bined with science the spirit of medicine, the force from within, arising from a sympathetic appreciation of the needs of the individual.

Let those who enjoy the thrills of creative thinking and experiment toil without thought as to how the new knowledge that they may reveal will find its place in human application. Let those who choose the field of medical practice make sure that they apply established facts with discernment and wisdom and run not after strange gods and fallacies. And let those who can do so approach the problem of disease in the spirit that has always proved productive in science, of seeing clearly the problem and seeking the truth by any means that may be serviceable to their purpose. But let us be sure that a means is constantly preserved by which whatever is usable in science finds its way, pure and unperverted, directly and swiftly to the needs of the individual man.

The workers who are coming forward to spend their lives in the small and newly tilled field of clinical research have a large share in keeping clear the way by which science finds its application to medical practice. This field needs further cultivation and should have the encouragement and respect of both workers in the natural sciences whose fields are well defined and organized and of the ancient order of physicians to whom is given the task of bringing the results of science to the needs of the individual.

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A NOTE UPON THE PROBABLE MODE OF EVOLUTION

When in any group of related organisms, such as a family or higher category in the natural system, the genera are plotted to the number of species they contain—provided only the genera be not too few to justify statistical treatment—a curve of characteristic form is obtained.

The fact was first observed by Dr. J. C. Willis in his statistical studies of recent floras and faunas. Mrs. E. M. Reid showed that analysis of Tertiary floras yields the same result. It may be noted, in addition, that the data regarding such groups as Trilobites, extinct since the Palaeozoic, Tetrabranchiate Cephalopods—with the exception of *Nautilus* now extinct—and Brachiopods, of which a considerable number of species still live, when plotted as stated yield additional examples of the same curve. This, then, is a graphic expression of some universal phenomenon in the organic world. Rather, the "hollow curves" of Willis are a class, which, as parabolas in their variety define the paths of projectiles moving under the influence of gravitation and their initial velocity, record the detail in which this universal process has expressed itself in the particular groups of organisms to which they respectively apply.

Drs. Willis and G. Udny Yule at first identified this enigmatic curve as that of a geometric series. There is much to justify such identification. When, for example, instead of the actual numbers of genera being plotted to their respective numbers of species, the logarithms of the numbers of genera are plotted to the logarithms of the numbers of their species, the hollow curve is transformed, and the curve obtained as a result of the transformation is, throughout a considerable portion of its length, approximately a straight line. Moreover, the earlier and larger numbers in the series from which the curve is directly plotted yield, when each term is divided by that immediately preceding it, a series of quotients approximating 1/2 more nearly than any other such simple fraction.

The curve obtained, however, by the substitution of logarithms for natural numbers is *not* a straight line. Nor does the one limb of the original curve, or the series of numbers from which it is plotted, more clearly bear the stamp of $1/2^n$ than the other bears that of a series whose common ratio lies near unity. The hollow curve, we may therefore reasonably assume, results from some sort of compounding of a series of geometric series of different common ratio, but all lying between the limits of 1/2 and 1.

Now the series $1/2^n$ in its successive terms shows, for example, what proportion of a group of individuals tossing pennies for the longest run of heads would eventually be distributed in each class by achievement—how many would throw no head, one or two heads, and so forth, till even the longest probable sequence had been broken. A different ratio would give the distribution similarly of another group in which the chances of making a comparable gain were different.

With these ideas in mind it is clear that if we might know how many groups were playing a game of chance, the number of individuals in each group and the chances of winning upon any one play in each, the authentic curve showing the final distribution of all players by number of successes scored might be constructed very simply. It would be a graph the first ordinate of which would be proportional to the sum of the first terms of a series of geometric progressions of differing common ratio, the second ordinate proportional to the sum of the second terms, and so to the end. It is upon this system that the geometric series to which the hollow curve owes its peculiarities appear to be compounded.

There is one patent indication regarding the hypothetical series, whose nature and relations it must be the aim of investigation to discover. It is the fact that in their grand total the series based upon $1/2^n$, or an approximation to $1/2^n$, are much greater than those based upon ratios equally closely approaching unity—their limit, since it measures the prospect of success in each trial indefinitely.

A condition in which the greater number of individuals, measured with respect to whatever quality, lies near the mean directs attention to the normal curve.

If now the half of a polygon of normal frequency lying on one side of the mean be divided into a number of parts of known area—four equal parts will do very well—the average ordinate of each part may be determined from the table of the normal curve, and next the abscissa of that ordinate. This abscissa will measure the amount by which the average individual in the fraction to which it pertains exceeds the average of the entire polygon in respect to the character considered. But the general average may be represented by the fraction 1/2: and the abscissas above, upon being reduced to fractions of the base of the half-polygon and added separately to 1/2, yield a series of fractions which may be used as common ratios in such a series of geometric series as it has been suggested may, when compounded, give the hollow curve.

When these several series are calculated, their homologous terms added and the graph of the resultant series plotted, the characteristic curve is in fact obtained. Before discussing the biological significance of this discovery two additional points should be considered. First, may either half of a skewed distribution, when treated as above, give a typical hollow curve? Second, granted that it may, do skewed distributions as a matter of fact serve as the mother-polygons of these curves?

The hollow curve in its typical form depends upon the concurrence of two conditions in the mother-polygon from which it is derived. That polygon must have its area lying largely near the mean in order that the series of $1/2^n$, or those approximating it, may leave the impress upon the resultant that they do. It must have, however, a part, not inconsiderable, far removed from the mean, which, distributed in a number of series with the highest common ratios, leads to the formation of the greatly extended "tail" of the curve lying along the axis of X. In a typical skew curve the half lying to one side of the mean has a concentration toward it which would produce the first effect, the other half the dispersion which would produce the second. Neither half has both. The skewness, if any, in the mother-polygon must therefore be relatively little.

While conditions remain constant, all populations in their growth follow some specific "logistic" or population curve. If conditions change, their growth-rates change, but follow as accurately as ever other curves of the logistic series. It is evident from what has gone before that that process which the hollow curve records is also self-regulating, for secular changes in conditions do not change its type. If this train of thought be pursued in the light of the interpretation placed below upon the curve itself, reason may be discovered, it seems, for excluding the skewed distribution from further consideration.

To proceed with the interpretation of the curve of genera plotted to species, it must first be stated that it is the law of organic evolution which it expresses. In detail, it is really a half-curve of normal frequency whose peculiarities of form and derivation appear to have this meaning:

Genera arise actually, or in effect, as monotypes. With regard to their respective abilities to maintain themselves where first established the prime species of genera in any considerable group of organisms have the distribution of variates forming together a half-polygon of normal frequency lying on one side of the mean.

The success of each prime species in multiplying species within its genus is correlated with its own position in the scale of ability. Strong ones are not more variable than weak. But new species produced by those whose place is insecurely held will, up to full half, fail to maintain themselves. Almost half those genera whose prime species were among the weakest will gain no second. Of those of similar weak ancestry which rise to the rank of ditypes, almost half will advance no farther. Of those whose prime species were fitter for survival under existing conditions a smaller proportion will halt at each stage, and genera whose first representatives were fittest will multiply their species freely. It is to their inclusion in the total that the curve of genera plotted to species owes its great extension along the axis of X, where for many successive stages the division of one term by the preceding gives, not 1/2 as it should if they belonged to the series $1/2^n$, but a fraction much more closely approaching unity.

These are conclusions whose implications are so far reaching that every possible check upon them must be applied. The following suggest themselves.

In a stable environment the successful types are those whose specialization is most complete. But if conditions change, precisely these are the greatest sufferers. This seems a fair conclusion from the data of paleontology. It may be inferred also from the course of events in every political, social or economic revolution.

But conditions in the world are constantly changing; if for no other reason, as a result of the evolutionary process itself, which introduces new species to form part of the environment of the old. Therefore, with whatever advantage the first representative of a new order may arise, the first species of new genera, springing from it and persisting, in ability to maintain themselves tend to attain as their limit the distribution of a half-curve of normal frequency. This may be called the Law of Like Distribution of Prime Species. Broad as this generalization is, it covers only a special instance or group of instances included under another still more comprehensive, *i.e.*, in a disturbed system every part tends to reach the position where its potential energy is at a minimum. The half-polygon of the law in its limited sense is the mother-polygon of the curve of genera plotted to species.

Again, the earth, the sea and sea-bottom, as intensive study of the distribution of species in or upon them shows, may be considered a fine mosaic of habitats, differing among themselves and severally suited to the needs of vast numbers of species. Of great numbers of new species arising by mutation, single or superimposed, those groups, which upon units of the multi-faceted world upon which they first establish themselves barely succeed in maintaining themselves, will have smaller success in extending their ranges to even one additional facet than like groups which, establishing themselves under like circumstances, are able to maintain themselves with less difficulty.

The situation is in essence the same as has been discussed above, since for any organic type to add to its range unit after unit unlike that it first held, or even like that first one, is a process analogous to adding species to species within a genus. Both are of that type of success which may be attained in successive trials of a series where the chance of a specified event's occurrence is each time the same. The curve of species plotted against the areas they occupy should be, then, and is, of the same type as that with consideration of which this note began. The fact has been established by Dr. Willis in studies upon the distribution of endemic Angiosperms of Ceylon and New Zealand, the endemic orchids of Jamaica, and by other similar tests. It is confirmed further by the distribution of snails of the genus *Partula* in Raiatea according to Garrett's, and by that of the varieties of species of *Partula* in Tahiti, according to Crampton's records.

It is highly improbable that these are exceptional instances. The first ordinate of the curve derived from the normal polygon of mathematical tables by the treatment outlined above is almost exactly 39.0 per cent. of the sum of all the curve's ordinates. Thirty-eight and six tenths per cent. of the genera of angiosperms are monotypes (Willis); 42.2 per cent. of the genera of Chrysomelidae, Cerambycinae, snakes, lizards and bats; 41.2 per cent. of North American fossil Tetracoralla, trilobites, tetrabranchiate cephalopods and brachiopods. Forty per cent. of endemic Jamaican orchids occur upon unit area, according to Willis's count. Forty and nine tenths per cent. of the varieties of Tahitian Partulae collected by Crampton come from single valleys. Thirty-eight and five tenths per cent. of infants dying under one year in Hamburg in 1912 died in their first month; 42.0 per cent. of male infants and 37.6 per cent. of females similarly in Boston, Mass., in the same year (Whipple). But if they be not exceptional, there is the same reason as above for thinking that the species and varieties concerned have with respect to ability, in each group, the distribution of variates in a half-polygon of normal frequency.

The Angiosperms and Orchidaceae are groups so large and old that prime species of their different genera have probably attained the statistical distribution of variates in a half-curve of normal frequency. The species in their different genera in ability tend to resemble their respective prime ancestors. Thus the distribution of ability in either group as a whole is such that the prevailing distribution of species by areas might have been anticipated. With the single genus it is different. In Tahiti and Raiatea *Partula* behaves in a representative way. But there must be flourishing genera of recent growth which have a disproportionate number of strong species. The first ordinate of the curve of species of such genera plotted to their areas should not be so large a fraction of the sum of all ordinates of the curve as is usually the case.

That the success of each prime species in multiplying species within its genus should be correlated with its own position in the scale of ability implies that the causes of variation are to be sought in the action of manifold external influence upon a complex and unstable germplasm, and that trends in variation under the influence of constant conditions resident in the organism or imposed upon it by its surroundings do not occur. Novelties of whatever possible taxonomic grade have a normal frequency distribution about the parental mean. Not the potential distribution of variates, but the actual distribution of survivors, is affected by secular changes in the environment.

It may be urged, of course, that the ability of organisms to maintain themselves is a resultant compounded from the effects of many variables, whose variation is separately directed by internal or external conditions, but without reference in any to the direction taken in others. But for this view an impasse is created by the fact that a single gene may affect the development of several characters, and that geneticists even venture to think that each gene may perhaps affect the development of all the characters of an organism.

The genes in general seem not at any moment to be narrowly limited with respect to changes they may undergo, or limited either with regard to the ultimate source of the influence to which their changes are due. Chance is arbiter in the field of variation, and the normal frequency curve is the type of distribution to which heritable variations in any stock or character tend to conform.

Given heritable variation uncontrolled in direction, natural selection everywhere operative in the intensity indicated and the undisputed effect of inheritance, it follows inevitably that with respect both to the size of their genera, and to the area their species occupy in the world, organisms must be related numerically as we have seen. It must be possible to say that the graph which summarizes the result of organic evolution, and expresses its law, is a curve derivable from the normal curve and one whose ordinates are successively the sums in order of the homologous terms of an infinite series of infinite descending geometric progressions, whose common ratios lie between the limits of 1/2 and 1.0.

Infinite in diversity, admirable in simplicity and unity, is the process whose order may be expressed so briefly.

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SCIENTIFIC EVENTS

THE GORGAS MEMORIAL INSTITUTE

The New York *Times* reports that a program for the participation of every Central and South American country with the United States and the Republic of Panama in an effort to place the Americas on a sanitary status comparable to that of the city of Panama and the Canal Zone, which were transferred by Major-General William C. Gorgas from pest holes of disease to one of the most healthful areas in the world, took form at the meeting of the board of directors of the Gorgas Memorial Institute on April 23.

The proffer by Panama of a site and building, formerly intended for a school of medicine at Panama City, but now dedicated as the Gorgas Memorial Laboratory for the study of tropical disease, was approved by the board.

Dr. Franklin H. Martin, president of the institute, pointed out the importance of this research to every great industry doing business around the Caribbean Sea, as well as its humanitarian significance. "If this laboratory in Panama can discover a cure for malaria," Dr. Martin said, "it would mean a saving for industry of millions of dollars, besides a saving of thousands of lives."

Vice-president Curtis was elected a director of the institute. Ex-president Coolidge, whose term as honorary president of the institute automatically expired with his office as president and whose place has been filled by President Hoover, was elected on the institute's advisory council, as was former Vice-president Charles G. Dawes. Florencio Harmodio Arosemena, president of Panama, and Henry L. Doherty, of New York City, were elected to serve with Mr. Coolidge and Mr. Dawes on the council.

Surgeon-General Edward Riggs and Rear-Admiral Edward R. Stitt, both of the United States Navy, were elected to the board of directors.

MEMORIAL TO DR. SALMON

Announcement is made by George W. Wickersham, honorary chairman, of the establishment of the Thomas William Salmon Memorial to give recognition to the scientific man who makes the greatest contribution of the year in the field of mental medicine. The memorial is in honor of Dr. Thomas W. Salmon, former professor of psychiatry at Columbia University and medical director of the national committee for mental hygiene, who died on August 13, 1927.

The plans of the memorial call for a series of lectures to be given by the person to whom the award is made in various cities of the United States under the auspices of accredited scientific, medical or educational organizations. It is intended to disseminate knowledge of value in the control and prevention of mental and nervous diseases.

The administration of the initial fund of $100,000 is to be vested in the New York Academy of Medicine. It will be a permanent and endowed establishment with national and international connections. The movement was started by one hundred and fifty leading neurologists and psychiatrists who are associated with leaders in the mental hygiene movement and in psychiatric, social service and nursing fields.

It is said that universities, medical schools, scientific societies and independent workers in this country and abroad are to be surveyed annually in a search for the individual, prominent or obscure, whose original work promises most in the line of relief to the states, municipalities, private organizations and individuals confronting the economic and humane problems incident to the increasing number of people suffering from mental and nervous diseases.

The honorary vice-chairmen of the memorial include General John J. Pershing, Dr. Nicholas Murray Butler, the Rev. Dr. Harry Emerson Fosdick, Mrs. Helen Hartley Jenkins and Dr. John H. Finley. The chairman is Dr. Frankwood E. Williams and the vice-chairman Dr. William L. Russell. Dr. Austen Fox Riggs is secretary; Paul O. Komora, assistant secretary; the New York Trust Company, treasurer, and Dr. Samuel W. Hamilton, assistant treasurer. The