, armadillo, and ant-eater, as their degenerate descendants. This can not for an instant be admitted. These huge animals have become wholly extinct, and have left no progeny. But in the caves of Brazil there are many extinct species which are closely allied in size and in all other characters to the species still living in South America; and some of these fossils may have been the actual progenitors of the living species. It must not be forgotten that, on our theory, all the species of the same genus are the descendants of some one species; so that, if six genera, each having eight species, be found in one geological formation, and in a succeeding formation there be six other allied or representative genera each with the same number of species, then we may conclude that generally only one species of each of the older genera has left modified descendants, which constitute the new genera containing the several species; the other seven species of each old genus having died out and left no progeny. Or, and this will be a far commoner case, two or three species in two or three alone of the six older genera will be the parents of the new genera: the other species and the other whole genera having become utterly extinct. In failing orders, with the genera and species decreasing in numbers as is the case with the Edentata of South America, still fewer genera and species will leave modified blood-descendants.

UNNECESSARY TO EXPLAIN THE CAUSE OF EACH INDIVIDUAL DIFFERENCE.

Animals and Plants, vol. ii, page 425.

In accordance with the views maintained by me in this work and elsewhere, not only the various domestic races, but the most distinct genera and orders within the same great class—for instance, mammals, birds, reptiles, and fishes—are all the descendants of one common progenitor, and we must admit that the whole vast amount of difference between these forms has primarily arisen from simple variability. To consider the subject under this point of view is enough to strike one dumb with amazement. But our amazement ought to be lessened when we reflect that beings almost infinite in number, during an almost infinite lapse of time, have often had their whole organization rendered in some degree plastic, and that each slight modification of structure which was in any way beneficial under excessively complex conditions of life has been preserved, while each which was in any way injurious has been rigorously destroyed. And the long-continued accumulation of beneficial variations will infallibly have led to structures as diversified, as beautifully adapted for various purposes and as excellently co-ordinated, as we see in the animals and plants around us. Hence I have spoken of selection as the paramount power, whether applied by man to the formation of domestic breeds, or by nature to the production of species.

If an architect were to rear a noble and commodious edifice, without the use of cut stone, by selecting from the fragments at the base of a precipice wedge-formed stones for his arches, elongated stones for his lintels, and flat stones for his roof, we should admire his skill and regard him as the paramount power. Now, the fragments of stone, though indispensable to the architect, bear to the edifice built by him the same relation which the fluctuating variations of organic beings bear to the varied and admirable structures ultimately acquired by their modified descendants.

Some authors have declared that natural selection explains nothing, unless the precise cause of each slight individual difference be made clear. If it were explained to a savage utterly ignorant of the art of building, how the edifice had been raised stone upon stone, and why wedge-formed fragments were used for the arches, flat stones for the roof, etc., and if the use of each part and of the whole building were pointed out, it would be unreasonable if he declared that nothing had been made clear to him, because the precise cause of the shape of each fragment could not be told. But this is a nearly parallel case with the objection that selection explains nothing, because we know not the cause of each individual difference in the structure of each being.

The shape of the fragments of stone at the base of our precipice may be called accidental, but this is not strictly correct; for the shape of each depends on a long sequence of events, all obeying natural laws; on the nature of the rock, on the lines of deposition or cleavage, on the form of the mountain, which depends on its upheaval and subsequent denudation, and lastly on the storm or earthquake which throws down the fragments. But in regard to the use to which the fragments may be put, their shape may be strictly said to be accidental.

"FACE TO FACE WITH AN INSOLUBLE DIFFICULTY."

Page 427. And here we are led to face a great difficulty, in alluding to which I am aware that I am traveling beyond my proper province. An omniscient Creator must have foreseen every consequence which results from the laws imposed by him. But can it be reasonably maintained that the Creator intentionally ordered, if we use the words in any ordinary sense, that certain fragments of rock should assume certain shapes so that the builder might erect his edifice? If the various laws which have determined the shape of each fragment were not predetermined for the builder's sake, can it be maintained with any greater probability that he specially ordained for the sake of the breeder each of the innumerable variations in our domestic animals and plants—many of these variations being of no service to man, and not beneficial, far more often injurious, to the creatures themselves? Did he ordain that the crop and tail-feathers of the pigeon should vary in order that the fancier might make his grotesque pouter and fantail breeds? Did he cause the frame and mental qualities of the dog to vary in order that a breed might be formed of indomitable ferocity, with jaws fitted to pin down the bull for man's brutal sport? But if we give up the principle in one case—if we do not admit that the variations of the primeval dog were intentionally guided in order that the greyhound, for instance, that perfect image of symmetry and vigor, might be formed—no shadow of reason can be assigned for the belief that variations, alike in nature and the result of the same general laws, which have been the groundwork through natural selection of the formation of the most perfectly adapted animals in the world, man included, were intentionally and specially guided. However much we may wish it, we can hardly follow Professor Asa Gray in his belief "that variation has been led along certain beneficial lines," like a stream "along definite and useful lines of irrigation." If we assume that each particular variation was from the beginning of all time preordained, then that plasticity of organization, which leads to many injurious deviations of structure, as well as the redundant power of reproduction which inevitably leads to a struggle for existence, and, as a consequence, to the natural selection or survival of the fittest, must appear to us superfluous laws of nature. On the other hand, an omnipotent and omniscient Creator ordains everything and foresees everything. Thus we are brought face to face with a difficulty as insoluble as is that of free-will and predestination.

WHY DISTASTEFUL?

Descent of Man, page 618.

The main conclusion arrived at in this work, namely, that man is descended from some lowly organized form, will, I regret to think, be highly distasteful to many. But there can hardly be a doubt that we are descended from barbarians. The astonishment which I felt on first seeing a party of Fuegians on a wild and broken shore will never be forgotten by me, for the reflection at once rushed into my mind—such were our ancestors. These men were absolutely naked and bedaubed with paint, their long hair was tangled, their mouths frothed with excitement, and their expression was wild, startled, and distrustful. They possessed hardly any arts, and like wild animals lived on what they could catch; they had no government, and were merciless to every one not of their own small tribe. He who has seen a savage in his native land will not feel much shame, if forced to acknowledge that the blood of some more humble creature flows in his veins. For my own part I would as soon be descended from that heroic little monkey, who braved his dreaded enemy in order to save the life of his keeper, or from that old baboon, who, descending from the mountains, carried away in triumph his young comrade from a crowd of astonished dogs—as from a savage who delights to torture his enemies, offers up bloody sacrifices, practices infanticide without remorse, treats his wives like slaves, knows no decency, and is haunted by the grossest superstitions.

Man may be excused for feeling some pride at having risen, though not through his own exertions, to the very summit of the organic scale; and the fact of his having thus risen, instead of having been aboriginally placed there, may give him hope for a still higher destiny in the distant future. But we are not here concerned with hopes or fears, only with the truth as far as our reason permits us to discover it; and I have given the evidence to the best of my ability. We must, however, acknowledge, as it seems to me, that man with all his noble qualities, with sympathy which feels for the most debased, with benevolence which extends not only to other men but to the humblest living creature, with his godlike intellect which has penetrated into the movements and constitution of the solar system—with all these exalted powers—man still bears in his bodily frame the indelible stamp of his lowly origin.

"ACCORDS BETTER WITH WHAT WE KNOW OF THE CREATOR'S LAWS."

Origin of Species, page 428.

Authors of the highest eminence seem to be fully satisfied with the view that each species has been independently created. To my mind it accords better with what we know of the laws impressed on matter by the Creator, that the production and extinction of the past and present inhabitants of the world should have been due to secondary causes, like those determining the birth and death of the individual. When I view all beings not as special creations, but as the lineal descendants of some few beings which lived long before the first bed of the Cambrian system was deposited, they seem to me to become ennobled. Judging from the past, we may safely infer that not one living species will transmit its unaltered likeness to a distant futurity. And of the species now living very few will transmit progeny of any kind to a far distant futurity; for the manner in which all organic beings are grouped, shows that the greater number of species in each genus, and all the species in many genera, have left no descendants, but have become utterly extinct. We can so far take a prophetic glance into futurity as to foretell that it will be the common and widely-spread species, belonging to the larger and dominant groups within each class, which will ultimately prevail and procreate new and dominant species. As all the living forms of life are the lineal descendants of those which lived long before the Cambrian epoch, we may feel certain that the ordinary succession by generation has never once been broken, and that no cataclysm has desolated the whole world. Hence we may look with some confidence to a secure future of great length. And as natural selection works solely by and for the good of each being, all corporeal and mental endowments will tend to progress toward perfection.

THE GRANDEUR OF THIS VIEW OF LIFE.

Page 429. It is interesting to contemplate a tangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent upon each other in so complex a manner, have all been produced by laws acting around us. These laws, taken in the largest sense, being growth with reproduction; inheritance which is almost implied by reproduction; variability from the indirect and direct action of the conditions of life, and from use and disuse: a ratio of increase so high as to lead to a struggle for life, and as a consequence to natural selection, entailing divergence of character and the extinction of less-improved forms. Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows. There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, while this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been and are being evolved.

NOT INCOMPATIBLE WITH THE BELIEF IN IMMORTALITY.

Descent of Man, page 612.

I am aware that the assumed instinctive belief in God has been used by many persons as an argument for his existence. But this is a rash argument, as we should thus be compelled to believe in the existence of many cruel and malignant spirits, only a little more powerful than man; for the belief in them is far more general than in a beneficent Deity. The idea of a universal and beneficent Creator does not seem to arise in the mind of man, until he has been elevated by long-continued culture.

He who believes in the advancement of man from some low organized form, will naturally ask, How does this bear on the belief in the immortality of the soul? The barbarous races of man, as Sir J. Lubbock has shown, possess no clear belief of this kind; but arguments derived from the primeval beliefs of savages are, as we have just seen, of little or no avail. Few persons feel any anxiety from the impossibility of determining at what precise period in the development of the individual, from the first trace of a minute germinal vesicle, man becomes an immortal being; and there is no greater cause for anxiety because the period can not possibly be determined in the gradually ascending organic scale.

I am aware that the conclusions arrived at in this work will be denounced by some as highly irreligious; but he who denounces them is bound to show why it is more irreligious to explain the origin of man as a distinct species by descent from some lower form, through the laws of variation and natural selection, than to explain the birth of the individual through the laws of ordinary reproduction. The birth both of the species and of the individual are equally parts of that grand sequence of events, which our minds refuse to accept as the result of blind chance. The understanding revolts at such a conclusion, whether or not we are able to believe that every slight variation of structure—the union of each pair in marriage—the dissemination of each seed—and other such events, have all been ordained for some special purpose.

Journal of Researches, page 503.

Among the scenes which are deeply impressed on my mind, none exceed in sublimity the primeval forests undefaced by the hand of man; whether those of Brazil, where the powers of life are predominant, or those of Tierra del Fuego, where death and decay prevail. Both are temples filled with the varied productions of the God of Nature; no one can stand in these solitudes unmoved, and not feel that there is more in man than the mere breath of his body.

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