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EMERGENT EVOLUTION AND HYBRIDISM

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THE essential supposition of emergence, or emergent evolution, appears to be that the product derived from the synthesis of any number of elements is often quantitatively and qualitatively supervenient over their mere sum, or resultant, and thus it becomes something chiefly novel, the important features of which may even be extraordinarily dissimilar from those of the elements and subgroups that entered into its composition. The laws relating to and governing the whole are therefore comparably as restricted and peculiar to it as the laws relating to and controlling the respective components are exclusive and limited to them, and those of the one may not be even adumbrative of the others.

It has been long recognized that familiarity with the attributes of elements does not confer the ability to prognosticate the qualities of the wholes resulting from their syntheses. The behavior of neither hydrogen nor oxygen gives the slightest suggestion of the properties of water. The possibilities of gunpowder may not be deduced by an examination of the properties of either charcoal, sulphur or saltpeter, or of a combination of any two of them. Carbon, hydrogen and oxygen, each examined with respect to its qualities, or any two together, afford no connotation of the characteristics of ethyl alcohol, if these elements be combined in the one way, or of the ether they make when there is another arrangement of them.

The behavior of molecules may not be ascertained through a knowledge of merely the properties of their separate constitutive atoms; the molecular compounds do not present attributes which by simple additions result in the properties of cells; many of the properties of individual animals and plants are vastly different from the sums of the properties of the respective cells of which they are composed, and the qualities and appurtenances of plant, animal and

human societies are far from representing nothing but the sums or mosaics of the characteristics of their several individual and subgroup constituencies.

This "novelty of behavior" has been well defined and interestingly discussed by a number of writers, and variously named "heteropathic causation," "emergency," "creative synthesis," "emergent vitalism," "organicism," "holism" and "emergent evolution." The term *emergent evolution,* suggested by C. L. Morgan, has been adopted by W. M. Wheeler, whose recent book treats the subject with serviceable succinctness and lucidity. Several others, including Wundt, G. H. Parker, Spaulding, Alexander and Smuts, have approved and elaborated the proposition, in one way or another, and Jennings has waxed enthusiastic to the point of declaring that "the doctrine of emergent evolution is the Declaration of Independence for biological science."

It is not inferred from the writings reviewed, Smuts possibly excepted, that the entire problem of evolution has been or may possibly be solved through the application of the principles of emergence. However, if nothing more, the hypothesis suggests a somewhat novel and interesting means of viewing the phenomena of a considerable section of the universe, including protoplasm, mind, personality and societies.

In an editorial[1] H. H. Laughlin stated that "geneticists, including students of eugenics, are deeply concerned with the facts of emergent evolution," and he also extended the idea to cover the phenomena observed in connection with qualities which seem to emerge from complexes of characters in organisms and particularly in man. He further suggested that some mutations may be of this nature. So far as I have been able to ascertain, Dr. Laughlin, in these suggestions, was the first to recognize the apparently pertinent coincidence between the supposition of emergent evolution, as outlined, and the apprehension of hybridism, or hybridity, as elaborated by Darwin and earlier observers, and especially by G. H. Shull, East, Hayes, Jones, Riddle, Jeffrey, Lotsy, Peacock, Harrison and other recent writers.

The term hybridism, or hybridity, as commonly employed by scientific plant and animal breeders, appears to signify a heterogeneous (we now know not necessarily heterozygous) condition of an organism with respect to two or more genes responsible for characteristics of discernible discreteness, whether they are linked to the extent of allowing crossing over, are allelomorphs or are distributed among two or more linkage groups. All these conditions usually prevail, wherein an organism may be heterozygous for certain genes and homozygous for others, all in one linkage group or distributed among two or more pairs of chromosomes. In this way bisexual plants and animals are commonly, to a less or greater degree, compositely hybrid in respect to a few, or several, characteristics for each of which they may be homozygous, and they would thus constitute true-breeding hybrids. In addition, they are generally heterozygous for several, or many other, factors with respect to which, of course, they do not breed true.

There are probably also genes that do not manifest themselves in the form of discrete characteristics even when contained in homozygous doses, yet they may become apparent as hybrid emergents when two or more different ones are represented in organisms in double doses, respectively, or some single and others homozygous. It is altogether likely that certain transient, apparently non-Mendelizing variations, or even some that remain constant as if they were outright mutants, belong to some such category. Several genes which modify recognizable characteristics, but which, of themselves, do not become manifest, have been reported. It is unlikely that any characteristic is ever the manifestation of the actions merely of one, or even two genes, or factors; each discrete characteristic is generally, if not always, the supervenient emergent of the interactions of several, or many genes. There are also other possibilities for heterogeneity, or hybridity of traits in bisexually reproducing organisms.

Darwin appears to have been the first to observe that it was the bringing together of dissimilar germinal substances, rather than the mere act of crossing, which produced extra size and vigor in hybrid plants and animals. Following his lead and in the light of Mendel's discovery and utilizing the results of their own and other extensive experimentation, G. H. Shull, East, Hayes and Jones have defined in some detail the probably precise means by which the changes, including additional size and vigor, as well as negative qualities, are obtained through hybridization. The hybrid vigor and increased size, as well as other superveniences derived from the crossing of different strains of Indian corn were emergents, each in respect to its properties, quite distinct from, and more than (rarely less than), the mere sum of the properties of the respective long inbred varieties. Numerous critically experimental results which support this thesis have been described by the authors named and by investigators who utilized for experimental purposes other plants and also animals.

More than three thousand named varieties of dahlias of widely differing color combinations, size and form have been noted by Jones, who states that all have been derived through hybridization from very

[1] *Eug. News,* January, 1929.

few elementary strains, with possibly a few mutants which occurred during the relatively short period of their development. It appears that most horticultural achievements have been attained by means of hybridization, either through man's intentional effort or by chance in nature. It is generally recognized that in all the higher and many lower forms of plants hybridization has performed a conspicuous part in the development of the limitless varieties found distributed among the almost infinite kinds of environment in which they live. Every important group, as cotton, wheat, corn, sorghum, all fruits, shrubs, trees, weeds, wild as well as cultivated flowers, and vegetables—all are well known to be largely and, in many cases, wholly of hybrid origin. In most of them the distinguishing characteristics of the contributive races have become largely dissembled by the respective hybrid emergences.

Starting with Darwin again, although the matter greatly antecedes his time, hybridization among animals, both the wild and domesticated, and including man, has been considered of major consequence. There is a vast literature dealing with the complexly hybridized condition of such domesticated animals as the fowls, cattle, sheep, dogs, cats and swine; in fact, all are involved usually to a high degree of heterogeneity, with infinite and incalculable numbers and varieties of supervenient emergences and probably with profound consequences in respect to distribution, tolerance and survival.

Among wild animals, hybrids are usually in such composite profusion, and so little do their hybrid emergent properties and the attributes of their constitutive elements adumbrate each the other, that it becomes quite impossible casually to distinguish them. Adequate analyses are feasible only if the organisms carry sharply contrasting characteristics and lend themselves to being bred in comparatively large numbers and over considerable periods of time. Among the more intricately complex, particularly the larger, slower-breeding, domesticated animals and man, rapid and commensurate analyses seem to be as yet impracticable, perhaps more because of the long time and excessive expense involved than on account of their complicated genetical natures.

The most extensive, critically experimental hybridization project of all time has been that of T. H. Morgan, his immediate colleagues and other workers throughout the world, in which the fruit-fly (Drosophila) has been utilized. Following Bateson's analogy and considering the genes responsible for the various characteristics as elements, the methods employed and the results obtained are closely coincident with those in chemical resolution and synthesis. The four hundred, or so, mutant genes of the fruit-fly have been allocated in a system such that they may be used in breeding synthesis and analysis in the identical quantitative way in which the chemical elements are employed. Other projects of this nature, contributing evidence in support of this generalization, all in the field of hybridism, have employed as experimental materials corn, tobacco, jimson-weeds, evening primroses, grouse locusts, mice, rats, guinea-pigs, rabbits, birds, fowls and, to some extent, the larger domesticated mammals and man, and a number of other organisms.

The methods, results and possibilities of genetics (experiments in hybridity) may be further illustrated by referring to the grouse locusts (Tettigidae) with which I have worked for several years. This subfamily of the Orthoptera has extraordinarily striking and variable color patterns. In one species (*Paratettix texanus*) a few over twenty-five distinct, dominant, elementary patterns have been resolved in the breeding processes. Twenty-two are so closely linked as not to allow crossing over; one is rather loosely linked with these, and one each appears to be on two other pairs of chromosomes. However, even with this arrangement, a prodigious number, mounting into the hundreds, of color pattern combinations have been developed. Many of these hybrid emergent patterns are stable, when inbred, while others are relatively so. In another species (*Apotettix eurycephalus*), in which linkage is not so close, other hundreds of true-breeding as well as unstable composites may be and have been developed from the thirteen conspicuous, diagram-like, dominant, primary color patterns.

Reference to the colored plates of my publications, or better, a view of the specimens in nature and in the laboratory, reveals the extraordinary extent of variations in color complexes, all derived from comparatively few primary patterns. Before experimental resolution and synthesis had shown how few original, primary characteristics were involved in the production of these numerous color pattern composites, speculation regarding them had been rife. The dominant, elementary color patterns, as well as the hybrids of the grouse locusts, are peculiarly discrete and diagram-like. They ought to lend themselves, the one to decipher the others, perhaps better than the characteristics of almost any of the other organisms hitherto submitted to Mendelian experimentation; yet in only exceptional cases, without previous experience, would it be possible to predict, merely upon inspection, what a specified group of elements would make, or what had gone into the production of a given complex. Now, with experience, numerous composites, each a supervenient emergent as novel in its attributes as any of the several components, may be

developed at will. If the mutants which certainly occur, though rarely in the grouse locusts, be included, the probability of increased numbers and variability of hybrid emergents would be proportionately enormously enhanced.

The work with the grouse locusts so far has been devoted mainly to syntheses and analyses of color patterns and combinations. However, it has also been determined that certain size, form and vigor properties, some negative and others positive, including the capability of reproducing parthenogenetically and to simulate death, are emergents of hybrid syntheses.

So, altogether, there have been employed a considerable number of color, form and vigor, primary characteristics, ranging from very brilliant to extremely dull, and from strongly vigorous to lethal, not to consider those too subtle to be easily recorded. All are readily capable of hybridizing in practically infinite variety, and there have, or may, come into existence supervenient hybrid emergents almost limitless in number. Paraphrasing a passage from C. L. Morgan, it is beyond the wit of man to number the instances of emergence, even among the grouse locusts.

In a considerable number of hybrids, to be sure, especially among the higher animals and man, some of the respective characteristics may be blended or arranged in mosaics in such manner as to indicate certain of the qualities of the component races. Even so, such composites generally exhibit, in addition, qualities extraneous to any shown by the original organisms, and at the same time some of the properties of the latter are lost in the process. In this category probably belongs the mulatto, many of whose qualities, in spite of certain degrees of blending, are superveniently different from the mere sum or mosaic of the several characteristics of the white and black races. The respective properties of the ass and the horse would not, by simple addition, or mosaically, make a mule, and the cattalo is far from displaying nothing but the sum or mosaics of the several attributes of buffalo and cattle. Nearly all the higher plants and animals when hybridized—and which are not?—exhibit extraneous qualities such that they largely, or completely effect the dissimilitude of the qualities of their several, contributive, primary races. The list of specified cases could be extended to great length and still remain within the bounds of quite familiar plants and animals. If, on first consideration, the appositeness of some of these illustrations comes into question, it is simply because of our familiarity with the production of such common hybrids. If they were coming into our knowledge for the first time, or if we should approximate precision in estimating their several qualities and appurtenances, as compared with those of the races that go into their making, the novelty of their emergent properties would be quite marked and bewildering.

The tendency to assume that hybrids represent nothing but the sum or mosaics of the characteristics of the races from which they may have been derived has led to numerous signal failures of efforts at producing desirable hybrid composites. Many statements and inferences of plant and animal husbandmen, anthropologists, sociologists and writers in general have brought me to this conclusion. The outlines of several state and federal (U. S. A.) experimental projects, with the expenditure of considerable effort and funds, have been based on this assumption. Familiar examples have been those proposing to develop double-purpose cattle and fowls by hybridizing large beef- with high milk-producing cattle, and high egg-laying with big meat chickens, respectively. The converse of this process have been the efforts, some in the field but mainly in museums, to determine by examination of their characteristics just what had been the original contributive races of various groups of plants, animals and man. It is almost needless to add that the results from most such enterprises have been radically different from those expected and generally disappointing. Even when gains did accrue they were not those aimed at. In general, without previous experience, hybrid emergents may be no better prognosticated than the emergent products of the first syntheses of chemical elements. It even appears to have been a common experience that positive or useful properties were quite likely to emerge from the hybridization of negative or useless characteristics, and *vice versa*.

During the past thirty years the principles of heredity have come to be quite well understood. However, the possibilities of application of these principles in human affairs remain largely to be realized. As noted above, we have not even passed the contingency of developing a strictly scientific technique for the production of valuable hybrid varieties. The uncalculating, extensive methods of hybridization employed by the Burbanks of all time, to such an extent appropriately deplored by scientists, yet in practical results quite successful, may even in this advanced day still remain the irreducible expedieney. Since we thus far probably have nothing better in technique to propose, our animadversions might very well be limited to censuring them for failure adequately to record the kinds of crossings and the resulting frustrations and successes. Among the most manifest and importunate requisites of practical biology to-day are great, adequately supported, continuous and perspicaciously conducted projects in hybridization among the respective varieties of the higher animals and plants. The prospects are that progress would

be closely analogous with that of chemistry. However, the knowledge of heredity and the casual accomplishments in hybridity already realized would probably make attainments considerably more rapid.

Mutations (neo-Darwinian variations) range from the ordinarily imperceptible, though possibly quite potential under circumstances of hybridism, to those of considerable magnitude. They are of multifarious, chance kinds and utterly without objective. Each new mutant gene in practically any group of higher plants or animals proportionately greatly augments the probabilities of supervenient hybrid emergents. These, in turn, are as much fortuitous sorts and without direction, or objective, as the mutants themselves.

Wheeler states "that there is not on the planet a single animal or plant that does not live as a member of some biocenose." It is likewise probably true that there is no single bisexually reproducing animal or plant which is not in some essential features a supervenient emergent of hybrid syntheses. Hybridity has probably been the efficient, ultimate agency by which the mutant characteristics of all varieties and races of bisexually reproducing organisms, including man, have attained whatever casual, eventual grade of supervenient emergency they may have severally occupied, whether they were among the preponderant legions below the point of ability to survive, those in the situation of being merely tolerated, or the comparatively small numbers which appear to have been reasonably well adjusted.

Natural selection creates nothing; it is strange that anybody ever misunderstood or misstated Darwin to the effect that it does. Mutations and hybridity furnish the materials, mainly, perhaps among the higher organisms wholly, in the form of supervenient individual hybrid and biocenose emergences of fortuitous kinds and without objectivity or direction. The vast majority perish, some linger awhile, others are suffered, while presumably relatively few are fairly well adapted to the dynamic, intra- and interpermeating complexes of the environment; which encompassing complexes are, in turn and in their aspects, as much supervenient emergences as are the intra- and interpenetrating organisms and societies they environ. Here, then, are the exclusive field and materials in and on which it is considered that natural selection operates.

We are probably not yet in the position, certainly it is not intended in this paper, to estimate the share, if any, that should be allotted to hybrid emergence as here defined, in the consideration of the causes of evolution. Bateson's challenge apparently still stands unanswered, at least experimentally; no one has yet demonstrated, either through hybridism or by any other means, a method by which progeny may be derived which are fertile among themselves yet which do not produce fertile offspring when mated back to the original stock.

We are still in a morass, it may as well be admitted, with regard to the ultimate problems of evolution. However, de Vriesian mutations (neo-Darwinian variations)—possibly irradiation-induced mutations, hybrid emergence (emergent evolution) and natural selection constitute features of a rough path, a sort of crude track through the jungle, beaten by Darwin's seven-league boots, that may soon open into somewhat of an upland clearing from which a further reconnaissance may be made.

BIBLIOCHRESIS: THE PILOT OF RESEARCH

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Whereby the sedulous worker
His laboratory course does steer.

BIBLIOCHRESIS, the scientific use of literature, has the pilotage of all scientific investigation. It has, in fact, the same relation to research as the latter has to management; it is the intelligence service of all orderly inquiry, the preparational agent of factual determination, the guide of experimental trial in eliminating chance, in the whole realm of science.

To be scientific, an investigation of any type must be made methodically—a condition that requires, primarily, that all scientific research be conducted in the light of recorded experience. This requirement applies to the exercise of the historical and analytic procedures of investigation as well as to the employment of the experimental method, whose use, whether for confirmation or for original work, rests upon prior knowledge and art, *i.e.*, accepted practice.

Bibliochresis, then, is the most indispensable tool in laying the foundation for scientific research. Since it enables the qualified worker to find the experience of his predecessors, as recorded in the literature, it confers upon him either the power to predict the results of effort—this is the outcome if the recorded information is evidently factual, *i.e.*, definite and confirmed—or the ability to plan further research on the same or an analogous topic. Reference is had throughout this communication to the proper use of the results of bibliochretic study and not to the incor-