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ORGANIC COLOR.

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THE colors of plants and animals may be due (1) to diffraction and interference from striated surfaces, as in some iridescent feathers and shells; or (2) to pigments whose function seems to be especially to give color; or (3) to the molecular structure of the tissues themselves.

The first of these causes is not a physiological phenomenon. It can be equally well exhibited by artificial means. The second and third are phenomena connected with the most fundamental elements of organic life.

The colors of tissues or pigments depend, of course, upon the portion of white light which is reflected from them. The white light of the sun falling upon an object is in all cases partly absorbed and partly reflected. This "light" is merely a series of undulations or ripples running through the ether, the ripples being of various sizes; and the color of the object depends altogether upon the quantity and the size of the ripples which are stopped or absorbed. The cause of the differences in color among various organic objects must lie in the varying power of absorption possessed by the tissues. The petals of a pink rose absorb the undulations of medium size, and reflect both the larger and smaller ones; while the petals of a scarlet geranium absorb the small undulations, reflecting only the medium and larger ones. But why should this difference exist in the absorbing power of the flowers?

Here is the *crux*, which is still a crux in spite of the much-lauded hypothesis of insect selection. Insect selection may account for something, but there is much more for the explanation of which it is quite unavailable. The supposed all-sufficiency of this hypothesis is completely answered by the fact that insect selection cannot come into play at all in the production of color until the plant has already shown its power to produce that particular color quite independently of insects. It is evident that the color is due not to insects, but to some inherent capacity of the plant, and that a plant which could produce a small pink petal could equally well produce a large one under suitable conditions. The utmost that can be claimed for insect selection is that it may accelerate the production of the large and showy petals by giving to the plants which show their tendency to produce such petals better opportunities of developing that tendency. The crucial question remains, What is it which gives to a plant this tendency to produce colored petals?

There are two fundamental laws of nature which, in the attempts to solve this question, have not been sufficiently regarded, viz., (1) the law of the concentrating wave, and (2) the law of sympathetic vibration. By studying the action of these laws, it seems possible to carry the solution at least one step further back from the position in which it now stands.

We are familiar with the simple wave of oscillation, as in the pendulum; and also with the wave of undulation, as in sound, light, and the spreading rings upon the surface of water; but the wave of concentration is less familiar to us, and has been less carefully studied.

All organisms are illustrations of this particular wave-form. As the kinetic energy of the swinging pendulum increases as it approaches the centre of its curve, and then again diminishes, so the energy of the organism increases as it approaches the climax of its life, and then diminishes. But, while the swing of the pendulum is a simple process, involving merely the alternate change of form of a given amount of energy, the growth of an organism is almost infinitely complex. The accumulation of energy which this growth represents takes place slowly and intermittently by the drawing-in of outlying units to a centre, the energies of these units being aggregated and assimilated to the forms of the original germ. This accumulation of energy continues, if not violently interrupted, until a certain definite degree of concentration is attained, after which a gradual dispersion of the energy sets in until the organism dies of old age. All organic individuals have a limited period of life, and pass through a similar series of periodic changes, gradually attaining a climax of concentrated energy, which is afterwards gradually dissipated. The ascending and descending phases of the wave are rarely equal, but probably always equivalent. One may be long and slow, the other short and rapid, or *vice versa*. The variations in this equivalence may be almost infinite.

It is clear that this law of the concentrating wave controls the life-history of every individual. It is not so demonstrable, but is, nevertheless, highly probable that the same law controls the development of species, genus, order, and class, and is, in fact, the fundamental law of the unfolding universe, at all events, of the organic phase of it.

What is the relation of this law to organic color?

Let us assume the general correctness of the molecular theory as the nearest approach which science has yet made to an explanation of the structure of matter.

Throughout all substances in which the temperature is above the point of absolute zero, as in all living organic substances, the molecules must be in continual motion. But, being linked together by powerful "affinities" (whatever these may be) into definite groups, and in all solid bodies packed very closely together, their motions cannot be altogether free. There must be certain directions in which they can move, and certain others in which they cannot move; and the group of motions possible to them will differ in each compound chemical substance. There will be a definite group of motions possible to the molecules of albumen, another to those of starch, etc. There will also be a definite but more complex group of motions possible to the totality of molecules which make up each kind of tissue, as skin, muscle, bone, nerve, etc., and a still more complex group possible to those which make up each organic individual. This characteristic grouping of possible motions may be called *molecular rhythm.*

One of the specific functions of organized matter is that of assimilation and growth. There is no organism which can assimilate matter of every kind. The power of selecting food depends upon the molecular rhythm of the organism. Substances whose molecules have possible motions which harmonize with those of the feeding organism can be assimilated and made to add their energies to the stock of that individual, causing it to "grow" in size and in accumulated energy. Substances whose molecular rhythm will not allow of such assimilation are not available as food for that organism.

The organism continues to feed, to assimilate, and to grow, in accordance with the law of the concentrating wave up to a certain point, but there is a limit which it cannot pass. Having reached that limit, concentration ceases and dispersion sets in. What determines that limit?

The phenomenon of growth is not a passing function, not a mere reception and assimilation of energy. Every organism is more or less active and parts with energy as constantly as it receives it. Growth is the result of the balance between these two processes. As long as the organism assimilates more energy than it dissipates by its various activities, growth continues.

The limiting-point is that epoch in life at which assimilation becomes so small as to be overtaken by the dispersion. But what diminishes the power of assimilation?

The molecular rhythm of any organism is necessarily of limited compass. In the embryo only the main chords are struck; the molecular motions are comparatively free, and some amount of modification is then possible. But, as the intervals are filled up by the harmonious motions of the assimilated molecules, the rhythm becomes fuller and, at the same time, more fixed, till a point is reached at which little more permanent assimilation is possible. This is the climacteric of the life of that organism. The limit is determined by the original outlines of the molecular rhythm in the embryo, slightly modified by the amount and the quality of the food assimilated during growth.

We have now to consider the action of the law of sympathetic vibration on the growing organism.

A tightly stretched wire may be made to give out a musical note by sounding near to it a certain note on a violin. The group of vibrations produced in the violin is communicated to the air, and the air communicates it to the stretched wire. It can only do this if the condition of the wire is such as to make that group of vibrations possible to it. If only some part of the group is possible to it, it may take up that part and reject the rest. This is a case of molar, not of molecular, vibration, but the same law operates in the case of the molecular vibrations of radiant heat and light, which are communicated through the ether. Such of these vibrations as are possible to some of the molecules of the substance receiving them will be absorbed, while the rest will be transmitted or reflected. The energy of those vibrations which have been absorbed will go to increase the amplitude of the vibrations by which they have been assimilated. They do not, as in the case of food, introduce fresh molecules with harmonic vibrations which occupy vacancies in the established rhythmical system, but they give increased force to certain existing vibrations, and thus alter the balance of forces in the established system. The vibrations so reinforced will acquire a more or less controlling influence throughout the total group, and there will be a tendency among the vibrations of less energy to fall gradually into the swing of these controlling vibrations. Thus the molecular rhythm of the total group may become modified within certain narrow limits by the light in which the organism lives, if that influence is continued for a sufficiently long period, as well as by the food which it assimilates.

It is evident that the tendency of the action of these two laws — the law of the concentrating wave and the law of sympathetic vibration — must be to enhance the energy of the original molecular rhythm of the embryo, to make it fuller, richer, more definite, and less capable of further modification as it approaches its climacteric, while, at the same time, it is simplified and cleared of a number of vibrations differing only slightly from the controlling ones, by the bringing of these gradually into unison.

The bearing of these results upon organic color remains to be discussed.

It is a well-known physiological rule, with possibly a few exceptions, that organisms in their embryonic and early stages are less brightly colored than they afterwards become. This is plainly seen in the young of birds. Germinating seeds are nearly always of a dull white, which means that about an equal, though small, quantity of every vibration in the sunlight is able to be absorbed. The color of the first leaves is the primary green, indicating that the plant, while able to absorb a larger proportion of the white light, is becoming less able to absorb the vibrations of medium size. As the foliage becomes developed, varied tints of green, with some reds and dull purples, are reflected, showing that there is a still less varied capacity for absorbing. Finally, in the blossom of the higher orders of plants, of which the color is nearly always some shade of the brilliant secondary hues, scarlet, orange, yellow, blue, or rose, it is evident that a great simplification of the molecular rhythm has taken place, so that the absorption is chiefly confined to one group of the light-vibrations, while large proportions of the other two are reflected.

This process of simplification in the molecular rhythm, as the concentrating organic wave approaches its climacteric, may be traced in various phases of vegetable and animal life. In a flowering tree or shrub there are three great systems of structure, viz., the stem and branches, the foliage, and the inflorescence; and these represent three stages of advancing development and vitalization. The color reflected by the system which stands lowest in the scale, the stem and branches, is generally dull green, brown, or plum, indicating that nearly all the light which reaches them is absorbed. In the uniform green of the foliage a certain amount of simplification is shown; and in the brilliance of the inflorescence we see the greatest simplification attainable by that species.

Those families of plants in each great class which have the lowest organization display, as a rule, the least color. The Coniferæ represent the earliest type of existing trees, and are nearly all sombre in coloring. The Amentiferæ stand next, and, though brighter in foliage and much more varied, do not attain to colored blossom. The numerous orders of "flowering" trees and shrubs are of most recent origin, and represent the highest phase of development in the great concentrating wave of vegetable life. The fern form is a very ancient one, and has never, even to the present day, developed much in the way of color. But, if it be true that the recent Monocotyledons are derived from the ferns, they may represent the simplified condition of the fern wave, and among them are many of our most brilliant flowers. The Fungus form must probably be an ancient one also, and among recent Fungi many brilliant hues are developed, which can have no connection with insect choice.

In the large class of birds, the Ratitæ (ostrich, emeu, rhea, cassowary, and apteryx) are the nearest to the reptilian type, and are all dull in color, with the exception of the head of the cassowary, which may have a special explanation. The gulls and albatrosses, which seem to stand next in order of development, are brighter in plumage, but with very little trace of the secondary hues. Brilliant color is almost confined to the more recent insessores.

Among mammals, the early types of elephant, rhinoceros, hippopotamus, hog, etc., are quite without color, while the Carnivora and the Ruminantia, more characteristic of the present epoch, have developed some warmer tints. The Mammalia, as a whole, however, constitute the most recent of the great classes, and it has not yet reached the stage of brilliant coloring. On the other hand, the Mollusca are extremely ancient, and among existing Mollusks a large number display the most brilliant coloring in all the secondary hues.

The final result of the foregoing argument is that the gradual development of organic color is a physiological necessity; that brilliant coloration is a mark of the maturity of some organic force-wave, in which the molecular rhythm has reached its maximum simplification; and that the effect of insect selection in the development of colored flowers is comparatively small.

The very curious appearances of mimicry, which are often supposed to be protective, but of which a large proportion seem to have no such function, may probably be attributed to sympathetic communication of the vibratory motions, which must be passing through the ether in all directions in the neighborhood of organic life.

An animal which spends its life in proximity to the brown bark of trees will be under the influence of the molecular rhythm of such bark, and may have its own molecular rhythm gradually modified by sympathetic action, or it may entirely resist such modification according to its fundamental molecular structure.

The possibility of sympathetic modification of weaker vibrations by a more energetic one, with which they are nearly synchronous, is clearly suggested by the action of a sensitive flame, which, while it is unaffected by vibrations which are palpably discordant, shows itself sensitive to such as are nearly, but not quite, in unison with it. An organism differs from a flame, as from a fixed string or a tuning-fork, in the fact that it is constantly growing, and the added molecules supply material which may be easily amenable to modification.

If the hypothesis here described should be found to explain satisfactorily the phenomena of organic color, the corollaries to be deduced from it will be far-reaching and of much interest, and will apply to beauty of form as well as to brilliance of color.

The world in its early stages must have been sombre and unlovely. The forests of the coal period, when the great Sycopods were at their climax, may have exhibited some brighter greens, with tendencies towards yellow or glaucous tints; the shells of the Amonites, in the Liassic seas, may have been colored to some extent; but the great concentrating wave of organic life in its progress towards an unknown climacteric must yield an ever-increasing glory of color and form to the surface of this planet.

The beauty of summer as we know it now, though it has never been paralleled in the past, will be as nothing to the blaze of brilliance which shall mark the summers of the future.

MINOR PHONETIC ELEMENTS OF MAYA HIEROGLYPHS.

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THE Maya graphic system, the earliest steps of which began as picture-writing, was the natural outcome of a desire to record knowledge made by a people who may be classed as the most intelligent and civilized of the American race. The language they used, monosyllabic and rich in homophones, is in fact quite as unique as the development attained in their graphic art in its progression from thought-writing to a certain degree of sound-writing, which has been denominated ikonomatic (D. G. Brinton; "Essays of an Americanist"), "writing not by things but the sound of the names of things." Scientific research has shown that there is less reason than formerly to doubt Landa's suggestion, and that of more recent authorities, in regard to its phoneticism, which is without doubt of a higher standard than has hitherto been supposed.

Dr. Cyrus Thomas has well said in a recent article (*Science*, Vol. XX., No. 505, pp. 197–201) that ". . . although we may know the chief phonetic element of each part of a compound character, we cannot interpret the whole. This will undoubtedly be true unless there are indications of the minor elements." Want of complete lexicons containing words that correspond to the archaic language of the hieratic and demotic script is also a difficulty which must be considered in the work of interpretation — yet with the almost insurmountable obstacles that exist, it may be said that progress has been made in the work. A study of archaic symbols and ideographs has been made in order to determine, if possible, how certain elements used in the Maya graphic art have been derived — in most cases, we think, from the animate and inanimate forms of nature, or from things invented by man for his necessities. In these researches we must not overlook the superstitious offices of early people in symbolizing ideas — basketry, pottery, and rock-scratchings affording many valuable hints of the changes from the nature-derived elements to the more conventionalized, used ideographically or as phonetic elements, be they chief or minor elements. The figures employed may have been in many cases mere conventionalities, but there is evidence in the work of the Maya scribes that the motives of this convention are based upon primitive realism — for they were but simple-minded children of nature, keen observers of her endless variety of forms, quick to adopt the motive she suggested where it could be utilized to serve a desired purpose.

That these assertions are not the outcome of mere theory we shall give, presently, a list from which we think have been derived what we deem to be phonetic elements of the Maya glyphs. Nature is the source from which have been derived the phonetic elements used by us in endeavors to interpret the Maya glyphs, and it may be said that the results are encouraging; the ideographic suggestion and the chief phonetic element having been obtained, recourse can be made to the "minor phonetic elements" — one analysis being a check to the other.

We have progressed far enough to feel sure that the Maya graphic system is based upon picture-writing, a necessary outcome in the progression of all graphic systems, from thought-writing to sound-writing. The majority of the glyphs, as we find them, whether hieratic or demotic, are associated with ideographs, many of these having combined with them phonetic elements which appear as glyphs or component parts of other glyphs — be they single glyphs or component parts of compound glyphs. An excellent example of an ideo-phonetic design is that of Hun Cimil, the god of the Maya hades (see plate C, Codex Peresianus, or Codex Cortesianus, p. 16). It will be remarked by consulting this first-named Codex, de Rosny's edition, that the abdomen of this figure is composed of the day-signs of Landa, the elements composing which, according to the analyses that we have made, are phonetic. In fact, we have found that sixteen out of twenty of the Maya day-signs, and many of their variants, are phonetic. We firmly believe that they will all prove to be phonetic when future study shall have demonstrated more exact methods of analysis. Between the legs are phonetic elements and the ideo-phonetic head (of a cayman?) to the right of the knee of the figure is connected with the glyph of Cimi. Around the ankles are designs that appear in the Codices, at times, as glyphs. The majority of the components of the head, arms, ornaments of the wrists, and the implements held in the left hand also appear as phonetic elements in Maya script. It is for this reason that the term "ideo-phonetic" has been used for the drawings, as they are composites conveying ideographic suggestions — the ideograph itself being intermingled at times or composed of phonetic elements that appear, as we have said, as the component parts of other glyphs. (See figure of Hun Cimil, pp. 53, 15, Cortesianus; p. 14, Tro., also, ibid, 3, 29, 14, 34.) Hundreds of other examples might be quoted, but as they abound throughout the Maya graphic system this will not be necessary.

The following list will indicate the animate and inanimate forms of nature and inventions of man which, it is thought, suggested certain phonetic elements of the Maya graphic system, viz.:—

Sky	Animals	Head	Huts
Sun	Birds	Eyes	Houses
Wind	Fish	Nose	Idols
Water	Reptiles	Jaws	Implements of war and of the chase
Lightning	Insects	Mouth	Clothing
Earth	Appendages of animals, birds, insects, and crustaceans, etc.	Teeth	Ornaments
Fire		Ears	Pottery
		Tongues	Colors
		Arms	Grinding-stones, etc
		Hands	Tortillas
		Feet	Maize
		Thighs, etc.	Honey, etc.

At a future time examples will be given of analyses of the Maya glyphs, the ideographic suggestion of the glyph, if any, and the drawings which accompany them, together with minor phonetic elements being considered. To give examples in this article, already longer than intended, will be impossible. The results obtained from the list to which we have assigned certain phonetic values, and used in interpretation, are encouraging — proving to our own satisfaction that minor phonetic elements undoubtedly exist in the Maya graphic system. These minor elements have in many cases been considered as meaningless decorations, component parts of ideographs. Many of the minor elements are so combined together that they are difficult to trace. Errors and omissions of the Maya scribes at times increase these difficulties and require especial study and aptitude for such analyses.

The colors, red, yellow, and black, seem to be used in the Peresianus, with phonetic and ideographic value (see plates xxiii. and xxiv.), and are combined at times with the minor elements of the glyphs. It is probable that colors are also used with a certain ideographic and phonetic value in the other Codices. Interesting combinations are to be remarked in the connection of the consonants with the vowel sounds, Landa suggests *ma, me, mo*, for the phonetic value of a certain glyph, and this method of assigning several phonetic values to a glyph is quite common; determinatives in many cases being used to indicate the value intended. Where these determinatives are wanting it is necessary to try the principal phonetic element through the vowel sounds. The principal phonetic value is, however, generally given by the minor elements of the glyph.

If the system and list of phonetic values adopted by the writer in the interpretation of the Maya glyphs, be correct, it suggests a higher standard of phoneticism than can well be accorded to a people, who, though the most highly civilized of the American races, were, we are to suppose, but an Indian people. Judging