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THE UNITY OF LIFE[1]

HUMAN kind is slow to learn; what it acquires in one generation it loses in the next. Great truths evolving from everyday experience make but difficult way into the consciousness of the average person and eventuate but seldom in guided action. Nations rise and fall into decay and others follow the same course to the same end without profit from the evil example. For every generation and every individual, constant repetitions of the most elementary truths are required to save them from destructive courses. A mental cataclysm such as the recent war brought upon us is followed by questionings of all faiths and beliefs and even of evidences. All the old superstitions and instincts suffer a recrudescence. Intolerance and ignorance, but lightly held at bay even under the best of conditions, insinuate themselves anew into the thoughts of people and color their acts. Impulses which, in our pride, we thought were eradicated from the human mind rise out of the murk of the past and obtrude themselves upon our startled vision. The very foundations of civilization are indeed shaken in some countries.

Little wonder then that amid all this questioning and striving the conclusions of science are brought down into the dust of the market place and made the playthings of the ignorant. At a time when science is proclaimed the chief reliance of organized society in securing its perpetuation; when through its ministrations human life is materially lengthened, made more effective and enjoyable; when the uncertainties of existence and the terrors of the unknown are yearly being reduced in significance, then we witness the paradox of vicious and unreasoning assaults upon the methods and conclusions of science by legislative enactments to cripple its progress and to limit its teaching. It would seem from all this that science is in our day and generation, but not of it. This is no doubt largely the fault of scientists who have ever been inclined to become absorbed in the pursuit of knowledge and to manifest little concern with the use that is to be made of it. In extreme cases there are men who take pride in the thought

[1] Address given on the occasion of the installation of a chapter of Sigma Xi at New York University on March 20, 1926.

that no apparent application can be made of the results of their studies.

The time has come for a change in the relation of science to society. If indeed this knowledge is sound, if it represents reality and mirrors truly the circumstances and conditions of life, then it must enter into life and become a part of life. While it is important that knowledge be applied and made useful it is vastly more important that the method by which this resource is gained be made the habit of thought in daily living. Other civilizations have equalled or exceeded our own in art, literature and philosophy, but within a century we have learned more of the conditions of existence and have acquired greater control over them than have the peoples of all preceding civilizations. But what has been accomplished is only a beginning; the heritage of conscious participation in the order of nature remains largely to be won. That it can and should be won appears certain from what has already been accomplished. The chief assurance here lies in the demonstration of the efficiency of the means by which we have reached our present position. The so-called scientific method, which is only a refinement of the common-sense way of attacking any problem, is so obviously the proper way of relating ourselves to reality that its continuous application and development is definitely indicated for the future. Real progress in any human endeavor is dependent upon its use. Were it universally applied, society would be changed over night from a struggling, incoherent thing into a purposeful and directed movement forward toward our ultimate heritage.

Of all the contributions of science toward such an end no more unifying and fruitful a principle has appeared than the one which is commonly called the theory of evolution. Within half a century it changed entirely the method of thought of all civilized peoples. For a conception of blind chance and cataclysmic, destructive changes operating upon the earth and its creatures, there was substituted one of law, order and continuity. In a surprisingly short time this new view established itself in the minds of practically all scientists. Soon it made its way into the thought of other intellectual groups and finally became the guiding principle in all serious efforts to explain relationships on the earth.

And yet there was nothing new theoretically in this conception. Over and over again it had been suggested in opposition to its alternative of chance and cataclysm. This time, in the hands of Darwin, it became definitely established, not through speculation or the weighing of probabilities, but by actual observation and the accumulation of facts. To explain facts that he and others disclosed there was no alternative conception. The explanation remains a theory because it applies over extensive periods of time, of which we can have but brief personal experience. Only by long-continued observation can the mass of facts be made so complete that all doubts are removed and the theory becomes merely a complete statement of actual conditions or a law.

It is natural that in so comprehensive a thought as was presented by Darwin there should arise confusion between the principle involved and the explanation of its operation. The essential element of the evolutionary theory, whether applied to the earth itself or to its inhabitants, is that of continuity. Lyell, the geologist, demonstrated that the surface of the earth had not been formed by a succession of violent disturbances, but that it is constantly undergoing change, and, by the operation of these changes over long periods of time, all geological phenomena can be explained. Darwin applied the same conception in explanation of the varied forms of animal and plant life. That is, he conceived them to be, not so many separate creations, but a series of related forms having much in common, but showing differences due to time and to the reaction between themselves and their environment.

It is not my purpose here to enter into a discussion of the theory of evolution. I desire rather to ask your attention to a series of facts upon which the theory is based. I shall also depart from the usual method of presenting structural differences and relations and will review some fundamental conceptions of organization and function showing the unity of all forms of life. The discussion will, therefore, primarily concern itself with known facts regarding plants and animals, *as they now exist,* and not with speculations about how they came to be as they are.

We speak naturally and without effort of life—the unity of its nature and manifestations, as contrasted with the inorganic kingdom, is clear in all minds. Without knowing what, in reality, life is, we are so familiar with it through our own experiences and observations that we readily comprehend its range and significance. The term connotes all living things, large and small, simple and complex, plant and animal, ourselves included. There is no effort to exclude any extremes, high or low, from the all-inclusive designation which distinguishes the living from the non-living. It is this reality then that we wish to consider; it is into the nature of its unity that we would inquire.

Here perhaps the most striking thing is that life is not "without form and void" but is a very definite and concrete thing which always manifests itself through discrete units which we call individuals or organisms. It is possible to conceive living matter acting in formless aggregates of indefinite mass and consistency, but no such conditions obtain in nature. The properties of life are those manifested by and through the harmonious cooperation of the differentiated parts of those highly characteristic complexes called organisms. But these entities do not constitute an infinitely graded series—they occur in groups the members of which show a greater resemblance in form between themselves than they do to members of other groups. Again, groups of the first order exhibit graded resemblances and constitute together a chain of forms passing from the very simple to the highly complex. It is to account for the relations of these kinds to each other that the theory of evolution was formed, and the basic assumption of this theory is that all organisms are essentially of a kind. Since the theory is to explain the origin of diversities it is natural that discussions regarding it should concern themselves with differences rather than with the underlying unity of which they are varied aspects. While, therefore, these diverse units differ endlessly in their form, they are only so many mechanisms for the performance of a definitely limited number of activities or functions.

Life, from this viewpoint, may be defined as a series of definite reactions between organisms and the physical universe in which they are placed. As the living units differ in various ways so do their common reactions in time, rate and degree, but in their fundamental nature they are similar. It may be well here to remind ourselves of the universal processes of life. First, we recall the unique capacity which living things have of taking foreign materials into themselves and transforming these into their own similitude. The plant, drawing in from the air the gas, carbon dioxide, and from the ground, water and certain salts in small quantities, by aid of sunlight combines these into food and then into plant tissue and in a year produces in one case a sunflower plant of ten feet in height, or by successive additions through centuries, in another builds the giant sequoia. The oceans swarm with minute plants which maintain themselves and grow in essentially the same manner. Directly or indirectly these are used by fish as food and becomes of their substance. At our tables the fish is consumed and converted into human flesh. The substance which I burn in my brain cells contriving the thought which shall picture to you this community of nature may be replaced by the converted flesh of the fish which recently swam in the Atlantic. Sooner or later, however, all living things draw upon the inorganic kingdom for the materials with which they build or replace waste, in order to maintain themselves and to grow.

Dependence of organisms upon this external world for all building and repair materials necessitates the possession of exact means for perceiving and appreciating the presence and character of these materials. Adjustments of many and varied character with the environment, inorganic and organic, demand the presence of these perceptive faculties. Because of a certain inherent property of irritability residing in living matter and specialized in various directions, reactions take place which serve to adjust the organism to the conditions under which it exists. While these reactions are specific in character in each case, they are fundamentally similar throughout. You pinch the leaf of the sensitive plant and it promptly closes; step upon the tail of the sleeping cat and the effect is much more immediate and vigorous. In each case an adverse condition, through the property of irritability, provokes a protective response. Continued adjustments to conditions of light, heat, sound, chemicals, etc., are the ever-present requirements for existence which make themselves known through this property of irritability.

It is not enough, however, that external conditions be perceived and appreciated—proper responses require spatial adjustments. The organism to reach the food it perceives or to escape a foe must be able to move appropriately. Thus we find that all animals possess within themselves some power of contractility, which, properly applied, results in movements. Plants generally have this response less highly developed, although it is present. The mechanisms by which animal movements are produced are extremely varied. There is the slow flowing progress of the protoplasmic blob, called the amoeba; the active darting of the slipper animalcule by means of countless vibrating hairs; the graceful rhythmic pulsing of the Medusa; the lightning flash of the squid with its reversible hydrostatic projector; the varied forms of fins and paddles of fish, amphibians and reptiles; the jointed limbs of insects, birds and mammals; the crawling motion of worms and snakes; the graceful winged flight through the air by insects and birds—these and countless other means of spatial translocation are all due to a common power of contractility inherent in protoplasm. These endlessly varied structural forms, expressing each in its own way an effort to set up a mechanism for producing motion, all owe their operation to the fundamental property of protoplasmic contractility.

But of all responses of organisms to their environment the one which continues the existence of the species or group by reproduction is most striking and characteristic. Not only does the individual maintain itself amidst all the vicissitudes of life, but it provides for the continuation of its kind. Indeed, this impulse often transcends all those making for self-preservation, and the individual life, which has cost so much effort to establish and maintain, is unhesitatingly sacrificed for the young it produces.

Most remarkable, indeed, is this power of individual reproduction—the multiplication in almost infinite numbers of the same form of protoplasmic organization. Given an unvarying environment it is conceivable that any form of organic structure might continue through infinite time to perpetuate itself. Even with the tremendous changes through which the earth has passed since life began upon it, there are now living forms of animals that began existence millions of years ago in the Cambrian period. And yet it is certain that in all this innumerable host no two such individuals were exactly alike. Reproduction shows always the paradox of likeness and unlikeness. The extent of unlikeness, or variation, in reproduction is a property of each individual form, and in this may differ from time to time and under changed conditions. Since wide variation from type means extinction, it would seem that reproduction is exact, but this is a superficial view and takes no cognizance of the immense losses during development. The possibilities of variation are great in many forms that appear exact in reproduction. Thus, for example, all insects have six legs, but certain strains of flies, under appropriate conditions, may be made to produce individuals with twice this number. In this case temperature determines whether an individual shall be like all other insects in its number of legs or whether it shall be a new kind with a double set.

Thus we see that all living things make a like series of responses to the conditions under which they are placed—in other words, they are adapted to their circumstances of life. These physical conditions differ in many respects, to be sure. Some organisms live in water, some on the land; some are fixed and immovable, others have great powers of locomotion through the air or water or over the land; some love the light, others shun it; what is one man's meat is another man's poison and so on. The range of adaptation in each case is definitely limited, but within this we note that the character of the response determines the character of the organisms.

There comes a time for each form of life when conditions may pass beyond the power of adjustment and extinction follows. Millions of different species have thus finally disappeared and are known only by their fossil remains—how many other millions have passed leaving no record is beyond guess. In a given case some very small cause may be sufficient to terminate existence, while other forms thrive. But when all is said and done the circumstances that determine the existence of all life are very narrow. Should the light of the sun fail us the earth would soon be lifeless. The removal of water or carbon dioxide would produce a like result. Indeed, as Henderson has shown, only the peculiar properties of these compounds, among all physical and chemical conditions on the earth's surface, are competent to meet the requirements of living things.

There is here no choice as between ourselves and the lower animals. Our lot is their lot. We stand or fall with them. Remove one of the essentials of life and we perish as miserably as the lowest creeping thing. We differ only in our capacity to understand and to take advantage of circumstances, but our nature and requirements are the same as those of all life.

There are many interdependences in life, so that it seems a very diverse affair. Thus only the green plants are able to take their food directly from inorganic sources—they constitute the immediate contact between living and non-living things. Animals, either directly or indirectly, feed upon them. Carnivorous animals could not live were there not herbivores to transform plant tissues into an appropriate food. There are a great series of symbiotic and parasitic relations which are absolutely essential at the present time to the existence of many kinds of organisms. Some plants require brilliant sunlight, others live in the dark; some grow in hot springs, others in water from melting ice; some are found only in desert regions, others thrive in an atmosphere saturated with water.

These many apparent diversities are, however, only modifications of a common series of conditions. Water is an absolute essential to every form of life—the method by which it is applied may vary greatly. Oxygen for the consumption of waste products is a necessity whether it is taken into the blood from the water through gills, or from the air directly by means of tracheae or lungs. The same requirement is made by plants.

In addition to these basic, underlying similarities in the reactions of all living things, there are others of more limited range, but of great consistency where found. Thus in the higher animals there are a series of psychic responses, eminently characteristic of advanced development. These, in most cases, can be traced back to more primitive states in lower forms. Hunger, the desire for food, is always present; love, the attraction between individuals, particularly of opposite sexes, is almost universal; fear, the impulse to avoid what is inimical or dangerous, finds expression almost as commonly. How impelling are these impulses and how they link us to the brutes we are often unpleasantly reminded when conventions fail and we are faced by primal conditions.

How is it, then, if there be such an underlying similarity of character in all organisms, there should exist such a diversity of form? This question looms large in all considerations of organic relations. The derivation of one form from another is the central element of evolutionary theories; the separate and independent production of each form is the essence of cataclysmic theories. Form, however, is only an expression of functional capacity. As we have seen, all manner of organisms have been able to sustain themselves under practically identical conditions, by the performance of a like series of processes. The rate, degree and character of these activities are very different, however, and are dependent upon the structures which perform them. Light perception is common to most organisms, but the formation of a perfect image is possible only in the presence of an organ like the vertebrate eye. Some sort of coordination of functions is accomplished by the central nervous system of all animals, but extreme precision is possible only under the operation of a well-developed brain. Speculations regarding the plan of nature and the place of different forms of life in it waited until a human brain was formed. It is of greatest significance to note that not only is there a common series of processes in all animals, but that, for a given one of these, a definite portion of the body is set apart for its special performance. This part is most alike in forms most closely related, *i.e.,* in a species all members are so much alike that they are sometimes individually indistinguishable, while small differences appear in closely related species and larger differences as we depart further. Structure then marks the degree of functional capacity and all the varied forms of life are expressions of a series of functional developments. It is quite as useless to separate a consideration of structure from function as it is to attempt a consideration of organisms apart from their environment. Since, however, the measure of performance is so well expressed in structural mechanisms it is right and proper, as well as expedient, to measure organic relationships in terms of structural complexity. But for our present discussion we may note that in the face of the overwhelming diversity of forms producing species by the millions, there prevails throughout the operation of a limited number of processes common through all the diversity. Complexity of mechanism is then the visible evidence of underlying specialization and refinement of the all-pervasive and essential functions of living matter.

The essential unity of life, so well indicated by the universal exhibition of a few fundamental and necessary functions, is marked also by a structural character, likewise practically universal in all organisms and therefore strongly suggestive of a common nature. From earliest times thoughtful men tried to conceive the intimate nature of their bodies. It was readily perceived that they are not homogeneous, for bones, muscles, tendons, blood, etc., were readily noted, but the question is insistent; is there something more elementary back of all these things? Not until the human eye was strengthened by the invention of the microscope was this question answered. Then it was found that there are elementary structural units out of which the body is composed, and that these are the building blocks of all organisms—plants and animals alike. They differ between themselves in form and size, and by the modification of a common series of parts, great diversities occur, but fundamentally these units, or cells, are essentially alike and there is already a new science, cytology, which considers the nature of cells in general and the peculiar modifications of various types.

It would be quite impossible to overestimate the significance of the fact that all organisms have a common structural unit, because it means that the operations of living things can be analyzed in terms of the functions of cells. Different functions are found to have their own peculiar modifications of the cell, so that we study, for instance, the contractility of muscle by observing the form of the cell which is the unit of muscle structure. In turn we compare the contractile cell with the one which has been modified for perception of stimuli or for secretion or for support. Thus we learn that the external visible differences in the bodies of plants or animals represent the summation of internal cellular specialization, designed to exhibit in a marked degree one of the general properties of living matter possessed in common by all cells. Roughly, the condition is comparable to what an architect would find in the study of the structure and properties of houses if they were all built up of bricks of various kinds, each designed in size and shape for a particular purpose. Certain of these would be fitted to form the outer, protecting walls; others would be adapted for the finish of the interior; still others would be shaped to produce tubes and ducts and so on. One familiar with these conditions could then recognize from what part of a house any form of brick was derived, and if the parallel held, could identify the particular kind of house in each case.

This would be interesting and remarkable enough, but it is simplicity itself compared with what we find in living things, for here every plant and animal at one stage of its existence consists of but a single one of these units or cells. There are always specific differences at this time, but they are often so minute as to be entirely indistinguishable. A man at this period of his existence differs in no recognizable way from the meanest beast of the field at a corresponding period and in only minor ways from the grass upon which it feeds. The unity of living things is indeed most complete at this time.

But each of these kinds of temporary one-celled organisms has its own inherent character which becomes revealed by a series of processes much alike in principle in all animals and, to a lesser degree, in plants as well. A common start and a common series of processes reveals in the end inherent though invisible differences, and a man emerges in one case and a beast in another. Step by step in development complexity increases and diversities appear, but after all what we witness is the modification of a common series of structural parts principally by refinement and increased complexity in the higher forms. Starting as one cell the individual becomes two-celled, then four, eight and so on until millions and millions result. These cells present in each case a definite arrangement at each stage and inevitably emerge in a complex, whose pattern, to the most minute details, is like that of other members of that group of organisms. Cells appear, take their position, become modified in form, reproduce themselves, become coordinated with unlike cells and so build up the incomprehensible complexity and unity of the individual.

Now it must be remembered that these cells are microscopic in size; therefore, the field of operations and the mass of material involved are exceedingly small. Yet with the microscope we can discern an inner organization of exquisite beauty and nicety which may be traced to finer and finer details until the limit of our observational power is reached. Undoubtedly this continues even to molecular structure. But here again the phenomena are coextensive with the immense variety of life. Studies made upon plant cells are used as a basis for generalizations applying as well to animals. Diversity always, but equally, unity.

Nowhere perhaps in all nature is the community of her forms more impressive than in the orderly movement of the microscopic cellular parts wherever found. Particularly is this true when we consider those cells which are designed for the specific function of reproduction. The very fact that in multicellular plants and animals there are certain cells set apart for the perpetuation of the species is a striking enough indication of the existence of a common plan governing the nature and operation of living things, but when the exact correspondence in most minute details is observed the conviction is overwhelming that only the strictest community of nature could account for such correspondences.

Since apparently we deal here with the attributes of living things in their simplest and most obvious common terms it may be well to examine into these conditions, even though they may present unfamiliar aspects and involve us in the discussion of facts beyond common observation. Let us regard then the beginning of an organism—any one will do, in principle, for all. This, it seems to me, is the clearest evidence of the unity of life that we find on all the structural side. Such a representative of all organisms, in its earliest stage, is a single cell formed by the union of two cells—one derived from an individual with female qualities and the other from one with male qualities. It is a microscopic, spherical mass of a transparent jelly-like substance, and, so far as any one but a person very familiar with this particular kind of cell could tell, might be any one of thousands of similar beginning organisms. It is, however, just as much of its own kind as the latter individual into which it develops, marked and characteristic as that may be, but at the same time is a representative of all organisms at this stage.

When we come to pry into the inner nature of this seemingly simple, one-celled individual, we find it unbelievably complex—the diversity of many and varied parts, later to appear, is here compressed into the apparent simplicity of a few parts, and there is no visible hint of their relation. The consol of a pipe organ is a comprehensible object of a purely mechanical nature—certain keys in a definite position, some stops and levers within reach and a cable of wires to the banks of pipes. Such an organ may be operated mechanically by a perforated sheet, and the musical effect will depend entirely upon the pattern of openings in this sheet. The correspondence between the mechanical guide and the resulting combination of musical notes is, of course, exact, but is in altogether different terms, and can be understood only if the relations of all the parts are known. In a remote way this indicates something of the relation between the undifferentiated egg and its product. It possesses a pattern of its own, which, playing upon the common properties of the living substance, produces inevitably a certain combination of the parts common to living things. This guiding pattern of the egg is indicated by recognizable inner structures, but the nature of the correspondence is not known. Our only hope for knowledge of developmental processes lies in a study of this cellular pattern and already we have made some progress.

Now we have seen that all life represents a series of common reactions to a somewhat common environment; that it is exhibited through a wide range of structural mechanisms; and that all these varied structural forms are made up of a common structural unit. We have next to note more in detail the statement already made that these common units are constituted of a common substance—protoplasm. Indeed, all the series of activities which run through the manifold forms of plant and animal life, and bind them to unity because of their likeness, are only the functions of their constituent substance. This, as Huxley termed it, is "the physical basis of life." Much is known of this protean material, but its vital characteristic remains unknown. Why a particular form of combination of a limited number of ordinary chemical elements should produce a compound capable of metabolism, perception, movement and reproduction in all their manifold aspects yet remains a mystery. In inorganic substances there are certain analogies to the properties of protoplasm, but they remain analogies and exist in no such combination or degree as characterizes living matter. The physical forms of some plants and animals may be simulated by minerals or salts; the phenomenon of irritability has a remote counterpart in the varying responses of metals to heat and to physical stress; movements of various sorts occur in non-living substances; but nowhere in the realm of the inorganic do we find the capacity to take up foreign substances, and to make these over into the varied materials characterizing a given substance so that they compensate for a specific loss or add a specific gain. Above all only protoplasm has the power to so enlarge and organize a given microscopic bit of itself as to produce an aggregate similar to the one from which it was derived—an organization frequently of the most incredible precision and complexity.

No; protoplasm is unique—it is as yet incomprehensible, but its coextensiveness with the phenomena of life is certain. From the dust of the earth it must have come, because in it are only the elements of the earth—there is nothing there which is exclusively its own—but how the divine fire fused these into so wondrous a form, that phase of it which composes the human brain has not yet been able to conceive. Since, however, the constituent chemical elements are not unique, the inherent peculiar properties must be sought in the arrangement of the elements. At once we find that protoplasm has many of the characteristics which chemists recognize in that large group of gummy, glue-like substances they call colloids. Time does not permit a discussion of the nature of colloids, but it is sufficient for our present purpose to note that protoplasm, from whatever source derived, exhibits many of the properties of these substances. That is to say, there is unity in the chemical nature of all protoplasm.

There are many ways in which the unity of protoplasm shows itself aside from the broad likenesses physically and chemically already mentioned and in the general physiological functions which are its attributes. Some of these are of such a nature as to indicate that the interdependence of the differentiated protoplasmic elements set up in one kind of an organism exist in others. For a very long time it has been known that the varied activities displayed by the organs and systems of an individual are made to work in order and harmony through the integrative action of the nervous system. Much more recently it has been learned that there is, in back-boned animals, at least, another system with somewhat the same office. There are a series of glands known as ductless glands, each producing a characteristic secretion and having a specific action. Two of these, situated in the neck region, and one at the base of the brain, have much to do with the rate and character of growth. Sometimes these become diseased and thus betray their relation to growth.

Because of external conditions the inhabitants of certain regions are often subject to insufficiency in the action of one of these glands—the thyroid. In such cases growth is disturbed and hindered and individuals known as cretins result. Body and mind both are distorted and an otherwise normal individual is condemned to be a misshapen dwarf and idiot—all because a certain part of his body failed to supply an essential element of growth. Now if all organisms were unlike, or if man stood apart in nature, such a case would be hopeless unless the missing substance could be contributed by another man, for here is a protoplasmic product of a very specific sort so potent that only minute quantities make all the difference between normal growth and idiocy. But let such a prospective cretin be supplied during growth with the thyroid substance from whatever source and he puts aside the fate of mental inadequacy and becomes a normal man. The capacity to take from the environment certain substances, the function of a particular part of the body, lacking in man, is assured by supplying a substance elaborated in a similar part of the body of a sheep, a whale or what not. The difference between normal human mentality and its opposite is thus measured by the contribution of a lacking part by one of the lower animals.

Along with the evidences of a community of nature throughout the animal kingdom there are indications of graded relations quite as marked. These are very interesting because they give a scientific basis for the ancient conception expressed by the term "blood relations." Why it was ever supposed that the character of the circulatory fluid would betray relationship I do not know, but it turns out to be a fact. This evidence of protoplasmic specificity is of two sorts. First, there are the investigations of Reichert and Brown upon the form of haemaglobin crystals from which it appears that different kinds of animals are marked by characteristic crystallographic types and that forms conceived by other criteria to be related are found to have geometrically similar haemaglobin crystals. Thus we have in the blood of all the higher animals a peculiar substance whose vital function it is to take the oxygen from the air and make it available throughout the body for the burning up of materials to produce energy. They are alike, or related as is shown by the common characteristic. Here is an evidence of relationship in a matter of fundamental importance. The common characteristic of vertebrate structure distinguishing a great series of forms, which, in turn, are of almost infinite variety in their modifications, is paralleled by the existence within their bodies of a common substance likewise exhibiting geometrical variations of its crystals in conformity with the variations in body structure.

Then there are those subtile distinctions, comparable to the most delicate chemical tests, displayed by the reactions of soluble substances in the blood plasm. These are extremely varied, but highly specific so that it is possible to detect the presence of any form of protoplasm in much the same way as the chemist identifies inorganic substances. By these precipitin and agglutination tests not only are particular protoplasmic forms recognized but the degree of specificity indicated. Thus it is possible, for example, to say that a certain sample of blood is not from a dog or a horse, but whether it is from a man or an anthropoid ape can not be told with certainty, so similar is the character of reaction. The highly exact nature of these responses is indicated by the phenomena of immunity. Here a given kind of protoplasm, gaining access to the circulatory system of a foreign organism, provokes changes which produce certain antibodies which, in the future, inhibit the repetition of this action. These antibodies introduced into the body of still another kind of organism also protect it from the reaction. In every case, however, the result is specific and immunity against one kind of protoplasm confers no protection against others. These tests show us, first, that the protoplasmic substances of different organisms are specific in their character; and, second, that the relations between them are not discontinuous but graded. They identify particular kinds of living substances on one hand, and show their positions in a series on the other. With wide enough variation, no reaction occurs—between organisms shown to be nearly related by community of form the effects approach uniformity—which is only another way of saying that the form of the body is an expression of the character of the substance composing it.

A most striking example of protoplasmic relations is shown in the phenomena of anaphylaxis. In producing antibodies for a foreign protoplasm, the substance is introduced into the blood in successive doses until the effect is complete, the reaction becoming gradually less. If, on the contrary, only a small injection is given and then no other for an interval of ten days a second injection may then produce violent and fatal results. The first introduction of the foreign substance, instead of conferring an immunity, sensitized the individual to the alien material and results, on the second dose, in a reaction of such intensity as sometimes produces death in a very few minutes. The sensitivity produced by the first dose is specific, that is to say, a particular kind of protoplasmic substance in minute amount produces upon another an effect, the presence of which is demonstrated by the anaphylactic response. Like the precipitin reaction this is an indication of the highly developed specific character of different protoplasms and their products.

If chemists are justified in the identification of particular substances by their reactions and of grouping these by similarities, thus shown, biologists are equally justified in taking as evidence of specific character the occurrence of precipitin and agglutination reactions, the production of immunity and the constancy of crystal form in the red coloring matter of blood and of establishing relations through the degree and character of resemblances they exhibit. Any one of these tests is highly suggestive, the concordance of all of them is convincing; and the exactness of their agreement with the known facts of structure and behavior of the organisms from which they are derived is demonstrative on the one hand of the specificity of organic groups and on the other of their graded relationships. Specificity is always admitted—no one disputes the existence of "kinds" of plants and animals. A rose is not confused with a violet or a dog with a horse—their diversity of nature is our common experience. Subconsciously also we realize the community of their natures, because all of them we class as living things. We do not hesitate either, in these general terms, to ally ourselves with this world of living things, but when it comes to specifying degrees of relationship we may draw the line. While we may be quite willing to admit our derivation from the inanimate and formless dust of the earth we recoil from the thought of kinship with non-human forms even though they show likeness part by part to our own bodies and are made up of substances which, with most extraordinarily delicate tests, can not always be differentiated from similar ones within us.

Conceiving all those qualities which appertain to living things can we logically admit the specificity of groups and deny their relationships? Are these indeed not two ways of expressing degrees of relation? No two organisms are ever exactly alike. If we view the mass of living things and attempt to sort them into groups we take those most alike and call them one "kind," and another with slightly different concordances as another "kind" and so on. But no two people will agree exactly in their estimates of resemblances and differences. The groups are mental concepts, not realities. When one stops to consider the matter well, the astonishing circumstance about living things is not their diversity of form, protean as this may be, but the unity in the performance of a few common actions throughout this infinite variety of form. These functional characteristics are ever present and always observable—they are indisputable and convincing evidences of the common tie which binds all living things together—their operation, so precariously dependent upon a few, strictly limited physical conditions upon the earth, throws the fate of all into one balance. On the other hand, the continuity of form is not to be observed with any fullness. By far the greater number of "kinds" of plants and animals are extinct and of these only a few are known. Of the living, new ones are constantly being found. Our knowledge of the range and continuity of form must always be fragmentary. Form, indeed, is, in its nature, a matter of discontinuity; but function is continuous, always observable and susceptible of quantitative measurement. There is no escape from the conclusion that every living thing is kin by nature of its vital activities with all other living things. The unity of life is a reality. This is the important thing in all our thinking. We will always strive for fuller knowledge of the relations in time of the many forms under which life presents itself, but we do this in the realization that we can never know in full detail the whole story. It is beyond the compass of human experience.

C. E. MCCLUNG

UNIVERSITY OF PENNSYLVANIA

THE AMERICAN ASSOCIATION THE ANNUAL PRIZE AWARDED BY

IT was at the Cincinnati meeting, in January, 1924, that the first of its annual prizes was awarded by the American Association. Since that time two other prizes have been awarded, one at the Washington meeting, in January, 1925, and the other at the Kansas City meeting, last January, and the fourth prize in the series will be awarded at the approaching Philadelphia meeting in convocation week. The three awards thus far made are as follows:

1. To Dr. L. E. Dickson: Researches on algebras and their arithmetics.
2a. To Dr. Edwin P. Hubble: Researches on cepheids in spiral nebulae.
2b. To Dr. L. R. Cleveland: Researches on protozoan parasites of termites.
3. To Dr. Dayton C. Miller: Researches on the ether-drift experiment.

The sum of $6,000 was given to the Association, by a member who wishes his name withheld, to be awarded in six annual prizes of $1,000 each. Three future prizes are at present cared for. The second award was divided equally between two prizemen, as shown above, but future awards will not be divided. The award is made at the end of the annual meeting, to the author of some noteworthy contribution to science, presented in the program of the meeting. There is no competition in the usual sense. Because contributions in different fields of science are generally not commensurable, it is not intended that the prize paper is to be necessarily the best of the meeting. It is to be one of the very good ones. Membership in the association is not considered in awarding the prize and the programs of all the organizations that meet with the association at the annual meeting are considered, as well as those of the association itself. This feature of the meeting greatly increases interest and enthusiasm and it has clearly demonstrated the wisdom as well as the generosity of the donor.

The award is made by the committee on prize award, named by the council or by its executive committee. This year the membership of the committee on award is as follows:

C. E. Seashore, University of Iowa, Iowa City, Iowa, *chairman.*
Otis W. Caldwell, Lincoln School, Columbia University, New York, N. Y.
C. B. Davenport, Station for Experimental Evolution, Cold Spring Harbor, Long Island, N. Y.
Lauder W. Jones, Princeton University, Princeton, N. J.
C. F. Marbut, U. S. Department of Agriculture, Bureau of Soils, Washington, D. C.

Nominations for consideration by the committee on award are received during the meeting, from secretaries of sections and secretaries of societies meeting with the association. From these nominations and from additional ones that may be made by members of the committee itself, the committee on award elects the prizeman for the meeting.

BURTON E. LIVINGSTON,
Permanent Secretary

CURTIS GATES LLOYD

ON the morning of November 11, Curtis G. Lloyd died at Bethesda Hospital in Cincinnati at the age of 67. During a lifetime that was largely devoted to scientific work he built up in Cincinnati a great mycological museum. It would be impossible to give an accurate estimate of its extent. More than fifteen years ago he printed the statement that there were then ten times more Gasteromycetes in his museum