EXPERIMENTAL EVOLUTION.

BY DR. HUGO DE VRIES.

What is that in the egg which enables it to develop all the qualities of the bird? Something must be there, and we may even assume that all the separate qualities displayed by the bird have their representatives in the egg.

Now, if it were only possible to get at these representative particles within the egg, what changes might not be effected in the development of the bird! To take a very simple example, the peacock has a white variety, lacking the bright colors of the feathers. If in the egg of an ordinary peacock we could seize upon the representative particles of the color and impede their development, perhaps we would succeed in reproducing the white variety at once and quite artificially.

Obviously this is the heart of the matter, for if once the principle should be discovered to dislocate such a representative, we might apply it to numerous other instances. A white peacock would be no novelty and no gain, but we would be able to make white varieties of other birds and other animals, and perhaps even of the bright-colored flowers, which until now have resisted all endeavors of breeders in this line of work.

Methods of attacking this problem are not at all failing. We might try to kill some of the representative particles in the egg, or to stun them, or to injure them in ever so slight a measure, so as only to retard their development. More than one starting point for such an attempt is at hand. Engelmann has shown us a method of lighting and heating small parts of a living cell. He uses the focal point of a glass lens, which he directs upon the cell while lying under the microscope. If now a very small part is overheated and thereby killed, the remainder of the cell is seen to be still living and apparently uninjured. By refining this method some of the most sensible representative particles might perhaps be killed without too much injury to the others.

Other agencies might be tried. The finest and most effective methods offered by allied sciences must be applied. If one fails, another may succeed.

The process of the evolution of animals and plants must be attacked by direct experiment. This evolution, however, has a long history, covering many millions of years. Its historical part, of course, is not accessible to experimental work. From its innermost nature it must be studied according to historical and comparative methods. In laboratory work we may simply pass it by.

After eliminating this great mass of detail concerning the pedigree of the animal and vegetable kingdom, two points remain, which present themselves for experimental study. These are the beginning and the end. Obviously the real end is not yet reached. Evolution is going steadily on even now. In the same way we may assume that the beginning is not yet finished. The laws that ruled the material world some twenty or thirty millions of years ago must have been the same that are still ruling it in our days. Circumstances may have changed, but it is not very probable that those which permitted life at the beginning and those which have made it possible during the long geological ages should have been widely different. On the contrary, it seems only natural to assume that new life may nowadays originate as well as in former times. It is only a question of where we are to look for it.

On this very difficult point I like to be guided by the genial conceptions of Brooks. In his "Foundations of Zoology" he depicts the primeval seas and their living population. All life must have been limited at those early periods to the high sea; all organisms were floating amid the waves, going only to a depth of some few meters. Here the main lines of the animal and vegetable pedigree must have been produced, starting the great divisions of both kingdoms. The only exceptions are offered by the flowering plants and the vertebrate animals, which seem to have originated on the shores or perhaps on the land itself. As long as all life was in this floating condition, evolution proceeded rapidly and broadened out. Then came a period when, as Brooks says, the organic world made the discovery of the possibility of living on the bottom of the sea, feeding on the sinking remains of the floating world. This great change was the starting point for numerous adaptations and for the evolution of a richness of forms and structures, but without the previous progress in the production of many really new divisions.

It is a very attractive picture. For us it points to the probability that the very first organisms must have been inhabitants of the upper sea, floating on the waves; or they must have been members of the plankton, as it is now called. Thence the conclusion that it is within the plankton that new creations are to be sought for. If really they are still occurring in our days, it must be the high sea that conceals them. Obviously these first organisms must have had the lowest possible degree of organization. They were not cells, they cannot have had any differentiation. They must have consisted of a uniform jelly, with only the capacity of increasing their mass. If such a jelly could be detected, what possibilities would not be opened to experiments on evolution! The chance may seem very small, but then, before Röntgen and Curie there was no chance at all of discovering X-rays and radio-activity. The plankton has to become one of the main points of interest for all who care for experimental evolution.

The other end of the evolutionary development is the evolution that is still now going on. Here we are on surer ground, though even here the methods and the starting points have yet to be discovered.

Two main lines have to be followed. One is the direct study of variability; the other relates to the dependency of this variability on the outer conditions of life. The first line uses the statistical method, while the second relies chiefly on experiment. Both have to be cultivated on botanical as well as on zoölogical ground.

The experience of agriculturists and horticulturists has long since established the fact that new forms of animals and plants from time to time arise. How they originate is another question, which it is not the task of practice, but of science, to answer. The fact, however, is undeniable, and all observations point to sudden changes or so-called sports as the first beginning. Especially in the dominion of horticulture Korshinsky has shown, by an ample critical survey of the historical evidence, that sudden sports are the prevailing rule and probably even the exclusive manner of originating new varieties.

Such considerations have led to the conviction that what occurs in horticulture must also occur in the experimental garden. If the conditions are the same, why should not the phenomena be the same, too? If mutations are rare in horticulture, the experimenter has only to arrange his work so as to be able to detect rare occurrences in his cultures, too. In doing this I have succeeded in observing mutations quite analogous to the horticultural instances, and collecting all the evidence concerning their ancestry and their descendants as well as concerning the mode of their appearance.

Moreover, I have had the good fortune of discovering a wild plant which is even yet in a condition of mutability. Yearly it is observed to produce new species. It is the large-flowered evening primrose, which bears the name of Lamarck, the founder of the theory of evolution. It clearly shows how new species arise from an old stock, not by continuous and slow changes, but suddenly. The stock itself is not altered by the process nor even noticeably diminished. The new species which it produces arise on all sides. Some of them are in a higher, others in a lesser degree fit for their life conditions; some persist during years, while others disappear nearly as soon as they arise.

This instance of experimental mutation is found largely to agree with the experience of breeders, especially in horticulture, and likewise with the conclusions that have been drawn from comparative studies. The assumption that those species and genera which now consist of large groups of closely allied forms have originated in the same way seems quite undeniable; and as soon as the validity of this generalization is granted for these cases it will have to be considered of general, if not universal, bearing.

Two main lines have to be distinguished: the study of the phenomenon itself and that of its causes. Mutations, of course, cannot be assumed to be a special feature of the evening primroses. They must occur elsewhere, too, and these must be sought. The Oenothera was one of a lot of nearly a hundred species tested as to their constancy; it proved to be the only changeable form among them. By testing a hundred other species or other strains of the same forms it seems probable that one or two new instances of mutability may be detected. The best way is to try the wild species of the nearest environments or of other regions with a corresponding climate, since large numbers of seedlings have to be examined. One or two novelties among thousands of individuals of the common type are not easily found, especially when the differences are slight and new, and thereby apt to be overlooked. Much care is to be given, and the trials have to be repeated with the same species in succeeding years. With increasing experience the chances of discerning the small indications of novelties are rapidly augmented. No differentiating marks, however slight, should be considered as insignificant. All aberrant individuals should be planted separately and protected with all the care required to insure the fullest development. Many of them afterward prove to be only fluctuating variants or to have deceived the experimenter. They are simply discarded. It is quite sufficient if some remain and prove to be mutants. As soon as in this manner a mutable strain will be discovered the greater part of the other species may be excluded, although the search for new mutable species should never be wholly neglected. Each year some new forms should be taken into culture, in order to have sufficient chances of gradually increasing the evidence concerning the occurrence of mutability in nature.

The chief object of this inquiry, however, must be the study of the mutable strain itself. Some of its seeds yield new species, while others are more conservative. Thence the question, Which seeds mutate, and by which causes are they elected to do so? The location of the mutating seeds within the fruit, the position of the preferred fruits on the spikes, the influence of the individual strength of the sundry branches, and many other points have to be investigated. Further, it is probable that the degree of mutability, or, in other words, the yield of mutating seeds, is more or less dependent on the outer life-conditions. Thence the necessity of studying the influence of culture in general, of light and heat, of soil and water, and last, but not least, of manure. Extreme combinations of these factors should be tried to see whether perhaps they may give extreme results.

Underlying all and directing all the efforts should be the hope of obtaining such a knowledge of the phenomenon as would enable us to take the whole guidance of it into our own hands.

SCIENCE NOTES.

Of exploration pure and simple very little remains to be done. The charm of traveling through and describing an entirely new country which may be practically serviceable to civilized man has been taken from us by our predecessors, though limited regions still remain in Central Asia and South America of which we know little in detail. The Polar regions are in a somewhat special category, as their opening up affords few attractions to many people. But a knowledge of the past history of our globe—fit study for human thought—can be gained only by study of the portions still under glacial conditions.

A method for detecting the presence of aniline or salicylic acid in foods has been developed by C. Lawal. Pieces of wool are first prepared, from which the oily matter has been well removed by boiling in a soda solution and washing until all the alkali has disappeared. The substance to be analyzed is diluted with water and filtered. We take 100 c. c. of the filtered liquid, adding 4 c. c. of hydrochloric acid and put in a wool strip. The wool is then washed in cold water, then boiled in slightly acidulated water. In the presence of aniline colors, the wool becomes colored and the color is soluble in ammonia. It re-appears upon acidulation, while the vegetable colors turn to red, green, or yellow in contact with ammonia. To detect salicylic acid, we treat the substance with water and sulphuric acid, taking up the liquid with ether. The latter is then evaporated on a watch glass and the residue is treated with ferric chloride. A violet coloration indicates salicylic acid. A flesh-colored precipitate shows benzoic acid. Should tannin be also present, it must be first precipitated by means of sub-acetate of lead.

Some highly scientific results have been achieved by the Sladen Trust Expedition to the Indian Ocean for the exploration of those waters. One important point which was ascertained, according to Mr. Stanley Gardiner, M.A., Lecturer in Zoology and Fellow of Caius College of Cambridge University (England) who was in charge of the party, was the extension outward of all the reefs, on their own remains or debris, in much the same way as a moraine is formed at the base of a glacier. These masses of rock were found to be thickly covered by various growths and marine animals. Huge stems of black coral (the rarest variety) extending to seven feet in length were secured, though white coral was found to be the principal constituent of the reefs. Numerous quantities of deep-sea fish were secured. The greater proportion of these are believed to be absolutely new and hitherto unknown specimens. Some were possessed of enormous eyes, others had only rudimentary ones scarcely larger than a pinhead, while many were quite blind. It was also ascertained that there is an abundance of life existing at a depth of 1,200 fathoms in waters 2,500 fathoms deep. This floating life comprises the food of whales and other deep-sea fish; and this discovery is of great scientific interest, since it has hitherto been believed to thrive only near the surface. The expedition secured a large number of huge squids of great variety, jelly-fish, and prawns, some of which were six inches in length. Curiously enough, while some of the latter were quite blind, others had eyes of large size. This deficiency in the former was compensated for by long delicate antennæ, which in some cases extended to twice the length of the body. Nearly all, however, possessed phosphorescent organs, due to the great depth at which they live.

The first of three turbine steamships for the Great Western Railroad of England has been launched for the Channel service between Fishguard in Wales and Rosslare in Ireland, a distance of 62 miles. These vessels will constitute the fastest turbine steamers that have yet been constructed, the contract speed for the Parsons machinery being 22½ knots per hour. Each vessel will have accommodation for 1,000 passengers.