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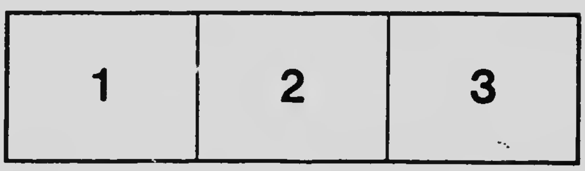
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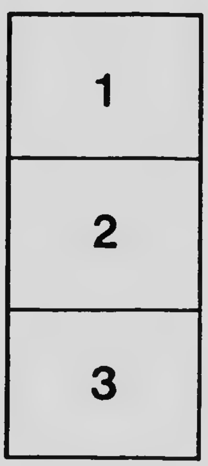
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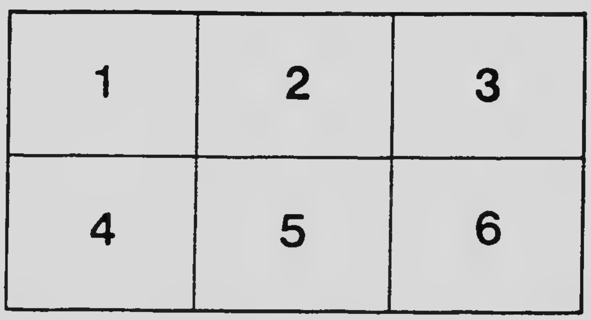
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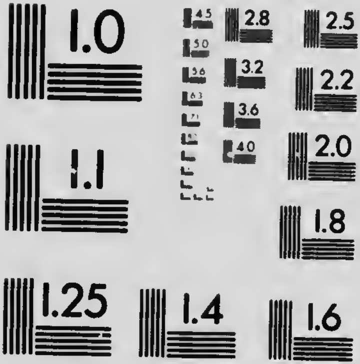

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CERTAIN BIOLOGICAL PRINCIPLES AND THEIR PRACTICAL APPLICATION IN THE IMPROVEMENT OF THE FIELD CROPS OF CANADA.

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To learn what is true in order to do what is right is the summing up of the whole duty of man.—T. H. HUXLEY.

Modern science has done much to awaken a greater interest in the improvement of the lot of man by giving us a better understanding of life processes. A more comprehensive knowledge of the laws which determine our well-being in the physical world has resulted in the control of many dread diseases. A greater knowledge of the interaction of, and the relation between, hereditary forces and environment places within the reach of man a remarkable power in guiding and controlling the creative forces of nature. This last makes possible the betterment of the condition of man through the improvement of his food.

The world's supply of food to-day is directly dependent upon one great kingdom—the vegetable kingdom. At first man depended for his livelihood upon the chase and the fruits, seeds and herbs which nature provided. This source, however, soon required to be supplemented so that we find even our primitive races resorting to the raising of crops as a means of sustenance. The native forms of plant-life which were utilized soon responded to the hand of man, and from this early beginning dates the improvement of plants.

The great complexity and diversity in the forms of vegetation which clothe the surface of the earth has long been a question to haunt the mind of the scientist and the philosopher. That new species were constantly being produced in nature was a recognized fact as long ago as before the birth of Christ, but the exact manner in which these were brought into existence has long remained obscure and puzzling.

For many years our leading naturalists and biologists have been engaged in investigating these problems and in classifying their observations under natural and well defined laws. It is only within recent years, however, that the student of natural progression has been able to deduce from his observations and study any suggestion as to how plants under domestication might be "bred up" by the applications of principles common to all living phenomena.

HISTORY OF THE PROGRESS OF THE IDEA OF SPECIES FORMATION.

In order that we may clearly understand the possibilities of the artificial interference in plant life as a means of evolving improved races and strains, and that we may see how far such work is based on scientific and, therefore, sound principles, we shall examine briefly some of the various theories and ideas which have been advanced respecting the manner in which our present species, varieties and strains have come into existence.

We find that the idea of organic progression or evolution had its birth among the early Greeks, its renaissance among the early natural philosophers beginning with Bacon and extending to the time of Herder (1744-1803) and that these men in turn served to inspire further investigation and study by Buffon, Erasmus Darwin and Goethe, all of whom are considered as contemporaries of Darwin, the first real propounder of evolution.

Evolution, as a natural explanation of the origin of the higher forms of life, developed from the mythological teachings of the early Greeks into the general conception of Aristotle (384-322 B.C.) who, over 2,200 years ago, believed that higher forms of life originated or were developed from lower forms in some mysterious way. Development or the gradual perfection in the structure of an organism was Aristotle's main thesis and constituted the principle thought in his natural philosophy. He was also a strong believer in the law of adaptation and in atavism. The principle of Syngenesis was recognized long before Aristotle's time by Empedocles, who may be said to be the father of evolution. Empedocles conceived the idea of "The survival of the fittest" six centuries before Christ.

Epicurus (341-270 B.C.) established the distinction between natural and supernatural causation, and gathered arguments from his predecessors to support the principle of natural law.

The idea of the changing rather than of the fixed order of things had its origin among the Greeks in Heraclitus (505-475 B.C.)

For many centuries all study was subject to the approval of the church so that from the time when Christian doctrines shook off Aristotelianism or the scientific reading of the Bible until

Suarez' time in the middle of the 16th century no progress was made in the evolution idea.

In the latter part of the seventeenth century and in the early part of the eighteenth there were three main classes of writers, viz.: The Naturalists, the Speculative Evolutionists and the Natural Philosophers. To the latter class belong such eminent writers as Bacon, Descartes, Leibnitz and, belonging to the German School, Kant, Herder, Lessing and Schelling.

Bacon (1561-1626) was the most active of the early writers pointing out the evidences of the mutability of species and in attempting to show the bearing which variation has upon organic progression. There was also shown at this time the analogy between artificial selection and natural selection. It is interesting to know that at this early period (beginning of 17th century) mutability of species was recognized and looked upon as a live question.

SCIENTISTS OF THE EIGHTEENTH AND NINETEENTH CENTURIES.

In the eighteenth and early nineteenth centuries, we find many writers of note propounding theories as to the manner in which species have originated. De Maillet (1656-1738) tried to show the influence exerted by habit and environment in inducing changes in the nature and form of a plant, but, unfortunately he went to extremes by claiming that modifications acquired during a single life were transmitted in toto.

Maupertuis (1698-1759) advanced a theroy of generation resembling closely that of Darwin, and which anticipated to some extent the modern idea as to the causes of fortuitous variations.

Linnaeus, a Swede, (1707-1778) the great father of botany, marked the beginning of zoology and botany as now understood. The binary system of nomenclature proposed in his great work Systema Naturae enabled him to show the relation of animals and plants to each other. At first, Linnaeus looked upon species as having been created directly by the Creator and he believed in the absolute fixity of species. Later, however, he was compelled to alter his views somewhat owing to the multiplication of species which he observed everywhere in nature. We therefore see in the revision of Systema Naturae, which he made in 1760, a pronounced change, the mutability of species being more clearly recognized.

Buffon (1707-1788) took more radical views re the mutability of species than did Linnaeus, and laid the foundation of modern evolution in zoology and botany. He was the first to point out clearly the relationship between mutability of species and environment. He is thus the first to indicate some of the causes of mutability.

Erasmus Darwin (1731-1802), grandfather of Chas. Darwin, was one of the poets of the evolution idea. Like some of the early Greek writers he believed in the doctrine of spontaneous generation, but in the lower forms of life only. In the chapter on Generation in his "Zoonomia" (1794) he takes little account of the laws of heredity, but believes that by the addition of parts resulting from changes of environment exciting the "living filament" into action, new characters are acquired and these are capable of being transmitted. This theory it will be seen anticipated that of Lamarck.

THE LAMARCKIAN THEORY.

Lamarck (1744-1829) was the real founder of the modern theory of descent and is the most noted scientist and writer between the time of Aristotle and that of Chas. Darwin. Laboring under discouraging conditions and receiving nothing but disdain by the majority of his contemporaries he succeeded nevertheless in contributing much to natural science. In his "Philosophie Zoologique" *(1809) he expresses certain views which correspond closely with those held by E. Darwin and expressed by him in his Zoonomia. The main theory which Lamarck advanced and which is now known as the Lamarckian theory in contradistinction to the Darwinian theory, claims that evolution takes place through the inheritance of characters acquired during the lives of individuals so that in time new species may be created. The endeavour to satisfy certain wants brings about certain modifications which are inherited in part at least. This theory made no great impression at the time although it has been revived within recent times by a school known as the Neo-Lamarckians to which school Herbert Spencer and other prominent scientists belong. While the theory seems to explain many of the facts of inheritance yet it fails to show a case wherein a single acquired character has been permanently transmitted. As an instance we have the continued docking of horses and lambs, yet there is no case on record of one of these animals being born without a tail.

Goethe (1749-1832), the great poet of evolution, developed the "unity of type" idea in 1796. This led him to explain the existence of vestigial structures which constitutes one of the strongest evidences of evolution.

Bory de St. Vincent (1780-1846) believed that species are formed spontaneously and that this process goes on more rapidly in countries of comparatively modern formation. His idea was that the existence of a long series of ancestors tends to fix the type.

Isidore St. Hilaire, (1805-1861) son of Geoffroy St. Hilaire, advanced the theory that species were limited in their mutability. He claimed that new characters may be produced as a result of two forces:

(1) The modifying influence of new surroundings.

(2) The conserving influences of heredity.

Dr. W. C. Wells in 1813 was the first to apply the principle of "The survival of the fittest." He based his theory on the observation that no two individuals are alike and that those which are best fitted to withstand the exigencies of a particular country or locality are most likely to survive. In 1831 Patrick Matthews applied a similar view in a book on naval timber.

THE DARWINIAN THEORY.

It remained with Chas. Darwin (1809-1882), to bring out a well rounded theory attempting to explain the origin of species and varieties. His great work under this name was inspired by an essay by Malthus on "Population" written in 1798. After many years of most thorough work in which he collected an immense amount of evidence he crystallized his views on the subject into a theory known as the "Theory of Natural Selection." In a word this theory implies that favorable variations are preserved while the injurious or inferior variations are rejected. That is to say that in the struggle for existence only the strongest individuals survive while the weaker succumb to the various active forces of nature. This principle assumes that constant variation is going on within the race and that by the gradual accumulation of slight favorable variations new species are formed. Darwin based his theory of natural selection largely upon the results realized by man in artificially selecting from his flocks and herds. He recognized that variation might be induced as follows: (1) By environment. (2) By the use or disuse of parts. (3) By certain inherent forces causing definite variation. (4) By the tendency of variations to become co-related. (5) By reversion. (6) By telegony. Two main classes of variation were recognized, viz.: fluctuating variation and discontinuous variation. Darwin believed that fluctuating variations had been utilized most by the breeder although it is difficult to distinguish between the two. According to Quetelet, Galton and others, these fluctuating variations are grouped around a "mean" in such a way that approximately half are below the mean and half above.

Wagner claims that variation, isolation or selection, and heredity constitute the tripod of organic evolution. In other words, plants are constantly changing in character, and, since like tends to beget like in plants just as in animals, the isolation or selection from year to year of the most desirable individuals results in a gradual improvement in the race until certain limits have been reached.

While natural selection is, without doubt, a potent factor in the developing or creating of new species in nature, and while its action there may suggest the value of artificial selection as a means of improving domestic types, yet, it fails to account fully for the existence of our present species. This assertion is based on the following facts: (1) Natural selection is based upon variations which it cannot explain. (2) Certain of these variations cannot have been of any possible use to the individual and, hence, cannot have operated in its evolution (3) Life, according to certain authorities has not been possible on the earth for a sufficient length of time to allow the development of all of our present species, had these been developed as slowly as would be required by the action of natural selection (4) The numerous transitional links between species, which would of necessity exist had evolution come about as gradually as would be required by the natural selection of the "fittest," are not found.

We must, therefore, look to some internal factor upon which to base the laws governing the origin of species. Darwin himself recognized the insufficiency of his theory at a later date, and attempted to supplement it with his theory of "Pangenesis," but failed to contribute much toward the elucidation of the problem.

ATTEMPTS TO FIND INTERNAL CAUSES OF VARIATION.

Passing on from the time of Darwin we find the leading investigators searching for an internal force to explain the origin of variation. The German botanist Nageli was the first to attempt to find within the organism itself a force which might account for the appearance of strange characters in the offspring. He assumed the existence within the organism of a tendency toward progression or perfect development and believed that in accordance with this tendency organisms are continually varying so as to rise in the scale of nature. He failed, however, in explaining the origin of this internal force, so contributed little toward our better understanding of the question involved.

Another theory is advanced by Mivart to the effect that species have arisen suddenly and not by slow modifications hence the theory of "extraordinary births." An instance of the application of this theory is found in connection with an experiment conducted by Dr. Godron, of Nancy, with *Datura Tatula*, (Purple Thorn Apple), the seed capsules of which plant are normally covered with spines. Seeds of this plant were sown and produced plants among which was found a plant whose seed capsules were smooth. The seeds of this were preserved and again sown with the result that all the plants coming from them showed the same peculiarity. Each successive [illegible]ens from this seed showed the same characteristics as long as the experiment was conducted. When the smooth variation was crossed with the original forms true hybrids were produced which, in the second generation, reverted to the original type.

We probably have many so-called rare species at the present time which have been created in a like manner. Mivart believes that all species arise in this way. He claimed to be able to recognize an internal law presiding over the action of every part of every individual and of every organism as a unit. His theory is a sort of a compromise between evolution and special creation. While it has many things in its favor and while many of the objections which apply to the theory of natural selection do not apply in this case, yet it will not account for all of the facts of nature, and can only be considered to constitute one of the possible factors in organic evolution.

WEISMANNIAN THEORY, OR NEO-DARWINISM.

In 1883, Weismann, a German Naturalist, undertook to show how acquired characters cannot be transmitted and how permanent variations can originate. He outlined the development of the individual from the single cell, the fertilized egg, showing how the cell divides and how, while these cells which go to build up the different parts of the body become differentiated, other cells, the reproductive or germ cells, remain constant. Continuing he attempted to show that the property of being able to transmit definite characters to the offspring is peculiar only to the germ cell, hence permanent variations must emanate from this cell. Since environment can effect the body or soma cells and not the germ cell, it is clear, according to Weismann that acquired characters cannot be permanently transmitted. At the same time it is reasonable to believe that the temporary "fattening" or "starving" of the germ cell due to the favorable or unfavorable environment of the individual which bears it would be noticeable for one or two generations as indeed seems to be the case.

Galton in his book on "Natural Inheritance" disparages the idea that progression can take place only by the accumulation of minute variations, and characterizes such an inference as fallacious.

Bateson, in his "Material for the Study of Variation" refers to the two possible ways in which variations may arise and points out the principle objections to the claims made for fluctuating variations while at the same time he collates many facts respecting the importance of discontinuous variations.

THE MUTATION THEORY.

From the evidence brought forth in connection with the theories held by biologists since Darwin's time, it is apparent that the efficacy of natural selection and of the use of fluctuating variations in explaining the facts of evolution, have been steadily losing ground. On the other hand there has been a gradual tendency to regard the part played by "discontinuous" variations or "mutations" as being of more importance in this connection. The supporters of the latter idea have received much encouragement from the work of DeVries of Amsterdam, which work with that of Mendel has served to place the problems of heredity in an entirely new light. The law of Mendel respecting the transmission of characters when two plants are crossed is a large subject in itself and shall not be discussed now. Suffice it to say that the hybridization of varieties as effected in the light of this law is probably the most potent means of producing new varieties that is now within the reach of the expert breeder. The work of DeVries is worthy of special consideration since his discoveries may be said to have marked a new epoch in the long line of investigations of the factors in evolution.

DeVries' idea is that plants and animals are made up of "distinct units" which correspond to atoms in chemistry. By crossing one individual with another the units involved may be combined but never split, just as combinations may be made in chemistry. Transitional forms do not exist between the elements themselves, which assumption goes to support the theory of descent rather than that of transmution as applied by Darwin and his followers. According to this theory it is possible for new forms to arise suddenly without passing through a transitional stage. The theory of DeVries has the support of certain evidence deduced from results gained from experiments with *Œnothera Lamarckiana*. At least 50,000 plants were cultivated by DeVries in his garden for a number of generations, and out of this number about 800 were found to possess characters distinct from those peculiar to the parent forms. These new forms, moreover, proved to be constant by breeding true in succeeding generations. The occurrence of these forms under domestication may account for the numerous "elementary species" that are found in nature.

The theory of DeVries is not new. We have noticed how he idea of the creating of new species by the sudden variation of organisms prevailed among some writers of a comparatively early period. In 1864 Von Kolliker, convinced of the weakness of the natural selection theory, promulgated the theory that new and distinct species are born suddenly by leaps. In 1899, Korschinsky, a Russian botanist, as the result of certain observations and study, formulated the mutation theory. The publication in 1901 by DeVries of his first book on "Die Mutationstheorie" was the first public recognition of importance which this theory received. DeVries' theory is alternative with that of Darwin's as regards the formation of new species, but as regards the general course of evolution and the great principles which govern it the mutation theory is not in contradiction to the descent theory through natural selection, but is rather supplementary to it.

After considering the main principles which are associated with the various theories we have outlined we are forced to make the following conclusions, viz.:—

(1) That no two plants are exactly alike.

(2) That while "like begets like" in the main yet there is a constant and continual variation going on within the species.

(3) That some of these variations are fluctuating and unstable while others are discontinuous and determinate.

(4) That artificial selection of desirable fluctuating variations may raise the standard above the average of the race at least, although the limitations of this method of selection are recognized.

(5) That the artificial selection of discontinuous variations may result in the developement of superior new strains.

(6) That a combination of desirable characters through hybridization may result in the creation of hybrids possessed of special merit.

With these conclusions in mind it is a comparatively simple matter to draw up a plan whereby man may systematically and scientifically utilize the forces of nature to his own advantage. The systematic selection of what we are now pleased to call fluctuating variations in field crops with a view to preventing deterioration is a very ancient practise. The idea of actually improving our crops is, however, of comparatively recent origin. Once improvement was considered possible several systems were devised. The Germans followed Darwin's enunciation that improvement was a gradual process resulting in the accumulation of slight favorable variations, hence, we have "The German system of plant improvement." We have a concrete example of the improvement that may be effected by this system in the famous Schlanstedt rye originated or developed by Rimpau. This system is practised largely in Canada at the present time by members of the Canadian Seed Growers' Association.

Le Couteur, an Englishman who worked during the beginning of the 19th century is said to be the first to apply the principle of selection to the improvement of cereals by selecting elementary types from the growing crop. One of his most noted selections is the Bellevue de Talavera wheat which originated from a single plant selected from the regular field. This was apparently a mutation as it continues to breed true and to show very slight deviation.

Patrick Sherriff, another Englishman, working about the middle of the 19th century produced the Mungoswell's wheat after making many attempts to isolate superior plants. This wheat is still said to be popular in certain parts of Great Britain.

In 1857, F. T. Hallett, of Brighton, England, began a line of work from another point of view. He believed that each plant had one best head and that each head had one best kernel. By making repeated selections through several generations the yield was materially increased when suddenly the maximum seemed to be reached and further improvement ceased.

During the last 20 years Dr. Nilsson, of Svalöf, Sweden, has been engaged in the breeding and improving of cereals and has secured some remarkable results. At first Nilsson practised the selection of such apparent fluctuating variations as appeared in the field sown in the ordinary way. He found, however, that his results by this method were not very satisfactory, so he changed his system and adopted the plan of selecting and propagating individual plants and, by a process of elimination, finally isolating those which were most desirable. This system enabled him to discover and take advantage of some of the mutations which might appear from time to time, and at the same time to choose a pure, superior elementary type as the foundation for a better strain, believing as he does with DeVries that our ordinary strains are composed of what the latter calls "a motley mixture of types."

This idea seems to have taken root in the minds of the majority of our scientific breeders of to-day who recognize, in the various methods they have adopted, the underlying principles which have been so ably demonstrated by these men. At the same time there is undoubtedly a very practical advantage in following the simpler practice of selecting fluctuating variations, a practice which the ordinary farmer can easily follow on his own farm.

THE CANADIAN SEED GROWERS' ASSOCIATION AND ITS WORK.

Realizing the great national importance of the use of "better-bred" seed on the farms of Canada as a whole, and recognizing the fact that much might and should be done by way of producing such seed on the individual farms throughout the country, the promoters of this work, notably Dr. Jas. W. Robertson, took certain steps which led up to the organization of the Canadian Seed Growers' Association as a means of encouraging its advancement.

The basic principle upon which the work of the Association is founded is that the artificial selection of the best seed from the best plants year after year without interruption is likely to result in a definite improvement within the ordinary strain, although the limitations of this method of selection as a means of improvement are recognized.

As to the exact course which is followed by each member of the Association who desires to improve any one or more of his crops through giving special attention to the matter of "breeding" in his seed this in brief is as follows: The grower first decides upon the variety which is likely to do best on his farm. This is done by testing two or three leading varieties in plots under similar conditions for the first year. The next step is to prepare a special area of land of about one-quarter acre in size and to sow thereon a good clean sample of seed of the chosen variety. When the crop on this plot becomes thoroughly ripe the grower goes through the plot with a basket or sack, picking here a head and there a head, his choice being based upon the vigor and general type, first of the mother plant and secondly of the head which it bears. Enough seed is secured by the selection of these specially desirable heads each year to give a sufficient quantity of seed to sow another plot the following year while the remainder of the plot is harvested in the usual way and the seed used for the main crop.

The above practise is, in essence, the selecting of fluctuating variations which, if continued, results in raising the "mean" of the ordinary strain to a higher plain. Some authorities such as Johannsen, Pearson and DeVries contend that the selecting of fluctuating characters can do little by way of improving the race.

They admit, in part at least, that the average or "mean" of the race or strain may be raised by this means, but claim that once selection ceases the erst-while improved strain will return to its original condition. Of this contention Plate says: "This theory is based on forms which have been highly modified within a few years, so that there has not been a sufficient time to modify the original hereditary tendency established by centuries. Many facts indicate that the intensity of heredity depends upon the number of generations during which selection has been practised. Long inherited characters are difficult to eradicate; recent ones easy. Many gradually selected races of doves are now almost entirely constant. A race developed artificially by slow, persistent selection for a great number of years would show the same relative fixity of types as do our natural species." The results realized thus far by the Association through this method of selection strongly show that a definite improvement has been made in the original strain. This improvement has taken the form of increased yields, better quality, greater uniformity and purity, greater vigor and greater ability to resist disease. Though it may be necessary to continue the selection from year to year in order to maintain the standard yet such seems to be justified by the results accruing therefrom.

In the past certain specially progressive and observant g owers have found heads of grain in their fields which were so distinctly different from any others that they kept them separate and sowed the seed secured therefrom in their garden with the result that in many cases new varieties have been developed. These strange plants were undoubtedly mutations. As examples of these we have the Dawson's Golden Chaff wheat, Goldthorpe barley and many other well known varieties. This is a line of work which should be encouraged as much as possible.

Other members of the Association have found time to follow the more complicated system of selecting and propagating individual plants separately, and by a process of elimination finally isolating the so-called "elementary" types. This latter method which is based on the DeVriesian theory, is probably the quickest and safest to follow, but on account of the amount of careful work and detail which is involved it is not a system which the Association is strongly recommending at present for the average farmer in the improvement of his smaller grain crops. In the case of corn and potatoes, however, this method is being followed with most gratifying success.

This article is designed to correlate the practical and the scientific side of plant improvement. Once the creation and development of forms of plant life become associated with recognized laws and principles, the prosaic element quickly disappears and we regard these things in an entirely new light. Then it is that real progress is possible. The associating of natural law with the every-day industry of crop raising is the primary aim of the Canadian Seed Growers' Association.