The Darwinian Theory.

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SEVENTEEN years ago a book was published which will hereafter rank in the annals of science with Bacon's "Novum Organum" and Newton's "Principia," viz., Darwin's "Origin of Species." The change it has effected in the opinions of scientific men is unexampled, for there is now scarcely any man of scientific standing who is not a believer in the theory which Mr. Darwin propounded in this celebrated book. It was entitled "The Origin of Species by means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life." This title, though it accurately describes the contents of the work, does not at first sight convey an adequate idea of the novelty, originality and importance of the theory which it enunciates. Similar theories had been suggested before. Twenty years earlier an anonymous work entitled "The Vestiges of Creation," a work which attracted much attention at the time, and raised considerable discussion in the scientific world, broached a similar doctrine; and at a still earlier period, Lamark, a French naturalist, propounded a somewhat similar hypothesis. The Rev. Mr. Waite, in the well reasoned paper he read to this Society in November last, called this theory "*Darwin's Dream.*" If he had so characterized the theories of Lamark, or that of the Author of the "Vestiges," I might have agreed with him. Yet, looking back, we see that the views then propounded gradually led up to the Darwinian Theory as it is now understood, and it is very interesting and instructive to note how nearly these authors approached the truth and yet missed it!

Lamark was, I believe, the first naturalist who suggested the theory of the transmutation of species. He seems to have formed that opinion through observing the difficulty of distinguishing species from varieties, which merge imperceptibly into each other. The author of the "Vestiges" formed the same opinion, but for a different reason.

The family likeness which prevails in the animal kingdom seemed to him to be in some way the result of family relationship or a common descent. We thus see they had a glimpse of the truth, but it was so shadowy and unsubstantial that they failed to awaken more than a passing interest in their speculations. It was reserved for Darwin to carry conviction to the public mind, and to prove, as he has done almost to demonstration, not only that all organic life has been evolved from a few primordial germs, but he has shown *how* and *why* this evolution has taken place.

The theory, which is as simple as it is profound, is based upon the following principles:—

First.—Every plant and animal varies slightly from its parent. This fact is undoubted, for no plant, animal, or child is exactly like another.

Secondly.—A greater number of plants and animals are brought into existence each successive generation than there is room for in the world, and there must consequently ensue among them a "struggle for existence."

Thirdly.—This contention for life between organisms which are ever varying, results in a "natural selection" of those which are strongest or otherwise best fitted to contend for life, (a result, which Herbert Spencer happily calls the "*Survival of the fittest,*") and which leads in the long run to a slow but constant and interminable modification of all living beings.

These are the principles upon which the theory is based. It is at first sight difficult to realize the immense consequences which follow from the application of these principles and the wonderful changes which can be traced to their operation. I shall consider my task virtually accomplished if I can prove the *redundancy of the production of organic beings*, for the consequences pointed out inevitably follow. Allow me then to repeat that all organic beings tend to increase in a geometrical ratio. In order that you may realize what this means, let us consider how long a time a plant, say a grain of wheat, requires to spread itself over the whole surface of the globe. Let us assume (what I believe is the fact) that the farmer requires four bushels of corn to sow an acre of land. How many years would these four bushels of corn annually re-sown take to cover the entire globe? If you have never happened to make this calculation before, you will probably be surprised at the shortness of time required. The extent

of the land surface of the earth is 64 millions of square miles, or reckoning 640 square acres to the mile, 40,960 millions of square acres, and reckoning four bushels of corn to an acre, 163,840 millions of bushels of corn will be required to cover the whole surface of the earth. Now an ear of corn contains an average of fifty seeds, and therefore, if sown, increases fifty-fold each year. It will be found by calculation that corn which multiplies fifty-fold yearly will cover the entire globe in nine years. This surprising result you may easily verify for yourselves, and if any misgivings remain as to its accuracy, you have only to consider that in one year more fifty times as much will be produced, and will cover (say) fifty globes of the size of the earth. In still one year more enough to cover 2,500 globes will be produced. I have assumed that each seed is productive, which of course would scarcely be the case, for some would fall by the wayside, and in stony places, while others bring forth fifty-fold, but we may conclude that in spite of every adverse circumstance there will soon be a vast redundancy of corn.

The rapidity with which both animals and plants increase and multiply is illustrated by many recorded facts which fully bear out the soundness of this calculation. For instance, the horse which was introduced into the new world from the old, that is since the discovery of America, about 350 years ago, now runs wild in droves over the Pampas, and is spread over the whole of the new world. The thistle, "which now clothes the wild plains of La-Plata to the exclusion of every other plant," was introduced from Europe within the same period. On the other hand, the potato was imported from the new to the old world. We read that two potatoes were sent to England as a present to James I., which proves their scarcity only two hundred and fifty years ago. Dr. Hooker writes in 1864, that "watercress" which was introduced into New Zealand from England in our own day increases in the rivers to such an extent as to threaten to choke them altogether. Endless illustrations might be added if time permitted, but we must content ourselves by referring to the many illustrations contained in the writings of Darwin and others.

Now let us consider the effect of this rapid increase. We saw at the eighth or ninth year fifty times more corn was produced than there was room for. What then occurs? There must ensue among the grains of corn a "*struggle for existence.*" There is only room for one grain of corn, the remaining forty-nine must perish. But which

of the fifty grains survives? Why (as Spencer would say) that one which is best fitted to survive, either by reason of its strength, its suitability to the soil, or the climate where it happens to be located. One seed of corn more hardy than the rest will best contend with a barren soil or a cold climate. Another may be better suited to a fertile soil or a warm climate. Through these varying circumstances, grains of differing qualities will naturally select themselves for future reproduction in different localities, and there will arise in time from this cause different varieties of corn. Lengthen the time, and the varieties will differ so much as to rank as different species. This is a simple illustration of what would occur supposing the contention were confined to one species only. But the struggle for life as we find it in nature is infinitely more complex than this. Instead of one species only contending with itself, we have thousands of species, both of plants and animals, contending with each other. The final possession of the earth by plants and animals, and the proportion of space that each occupies, is the outcome of this endless and complicated contention.

Mr. Darwin's book is filled with the most interesting illustrations of the interdependence and relationship which obtains between all organic beings as the result of this contention. We have time to quote only one illustration, and I must refer to the book itself for further proof. It is known that nearly all orchidaceous plants depend for their fertilization upon humble bees, which convey the pollen from one plant to another, and it is thus found that these insects are therefore indispensable to the propagation of heartsease and red clover. But the number of humble bees is regulated by the number of field mice which prey upon them. The number of field mice again is controlled by their natural enemy, the cat. So that where cats abound, as they do in the neighbourhood of towns, the production of field mice is checked, and because field mice are checked, humble bees multiply, and clover and heartsease are proportionately fertilized. Who would have supposed that the quantity of red clover and heartsease could be thus shown to depend upon the existence of cats? Indeed, some jocular Evolutionist carries the illustration a step further, and contends that because cats are so much favoured by unmarried ladies the existence of clover and heartsease is dependent finally upon the number of old maids!

Now we have seen that this fight for the occupation of the soil must

end in the survival of the strongest combatants. According to the proverb, "the weak go to the wall," and nature thus continually selects the fittest seedlings. Many of you may remember that a few years ago, when the Royal Agricultural Show visited Cardiff, some extraordinary specimens of beetroot were exhibited by an eminent agricultural firm. These gentlemen were in the habit of offering their customers prizes for the best beetroot produced annually, and they selected the finest specimens thus obtained for planting. In the course of years this artificial selection of the fittest specimens for seedlings produced a greatly improved beetroot. Now, precisely as these agriculturalists improved the quality of their beetroot, so does Nature, though on an infinitely grander scale, improve all her productions by constantly and unceasingly rejecting the weakest seedlings and selecting the strongest and fittest for reproduction.

We have thus proved *deductively* that the redundancy of reproduction must inevitably cause a modification of species, and here we might rest our argument. If we have satisfied you that an overwhelming redundancy of varying plants and animals are reproduced continually (and there can be no doubt of the fact), we have proved our case, for the consequences we have pointed out must inevitably follow. You see this is but the Malthusian theory of population extended and applied to all animated beings. But we need not rest the argument here, and indeed it must be admitted that the scientific philosopher will not admit its validity until its soundness is verified by observation and experiment. You know we are taught in books of logic that scientific proof consists of observation, induction, deduction and verification. When Leverrier and Adams proved by calculation that there must be in existence another planet, that was a case of proof by observation, induction and deduction. When they turned their telescopes to that part of the heavens where they concluded it must be, and discovered the planet Neptune, that was verification. Our argument for evolution is now advanced through the first three stages, and it remains to enquire in the last place what facts can be adduced to verify the conclusions at which we have arrived. Let us turn our telescope upon this great battle-field of nature. Can we trace any marks of the great contention? In the answer to this question lies the *verification*, and it forms the most interesting part of the enquiry. We *do* find in Nature evidence of this great battle for life, and the effects which must inevitably flow

from it everywhere strew the battle-field. We find it in (1) the Geological record of the earth's history, (2) in the Geographical distribution of plants and animals, (3) in the phenomena of Classification, (4) Morphology, (5) and Embryology, (6) and we find it in the existence of the Rudimentary, atrophied and aborted organs which almost all organisms contain. Let us shortly consider these several branches of evidence in the order I have named.

I.—It is a fact well known to all who have paid attention to geological studies that the history of the earth's inhabitants reveals a gradual progress from a lower to a higher type of organization. In the Laurentian rocks we find only protozoa, the simplest of all organisms. In the Cambrian and Silurian rocks we find only the simpler forms of marine life, but no land animals or plants. In the old red sandstone and Devonian rocks we find marsh plants, tree ferns and reeds—vegetation encroaching on the land—but still no land animals. It is not until the carboniferous period arrives that we meet with an air-breathing creature.* In the Permian system we first meet with reptiles. In the Triassic system land animals are still scarce, but they become more numerous in the Oolitic period, and it is not until we reach the Tertiary period that mammals can be traced. Last of all, man appears, but only during the most recent of the geological ages. We thus see that the geological record points to the conclusion that there has been a gradual evolution from a lower to a higher type of organization.

II.—The evolution theory is verified *secondly* by the geographical distribution of plants and animals. This is a large subject, and requires a whole paper to do it justice. It is, however, the less necessary to dwell upon it, for those who heard Dr. J. E. Taylor's lecture at the commencement of this session will remember that though he did not mention Darwin, he adduced many facts in support of his theory. He instanced the Malay Archipelago, which, as you may remember, consists of a collection of islands situate in a shallow sea, and if the land could be raised some two or three hundred feet higher these islands would become the highlands and mountain tops of a continent. But down the Strait of Macassar the sea is deep, and if the land were raised as I have supposed, the new continent would still be cut in two by this Strait of Macassar. All the land to the

* We may remark in passing that the oldest air-breathing animal known was discovered in the Carboniferous series near Llantrissant.

westward of the Strait would be added to Asia, and nearly all to the eastward would be added to the Continent of Australia. Very many facts go to prove that this has really been its geological history. This deep water strait is narrowed between the Islands of Bali and Lumbock to a width of fifteen miles. Now here is the remarkable fact. The zoological and botanical productions of the Island of Bali differ as much from those of the neighbouring Island of Lumbock as do those of England from those of South America; although, as I have stated, they are only fifteen miles apart. The productions of Lumbock and all the islands eastward of the Macassar Strait resemble mainly those of Australia, while those of Bali and land to the westward resemble those of Asia. Sydney Smith has amusingly described the natural productions of Australia, and as it helps us to realize the contrast which these two islands present, it is worth quoting—

"In this remote part of the earth," he says, "Nature (having made horses, oxen, ducks, geese, oaks, elms and all regular and useful productions for the rest of the world) seems determined to have a bit of play and amuse herself as she pleases. Accordingly, she makes cherries with the stone on the outside, and a monstrous animal as tall as a Grenadier, with the head of a rabbit, a tail as big as a bedpost, hopping along at the rate of five hops to a mile, with three or four young kangaroos looking out of its false uterus to see what is passing. Then comes a quadruped as big as a cat, with the eyes, skin and colour of a mole and the bill and web-feet of a duck—puzzling Dr. Shaw, and rendering the latter half of his life miserable from his utter inability to determine whether it was a bird or a beast. Add to this a parrot with the legs of a sea gull, a skate with the head of a shark, and a bird of such monstrous dimensions that a side bone of it will dine three real carnivorous Englishmen, together with many other productions that agitate Sir Joseph and fill him with mingled emotions of distress and delight."

The cause of such an extraordinary difference in the aspect of nature as this, in islands only fifteen miles apart is of course the circumstance that they have been separated from a remote geological period by the deep water in the Strait of Macassar, and that the animals and plants have thus been kept apart. But on the supposition that species do not vary, and that they now remain as they first left the Creator's hand, this separation ought to have produced no effect.

The phenomena presented by the Malay Archipelago suggested the theory of evolution to Wallace, who shares with Darwin the honour of its origination. Mr. Wallace has recently published a work on Geographical Distribution, to which I may refer for a full explanation of this branch of the evidence.

III.—The *third* test of the truth of the theory is that presented by the phenomena of classification. It is a significant fact that all living organisms admit of being arranged in groups within groups, as is shewn in the classifications of Naturalists. We are so familiar with this remarkable fact that it does not sufficiently strike us. All organisms, from the simplest protozoon up to man, may be arranged so as to form one vast unbroken chain of being, ascending link by link from the lowest to the highest type of organization. On the theory of the independent creation of species, this is, to say the least, an unexpected characteristic; but on the supposition that all creatures and plants are descended from a common ancestor, it is an obvious and necessary consequence. Before the theory of evolution was suggested as the explanation, the phenomena of classification seemed an empirical and puzzling characteristic. Pope described animated life as "a mighty maze, yet not without a plan." He saw obscurely that nature was arranged on a plan, but it was a strange and an unaccountable one. Why should the Creator have arranged the great scheme of creation in this particular way? The theory of evolution supplies the answer, and completely accounts for this systematic connexion of organic nature, while it lends to its investigation a new meaning and endows it with an absorbing interest.

IV.—Akin to the argument from classification is that furnished by morphology. Morphology may be popularly defined as "similarity of plan." It is conceivable that every animal should have been constructed upon a plan of its own, having no resemblance whatever to the plan of any other animal; and such we should expect would be the case if every species were independently created. But we find this is not the case; we find that the hand of a man, the paw of a gorilla, the foot of a dog, the paddle of a seal, the wing of a bat, and the foot of a mole, are all formed on the same pattern, though they are applied to dissimilar purposes. Why should this be so? The resemblance is simply unaccountable except upon the supposition that all are descended from a common ancestor. A vast number of creatures shew a resemblance unaccountable if they are not evolved

from a common ancestor. For instance, the horse and the bear have the same number of vertebræ. The giraffe, the elephant and the whale—one with a long neck, and the other two with short ones, have the same number of cervical vertebræ. Why should the Creator have placed the same number in the short neck of the elephant? The immensely varied forms of insects have this character in common that they are primarily divided into twenty segments, and what is more remarkable, crustaceans are composed of the same number of somites or segments. Why should they all have the same number? These facts, which might be multiplied to any extent, all point to resemblances unaccountable except on the theory of a common origin.

V.—Another test of the theory is that furnished by the phenomena of embryology. It is found that the embryo passes through the lower to the higher type of development. Commencing in the bisection of a cell, it passes successively into the form of an invertebrate, then into that of a vertebrate, then into a mammal, and so on. In fact, the development of the embryo is an epitome and embodiment of the development of species, and from which it differs only in the rapidity of the process. Those who wish to pursue this branch of the enquiry will find a popular account in Hæckel's "History of Creation."

VI.—Sixthly and lastly, there is the test presented by rudimentary, atrophied and aborted organs. This evidence has always appeared to me the most convincing branch. We find eyes without eyesight, we find the embryo whale has teeth and sheds them before the creature is born, and never has teeth afterwards. There are imperfections in all creatures, which are unaccountable if all are now as they left the hand of the Creator, but are at once explained by the theory of evolution. Take for instance the case of the rudimentary tail in the human skeleton. It points to a most unpleasant relationship between ourselves and creatures that have tails; and I fear I shall not be conciliating prejudice by introducing this illustration. But our consolation in this case must be that the connexion is exceedingly remote. It is believed that the apes, which most resemble man, viz., the ourang-outang, the gorilla, the chimpanzee, and the gibbon, are not his immediate ancestors, and it may be pointed out for the satisfaction of those who do not like the connexion, that there are essential differences which prove that man is descended from an

independent and, let us hope, a more respectable form, which has now disappeared.

I have thus in the briefest manner recapitulated the evidence by which the theory of evolution is verified, viz., by the geological record, proving as it does a gradual development of life; by the geographical distribution of animals and plants; by the systematic arrangement of which all animated nature admits; by morphology, by embryology and by the existence of rudimentary organs. But it must be admitted these remarkable facts after all only point to a high probability of the truth of the theory; it is so far a case of circumstantial evidence, and not established beyond cavil. The crucial test of its truth is of course the actual transmutation of species by experiment. It will be urged by opponents that neither Mr. Darwin or any one else has succeeded by experiment in transmuting one species into another, nor have any such transmutations been observed. But here we are met by a fallacy of definition. Species are first defined to be classes not transmutable, and when classes which previously ranked as species are transmuted it is objected that they were not species but varieties. Of course if by species you mean classes that are not transmutable it is impossible to prove their transmutation. This is what learned people call a *petitio principii*, or arguing in a circle. Now it appears to me that Darwin has amply proved the transmutation of species by experiment. He has, for instance, by crossing the different species of pigeons re-produced the rock pigeon, proving that all originated in this common ancestor, and other instances might be cited. An eager investigation of nature with a view to the verification of this theory is going on, and I have no doubt that every year will bring fresh experimental proof of its truth.

Before I conclude I must say a word upon the religious aspect of this theory. It is very properly one of the rules of the Cardiff Naturalists' Society that no question of a religious or political nature shall be introduced into our discussions. When I first determined upon giving this paper it did not seem to me that there was anything irreligious or heretical in it. We must bear in mind that all new discoveries in science have been at first deemed heretical. Many of us can remember how geology was opposed and misrepresented. When I first came to Cardiff it would scarcely have been prudent to avow openly a belief in geology, but now this society has a geological section, with a clergyman for its secretary! That is a

most happy sign of the times, and a few years hence the theological objection to evolution will have vanished into thin air, as it has done so often before in similar cases. So far from this theory being atheistical, it gives a more profound idea of the infinite foreknowledge of the Divine Artificer than the theory of independent creation. God said, "I will place a germ upon the earth from which shall spring forth every living creature after its kind." That is the Darwinian Theory as I understand it. Vain is the notion that we account for the origin of life by tracing it to a primordial germ. The question remains, in what did the germ originate? Even if it were borne to the earth on the back of a meteor, as some bewildered teleologist has suggested, we are no nearer to the solution of the difficulty than before. There is an Indian fable that accounts for the stability of the earth by the fact that it was firmly planted on the back of an elephant, and that the elephant stood upon a tortoise, but what the tortoise stood upon was unknown! Even so it is, with all attempts to account for the *origin* of things by the light of scientific investigation only, as Mr. Waite so ably pointed out in the paper to which I have alluded. All our investigations into the phenomena of creation must end in that Great First Cause, in whom we live, and move, and have our being. The evidence from design appears to me to be untouched by this theory. The argument of Paley and the reasoning of Butler are as cogent now as they were before. When Paley selects the eye and compares it with a telescope in illustration of his argument, it is *not* considered a sufficient answer to say that the eye cannot have been created because it appears to develop itself from a germ! It is no answer that the bird develops itself from an egg, or that the oak appears to create itself from an acorn. Neither does it invalidate the argument for the existence of the great Architect of the Universe to say that all living beings are sprung from that one marvellous primordial germ. I trust, therefore, that no one will be deterred from this investigation by these mistaken ideas, but that they will derive from it a nobler and truer idea of the work of the Creator. By the light of science we trace all created things to the footstool of the Almighty, and then we pass into the domain of the theologian. As students of science we stop there, but we may fearlessly assert there is nothing in this theory of Darwin that need alarm the Christian believer.

DECEMBER.

DECEMBER is generally a time of darkness and gloom in nature, which often strikes a responsive chord in the human breast. The sun has sunk to its lowest point, and the feebleness of its beams causes the pulses of organic life to throb in a languid and spiritless manner. In the physical world there is frequently more animation, and the atmospheric sea in which we live is whirled into violent stormy movements, and the watery waste of the ocean is lashed into sympathetic agitation. The past month was pre-eminently of this character, and nothing could be more wild and weird-like than the play of the elements. Barometric pressure was wholly out of balance, the temperature unseasonably mild, soft south and west winds for the most part prevailed, the air was loaded with moisture, rain fell heavily and almost incessantly, and caused considerable floods. Roads were miry and heavy, and in some places under water, so that the inducements to locomotion out of doors were small and few. In-doors there was less than the usual buoyancy; commercial troubles at home, and rumours of war abroad, caused depression and anxiety. The principal solace for these evils was derived from considerations connected with the Christmas season, and a hope of better times of which no one was wise enough, or rash enough, to predict the coming. The mild temperature induced many wild flowers to remain in bloom, and the robin continued to pipe his thanks for plenty and open weather. The thrush commenced about the 6th his rich and varied song.

The barometer was extremely low, and fluctuated perpetually through a limit of nearly two inches. The maximum height, 30·21, was reached on the 10th, and the minimum, 28·36, on the 4th, giving the wide range of 1·85. The instrument stood below 30 inches on no less than 27 days. The behaviour of the barometer was very interesting to observers, and, perhaps, perplexing to simple-minded folks who derive their meteorological impressions from the oracular words engraved on the full round face of the common wheel barometer. There were two remarkable depressions of the mercury. The first occurred from the 3rd to the 5th inclusive, when violent gales ravaged a wide tract of country, including this district, but they were less destructive here than in many other places. The second took place between the 19th and 22nd inclusive, and well illustrated the cylonic character which belongs, more or less, to all storms of wind. The readings of the mercury on those days were

Commencing with the plague of locusts recorded in the Old Testament, with which the Egyptian tyrant and his people were visited for their oppression of the Israelites, we find from ancient writers that Africa in general has always been peculiarly subject to the devastation of this insect. Pliny mentions that the law in Cyrenaica required the inhabitants to destroy the locusts in three different states, three times in the year—first their eggs, then their young, and lastly the perfect insect—and this law was not enacted without reason, for we are told by Orosius that in the year of the world 3800, Africa was infested by such infinite myriads of these creatures that after having devoured every green thing they flew off to sea and were drowned, and being cast upon the shore a pestilence arose which destroyed no less than 800,000 persons.

In the present day the agriculturists of America have to contend against the ravages of an insect called the Colorado Beetle, which destroys the potato crop to such an extent that a memorandum has been issued by the Canadian Minister of Agriculture on the subject, calling upon the inhabitants of that colony to take united steps to prevent its increase.

This is of general importance to agriculturists, especially as there is some reason to fear that the beetle has actually been introduced to Europe, and wherever it is fairly settled it appears to make itself very much at home. The Canadian Minister says they may be seen creeping on side walks, bridges and wharves, crawling up buildings, occupying fences, lodging themselves in every crevice, penetrating houses and dwellings, ascending and occupying vehicles of all sorts, finding their way into boats and vessels, and being found alive in situations where there would seem to exist no chance for them to find any sustenance. He recommends decided steps to be taken in opposing the invasion of this destructive creature by searching for and destroying it in all its stages. In our own highly favoured country we are not so subject to these annoyances as the inhabitants of tropical climates, but even here insects make us sensible of what their empire over the works of creation would be if unrestrained, and it is a matter of congratulation that the Almighty Creator has so arranged the order of the universe that a series of safeguards are provided to prevent these minute agents of His will from overstepping the bounds which He has ordered.

The common silkworm has doubtless familiarized most of you with

the various stages of insect life, and many a now famous entomologist has had his interest awakened in the science by watching the curious transformations of this useful insect; but for the information of those who may not have followed their marvellous changes I will briefly endeavour to describe them. Singular to say, there are but few insects who live to welcome their offspring into life and instruct their young ideas in the way they should go, for shortly after laying her eggs, which with wonderful instinct she deposits in a place where the infant caterpillars will be certain of a supply of good food, the female moth or insect dies. The eggs frequently remain through the bleakest winter entirely unaffected by the cold. They are hatched in due season, and the first thing the ungrateful little caterpillar does is to eat up the habitation that has sheltered it during the winter of its career. After having thus given its stomach this first lesson in the art of digestion, it proceeds at once to feed heartily, and rapidly increases in size. At this stage of its existence its depredations are so extensive that were it not for the ever recurring forays of the birds that are fond of caterpillar diet the farmers would be sorely taxed to provide food for so large a family. It requires sound knowledge to prevent the ravages of caterpillars, for in Germany the gardeners and country people used assiduously to gather large baskets full of a destructive garden caterpillar and then bury them. This was something like trying to kill a crab by covering it with water, for many of the caterpillars were full grown and ready to pass into the chrysalis state under ground, so that they actually appeared again the following year in still greater numbers. Insects which undergo metamorphoses are called larvæ while in the caterpillar state. They are mostly very small on their first appearance, so that a full grown caterpillar, of the willow moth for instance, is 72,000 times heavier than when it issued from the egg. After changing its skin several times the caterpillar prepares itself for the next or pupa state of its existence, which in the case of the silkworm is by spinning a yellow cocoon of silk attached to a leaf or a branch of a tree; other insects prepare themselves for their final change deep under the surface of the earth. While in this condition insects eat nothing and are enveloped in a case without exterior eyes or limbs, and exhibiting no signs of life except a slight motion when touched. In this form they sometimes remain for several months, and then finally emerge in the full beauty of the winged state, in the perfection of their nature.