SEARCHING FOR THE REAL ORIGIN OF SPECIES.

The theory that the countless varieties of life on this earth have been developed from a common origin is almost as old as philosophy. It was the French zoologist Lamarck, however, who made the first intelligent effort to explain the real cause of this development. It was his claim that the development had been brought about by stress of circumstances; that changes of environment render certain characters unnecessary, and that they are lost through disuse, while on the other hand other characters are made necessary by the new conditions and these are, in time, acquired through use or exercise, thus producing a new species. For example, he claimed that snakes have lost their legs owing to disuse in crawling through narrow passages, while on the other hand, the giraffe has developed a long neck owing to scarcity of vegetation on which he could browse, and the fact that he has been obliged to reach up among the trees for his food.

While Lamarck observed that there is a constant struggle for existence, the importance of this fact escaped him and it devolved upon Darwin to develop the doctrine and demonstrate the part it has played in the evolution of the species. Darwin's doctrine may be briefly summarized as follows: No child is exactly like its parents; the difference may be very slight, but it is sure to be there. All life is at war, each individual struggling either to overpower, fight off, or avoid its enemies. So fierce is the struggle that on the average not more than one individual in a thousand lives to the full term of its life. It is the natural inference then that this one survivor possesses certain characteristics which peculiarly adapt him for the life struggle. The same is true of each generation, and according to Darwin's theory this natural selection of the best in each generation results in the development of a new species, a development depending on the very slight variations between child and parent and hence requiring thousands of generations for its accomplishment. Darwin also advanced the doctrine of sexual selection, which, in a manner similar to natural selection, chooses the best and strongest of each generation.

It is nearly fifty years since the doctrine of natural selection was first published, but until very recently no advance had been made over the work of Darwin. The interim was spent in discussing his theories and digesting the enormous mass of information gathered by that indefatigable investigator from all parts of the globe. Lately several persons have begun seriously to question Darwin's theory. A careful study of heredity has been made. The methods of the expert horticulturist and the fancier have been investigated with the result that the shadow of a serious doubt has been cast upon the ability of natural and sexual selection alone to evolve a new species. Contrary to the general supposition, fanciers do not develop a new strain by successively selecting and mating those individuals which show slight variations in the direction of the desired strain. On the contrary, every new breed has its origin in some exceptional individual of the flock or herd which the keen breeder has detected and either blended with the normal type or preserved intact by intelligent cross-breeding. This does not necessarily mean that natural selection may not, in thousands of generations, evolve a new species. Our lives are too short to prove or disprove the theory by actual experiment. We can say, however, that the work of expert breeders, affecting but a few generations, does not conform with the general principles laid down by Darwin. Darwin realized that the methods of fanciers and horticulturists afford a valuable index to the processes whereby new species are formed in nature. Unfortunately, breeders are very reluctant to divulge their methods, preferring to give the impression that the new breed was obtained only after a long period of careful selection and cross breeding. Darwin was thus given the impression that the methods of the breeders corroborated his theory of the origin of species. However, he did recognize the fact of an occasional unaccountable production of an exceptional individual or "sport," and he suspected that this might be the origin of a new species. Curiously enough, however, Darwin's friends were so enthusiastic in their support of natural selection and so convinced of its infallibility that they actually laughed him out of the idea of seriously pursuing the new line of investigation. It remained, therefore, for Hugo De Vries, the Dutch botanist, to develop the doctrine that new species find their origin in sports, or "mutants," and that evolution, instead of being a gradual development due to the accumulation of minute variations, is rather a series of jumps, or abrupt changes from parent to child. According to this theory of mutation, natural selection still plays a part in determining the fitness of the individual to survive and perpetuate itself, but it does not necessarily imply the destruction of the parent type, as does Darwin's theory of evolution by natural selection.

An important law, which throws light on the preservation of the new species after a mutant has sprung into existence, was discovered about forty years ago by an Austrian monk named Gregor Mendel. The law was deduced from experiments with common garden peas. Its importance was not appreciated at the time and was apparently lost until by a strange coincidence the law was separately rediscovered a few years ago by three scientists, one of them being De Vries.

Mendel's law holds that the individuality of characters cannot be lost by cross-breeding; that the hybrid contains the characters of both parents equally, and that though one characteristic may dominate and thus completely obscure the other, the latent or recessive character would reappear in the progeny of the hybrid. For example, if red and white peas are crossed, the hybrid offspring will show red flowers only; but if the hybrids are interbred, one out of every four will have white flowers, and of the remaining red peas, one will always breed red peas and the others will show their hybrid character by breeding white peas in the proportion of one to three in the succeeding generation. The offsprings thus vary according to a mathematical law. Red is certainly dominant over white, so that hybrids of the two are always red, but the plant evidently contains the latent or recessive white characteristic in the same quantity as the red. When the hybrid reds are interbred we have all the possible combinations of the two characters in the offspring, namely, red and red, red and white, white and red, and white and white. This will give us but one pure red, and one pure white with two red hybrids, which shows that a pure breed can be produced by cross-breeding and that the purity of the breed cannot be determined by its ancestors but rather by its children. To be sure, in nature we have crosses of individuals which vary in more than one characteristic and the results are very complex. But if the breeding were carried on through a sufficient number of generations, and the children were sufficiently numerous, they would doubtless show every conceivable combination of the parent characters. We must remember, however, that all characters are not subject to Mendel's law. Francis Galton, in 1899, discovered that certain characters in parents are blended in the children. Prof. W. E. Castle, of Harvard University, has crossed a rabbit having lop ears (which are long) with a rabbit having short, erect ears, and obtained rabbits with ears of medium length which were sometimes lopped and sometimes erect. By crossing the hybrids with the pure lop-eared rabbits, he obtained a generation of three-quarter lops, thus showing the blending character of the lop-eared condition. Prof. Castle has also carried on interesting experiments illustrating Mendel's law and has discovered that in guinea pigs a rough coat is dominant over a smooth coat, and a short one over a long or Angora coat; also that in the color of the coat, there is a definite order in which each type is dominant over the succeeding, and recessive to the preceding, types as follows: 1, Agouti, or black, tipped with yellow; 2, black; 3, yellow; 4, white. In man a condition of hypophalangia (two-jointed instead of three-jointed digits) is dominant over the normal condition. In mice the peculiar waltzing habit of so-called Japanese mice is a recessive character in heredity.

Mendel's and Galton's discoveries throw a flood of light upon the processes followed by nature in producing a new species from a mutant. However, the real origin of the species is not found in a mutant. We must go back a step further and find the origin of the mutant. Efforts toward this end are now being made, particularly with plants and with insects. It has been suspected that temperature changes and new environments might have something to do with the origin of species, and the experiment has been tried of breeding butterflies at various degrees of heat. Dr. M. Standfuss, of Zürich, has done some very extensive work along this line, producing arctic and tropical varieties as well as intermediate forms by raising the butterflies in heated or cooled boxes. It is claimed that butterflies thus reared are not fixed species and will not breed true. In one case, however, Standfuss has apparently succeeded in obtaining a fixed species by this treatment. The achievement is described in his own words as follows:

"After much trouble a sufficient number of butterflies could be obtained only from *Vanessa urticæ*. In this work 8,281 pupæ were used. It was difficult to obtain very abnormal females. Four large tubs and other vessels filled with luxuriant nettle bushes and a number of smaller pots containing carnations were placed in a small glass house exposed to the sun. Arrangements were made to shade the house whenever it seemed advisable to do so. On the 7th of June, 1897, the first abnormal *Vanessa urticæ* were placed in the house, followed up to the 15th of July by the remaining individuals, in all forty-two individuals—thirty-two males and ten females. Almost without exception the males were of the most extreme type, with wings completely black at the posterior portions. Of the females only two individuals were of this type; the remaining eight were fringed with blue and were partly spotted with reddish brown toward the rear extremity of the wings. It must be confessed that this was a very small number of females from 8,000 pupæ. . . .

"The 25th of June came, and still there was no evidence of any mating. But mating must have occurred, for on the 26th of June I found the first heap of eggs on the under side of a nettle leaf. In the following days eight females were laying eggs, among them the most abnormal in color.

"It was impossible to determine how many eggs a single female laid, because the eggs were deposited during several days on various leaves. There could hardly have been less than 200, because nearly 2,000 pupæ were developed, despite the fact that of the ten females two were killed prematurely by spiders. Among those which were brought to an untimely end was unfortunately the least aberrative of the two extreme types. It was possible that this specimen did not lay any eggs, for the ovaries were found very full. On July 2 caterpillars appeared. At first they were allowed to feed upon the nettle leaves; later they were transferred to well-ventilated breeding boxes. The offspring of the most abnormal female were kept separate. On July 12 the first pupæ appeared. In the meanwhile an infectious disease appeared among the butterflies and killed off all but the strongest. In all only 493 specimens developed to the pupæ stage because of this unfortunate circumstance. Even of this small quantity only a few were preserved because of a parasite which had entered the breeding boxes and could not very well be excluded. It is possible these parasites were introduced when the flowers were brought into the glass house. The descendants of the abnormal female in their turn yielded 52 pupæ. These are included in the figures previously given.

"On July 21 the butterflies appeared. One individual was as normal as another. The first offspring of the abnormal female were also normal. But on July 28 appeared another individual, which was considerably different from the normal type. On July 31 and August 1 two more aberrants appeared, although not extremely abnormal. On the 5th of August appeared, among the last butterflies resulting from these experiments, the individual shown in Fig. 5, plate 5 [of the original]. This, like the three previously mentioned, was descendent from the abnormal female and all were males. In my excitement I had to ask my assistant to kill the creature for me, for I feared that I would myself either crush it or permit it to escape.

"This last individual, which resembles the parent type most narrowly, still differs from the parent in so far as the blue spots of the outer edge of the wing project back from the edge and into the wing surface.

"Summarizing the results of these breeding experiments we have the following:

"1. Two of the ten females did not breed.

"2. The offspring, of which only a small fraction reached the imago form, and representing the descendants of 7 pairs, were all normal.

"3. An eighth pair, from which only 43 butterflies in all were obtained, bred 1 individual which differed markedly from the parent type and 3 other individuals which differed less markedly from the normal type.

"4. These 4 individuals were all males.

"5. Only the most abnormal female (the 32 males, so far as their abnormal characters were concerned, were practically equal) transferred its characteristics, more or less, to a small part of its descendants. From this it would seem to follow that heredity had something to do with abnormality.

"6. Inasmuch as most of the specimens were killed by disease or parasites, it is most necessary to conduct another series of experiments."

Dr. Standfuss's experiments have been repeated in this country by a Mr. Seifert, who has gone a step further and endeavored to produce variations in butterflies by means of chemical injections in the pupæ. The experiment was only partially successful, for the pupæ died, but some of them developed far enough to show that new markings had been induced by the chemical treatment.

Much more successful have been the experiments of Dr. D. T. Macdougal, director of the Department of Botanical Research of the Carnegie Institution. Dr. Macdougal has actually succeeded in producing a new species by injecting the ovary of the plant *Raimannia odorata* with various solutions. The solutions used were a ten per cent sugar solution, a solution of calcium nitrate, one part in a thousand to two thousand of water, and certain radium preparations. Among the progeny there appeared a number which were very different from the parent. These have bred true and furnish the first indisputable instances of a new species being produced by artificial agencies. "The characters of the newly-arisen form," said Dr. Macdougal, "were so strikingly aberrant as to need no skill in their detection. The parent was villous-hairy, the mutant entirely and absolutely glabrous. The leaves of the parent have an excessive linear growth on the marginal portions of the leaf blades, and hence become fluted. The excess of growth in the mutant lies

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flow direct to the immense pumps which lift it into the siphon chamber. Here gigantic centrifugal pumps will force the sewage across the river through a pair of inverted siphons to the outfall sewer, through which it will flow by gravity to the outlet several miles down the river.

During heavy rainstorms, the gates of the sedimentation chamber will be opened, and the sewage will flow direct into this chamber instead of passing around it to the pumps. In this chamber sticks, sand, etc., will be removed before the sewage passes into the screening room and into the pumps. Should the rainfall prove exceptionally heavy, the storm water carried down in the large sewers will be divided by means of gates, which operate automatically, into four storm-water tunnels on the east and west sides of the pumping station. Through these tunnels the water not handled by the pumps will flow by gravity into the Eastern Branch. As a further precaution against flooding of the low-area district, immense storm-water pumps will be installed, and at the slightest indication of a flood, these pumps will be set to work pumping the storm water out into the river.

The solids removed from the sewage in the screening chamber will be pressed in hydraulic presses and loaded into a train of large buckets. These buckets, which are operated by electricity, run on overhead tracks, and carry their load through a conveyor tunnel extending around the east and west sides and across the north end of the pumping station, to a crematory.

The floor of the pump room is about twenty-five feet below the bottom of the river. In this room there will be thirteen powerful centrifugal pumps. Eight pumps on the west side, each having a capacity of 65,000,000 gallons a day, will be used for pumping storm water. The ordinary sewage from the high-level trunk sewers will be pumped by three pumps. each having a capacity of 65,000,000 gallons a day, while two pumps, each having a capacity of 20,000,000 gallons a day, will pump the sewage from the low-level system. The system has been designed to adequately handle the sewage of a city of 800,000 persons. All the sluice gates, valves, covers, and interceptor gates in the entire system, some of which weigh several tons and all of which are operated by hydraulic lifts, will be controlled by one man in the engine room, whether they are located in the station or a mile away.

The most interesting feature in the construction of this great system was that of laying the twin siphons across the river. Each of these siphons is five feet in diameter and 1,200 feet long. Most of the work was done under water by divers. The siphons were laid in forty-eight-foot sections, four twelve-foot sections being welded together on the pumping-station dock. Each forty-eight-foot section was fastened securely to the top of a fifty-foot caisson, simply an air-tight wooden box, and the caisson was towed into position and tipped over, so that the section of pipe floated under it. Ports in the caisson were then opened, allowing water to flow in, and gradually the caisson with its load of pipe settled to the bottom, where divers guided the section into place and secured it there. One twelve-foot section weighs 14,000 pounds, and the weight of the four sections handled by the divers is about thirteen tons. The siphons are laid on beds of piles driven in the bottom of the river, which has been dredged to the proper depth. From the siphon chamber the pipes go down with a steep slope to a distance of twenty-six feet below the surface of the water, and then rise an equal distance to the other side, where they connect with the outfall sewer in Maryland.

When this immense sewage-disposal system is put in operation in the spring of 1907, the most important work in the sanitation of Washington will have been completed, and the citizens who have been foremost in the enterprise can bend their efforts to the solution of the next important question—the sanitary housing of the poor of the national capital.

AN OFFICE BUILDING 612 FEET TALL—THE LOFTIEST MASONRY STRUCTURE IN THE WORLD.

When the tall office building, in the course of its rapid evolution, had attained the height of 300 feet, it was freely predicted that the limit had been reached, and that future structures in New York city would be of more reasonable vertical dimensions. That prediction was made not much more than a decade ago; and yet to-day there is in course of construction in lower New York a building whose summit will reach heavenward for over twice three hundred feet. The new building, which will be in the form of a tower and will constitute part of an extension of the present Singer building at the corner of Liberty Street and Broadway, will contain forty-one stories, and the top of its cupola will be 612 feet above street level. Not only will the Singer tower be the loftiest inhabited building in the world, but it will exceed in vertical height the famous Washington Monument on the banks of the Potomac, which, with its total height of 555 feet, is at present the tallest masonry structure erected by man. Although the Singer tower will lack some 300 feet of equaling the famous Eiffel Tower, it will be a far more difficult and costly structure to erect, and because of its narrow base will involve more complicated and serious engineering problems.

The new building will form the most important part of an extensive reconstruction of the old Singer building at the corner of Liberty Street and Broadway. Great credit is due to Mr. Ernest Flagg for his successful treatment of this unusual architectural problem and to his engineers for the solution of the constructional difficulties involved in the design of so narrow and lofty a building. An addition to the old structure, with a frontage of 76 feet on Broadway, is to be built on the northern side of the building, and the westerly portion of this addition will constitute the great tower. The original building and the addition will be fourteen stories in height, and the tower will extend twenty-seven stories above this.

Although in plan the tower will measure only 65 feet square, its total uplift is so great that its floor space added to that of the main building will be greater, with a single exception, than that of any other building in New York city, the total area amounting to 9½ acres. The elevator well will be oblong in plan and placed in the center of the building. For the service of the lower portion of the building there will be sixteen elevators, and, as the upper floors are reached, they will decrease in number, until there will remain four elevators for the service of the topmost floors. It is estimated that when the building is fully occupied it will accommodate about 6,000 people.

From a constructional point of view, the most interesting feature of this extraordinary structure is the means adopted in framing the steel skeleton, so that it will resist the enormous accumulated wind pressure, when the thunder squalls of the summer and the heavy gales of the winter sweep over Manhattan. Decidedly interesting also is the method of treatment which has given this tower an architectural character usually absent from our modern "skyscraper." The plan adopted, both in designing the steel skeleton and in the treatment of the exterior, has harmonized both the engineering and architectural requirements of the case. It was realized that, in order to obtain sufficient strength to resist the enormous transverse bending stresses due to wind pressure, it would be necessary to introduce diagonal wind bracing, and give to the tower a true truss form from foundation to top story. It was, of course, impossible to run continuous diagonal truss members clear across the building from wall to wall, because such an arrangement would have interfered with the windows. It was determined, therefore, to consider the structure as being built up of four square corner towers and a central tower consisting of the elevator well, with wind bracing running through each wall of each tower continuously, from base to summit, the five towers being tied together in lateral planes at the various floors. The corner towers are 12 feet square in plan, center to center of the columns. This provides an open space 36 feet in width, down the center of each face of the building, which is entirely free from diagonal bracing. These spaces are occupied by large bays filled in with glass, as shown in our perspective drawing. The lighting of the corner towers is by single windows, which are so disposed as to permit the diagonal wind bracing to be carried continuously throughout the whole height of the tower, without interfering with the lights.

Of course, this method of bracing resulted in very high stresses in the chords of the trusses, which in this case are the vertical columns of the tower, and these columns are of exceedingly heavy construction. The wind pressure was assumed at 30 pounds per square foot, uniformly distributed over the whole face of the building, and the total overturning moment of the wind reaches the enormous amount of 128,000 foot-tons. The total weight of the tower alone is about 23,000 tons; and yet so great is the wind pressure that on the windward side of the building, should a storm ever blow upon it with sufficient velocity to produce an average pressure of 30 pounds per square foot, the building would tend to lift, the total uplift on a single column amounting to 470 tons. In order to provide against this, the columns are anchored to the caissons, the margin of safety against lifting amounting to never less than 50 tons on the column. The figures for the loading on a single one of the columns will be of interest: The total dead load at the foot of the column in question will be 289.2 tons, this amount representing the weight of the steelwork and masonry. To this must be added 60 per cent of the maximum live load, under which is included furniture, fittings, and the maximum crowd of occupants. This reaches, at the foot of the column in question, a total of 131.6 tons, making a total dead and live load of 420.8 tons. The downward pressure on the leeward side of the building, due to the wind pressure, is 758.8 tons, which, added to 420.8 tons, gives a total load on the column of 1,179.6 tons. The greatest combined load on a single column is 1,585 tons.

The effect of this stupendous structure upon the already remarkable sky line of New York city will be to dwarf the immensity of surrounding buildings and deceive the eye as to their already lofty altitude. This will be particularly true of the stranger who visits New York for the first time, for he will find it difficult to realize that the towering skyscrapers which are dominated so completely by this tower are many of them between three and four hundred feet in height. The question of the future vertical increase in the dimensions of buildings will depend upon the financial success of the Singer Building. Should it prove possible to realize an adequate return upon an investment of this kind, it is not unlikely that corporations with whom the advertisement that is given by a spectacular structure of this kind counts for something will, in future years, attempt to rival or surpass it.

It is the confident expectation of the engineers that in spite of the great height there will be no perceptible sway in the Singer Building even in the heaviest storm.

SEARCHING FOR THE REAL ORIGIN OF SPECIES.

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along the midrib and the margins become revolute. The leaves are widely different in width, those of the mutant being much narrower. The parental type is of a marked biennial habit and near the close of the season the internodes formed are extremely short, which has the result of forming a dense rosette; the mutant forms no rosette, by reason of the fact that the stem does not cease, or diminish its rate of elongation, and hence presents an elongated leafy stem which continues to enlarge as if perennial."

The common evening primrose has also been treated by Dr. Macdougal with a solution of zinc sulphate and one individual produced which differed materially from the parent. Of course, this might be a mutant produced by natural causes and not induced by the chemical treatment, though the probabilities are against such a condition. In nature, ovaries of plants might be affected, Dr. Macdougal believes, either by the action of gaseous emanations, by radio-action, by the introduction of foreign pollen, or by the stings and incisions of insects.

Dr. Macdougal has also tried the effect of raising plants at various altitudes above sea level, and while markedly variant types have been produced, he has so far been unable to fix the new types; for when the plants were returned to their original habitat, they reverted to the normal type. At present Dr. Macdougal is breeding plants at New York, Jamaica, and the desert laboratory in Arizona, at sea level, and at altitudes of 2,300, 5,000, 6,000, and 8,000 feet. The experiment will cover a number of years, possibly a decade, to see if in that time any of the new characters induced by the change of environment will remain fixed or not.

The search for the real origin of the species is now on in earnest. Apparently we are at present on the right track, but even if the search is not ultimately successful it is sure to give us a much clearer insight into some of the most mysterious secrets of nature.

Illiteracy in the City and Country.

In the matter of illiteracy among children the cities make a much better showing than the rural districts. The line between city and country cannot, however, be very accurately drawn, because cities with less than 25,000 inhabitants are not, for the purposes of this study, separable from the distinctively rural areas. Accordingly the area which, for convenience, is designated as country includes many of these smaller cities. In the country as thus defined the illiteracy among children is 88.7; in the city, using this term to designate collectively cities of over 25,000 inhabitants, it is only 10.4. The contrast is least in the North Atlantic States, where the so-called country includes many large towns or cities under 25,000 in which the school systems are by no means inferior to those in the large cities. In this section of the United States child illiteracy in the city is 7.8 and in the country 10.8. In the South the difference is very marked; in the South Atlantic division, 32.4 and 193.4 for city and country, respectively, and in the South Central, 44.9 and 181.3.

The greater illiteracy in the country does not necessarily indicate that the regard for education is less there than in the city. One cause of the difference is the difficulty of providing school facilities for a scattered country population. The development of the school transportation system, already inaugurated in many country communities, will tend to remove this disadvantage. Another circumstance also operating to the disadvantage of the country population is their smaller per capita wealth, which necessitates a smaller per capita local appropriation for school purposes. Realizing that a certain amount of public instruction is indispensable for the general good of the State legislatures in many States have imposed a State school tax. This system, by which the wealthier school districts are made to assist the poorer, will naturally tend to lessen the difference between city and country in the matter of illiteracy.