

## HEREDITY RELATED TO MEMORY AND INSTINCT.

IT is a weakness of our scientific methods that they sometimes render us more intent upon theories of explanation than upon the recognition of facts. The instinct of causality dominates the other faculties of the mind and leads us to disregard the phenomena which we have no theories to explain.

Science has been defined as knowledge of causes, but unless the search for causes is preceded by knowledge of facts we soon wander into barren wastes of speculation. The history of philosophy warns us that the human mind is not to be trusted far from facts. After a few devious inferences our bearings are hopelessly lost. Logical consistency in the manipulation of abstract terms does not square us again with realities. As soon as we admit into our reasoning anything for which we have no familiar analogy or mental picture our conclusions also partake of the nature of abstractions. Our concrete problem becomes a metaphysical deduction, and our results have little or no value for practical application.

The literature of evolution and heredity affords many instances where zeal of explanation has outrun interest of perception and even beguiled us into greater obscurity. Answers have been announced before we knew how to frame the questions. Something has been learned regarding the external circumstances attending heredity, but we

can not yet claim to know anything regarding the ultimate mechanism, the structures and activities of the protoplasm through which the biological function of descent is accomplished. The free use of the scientific imagination has yielded only conjectures at once inadequate and improbable.

Heredity is our general name for the internal factors or agencies of descent, by which organisms are produced from other organisms in unbroken series. To call heredity a law or a principle avails us nothing; as yet it is only a word, a collective name for a group of phenomena which we do not understand. Heredity and reproduction, descent and evolution, are not separate phenomena, but mark rather the different standpoints from which we study the same processes of organic succession. Under the name heredity we seek to know the internal cellular and protoplasmic agencies which make reproduction effective for descent. The parents reproduce themselves in their offspring through the medium of heredity.

It is often supposed that heredity concerns likeness only, and that differences between offspring and parents mark failures or lapses in heredity. But if we are ever to understand heredity we must take facts as they are and not vitiate our judgment by preconceived opinions, such as the traditional idea of an agency which would make organisms alike, in exact duplications. That heredity does not do what we may have supposed, affords no reason for refusing to believe that the phenomena of heredity are concrete, and the processes truly physiological. To deny that heredity exists is merely to wipe the previous conjectures from the slate, but the problems remain to be solved. The like-from-like equation gave us no hope of a solution, for it did not represent the facts.

What we really need to understand is the making of unlike from unlike, for this is what happens in the world

of organic nature. It is this kind of heredity which we seek to bring into relations with other groups of phenomena. We would know whether there are any familiar facts or functions which heredity resembles, whether there are any analogies which enable the problems of heredity to be stated more nearly in terms of experience, instead of being viewed so completely in the abstract.

Of the nature of the material basis or mechanism of memory we know as little as of the structure of matter, but we are much better acquainted with the workings of memory. The phenomena of memory lie partly within the field of consciousness, close to the citadel of our intelligence, and afford more definite analogies with heredity than those drawn from physics and chemistry. Heredity we observe from without, but of memory we have experience from within. This experience should make us more tolerant of some of the facts of heredity—facts which we commonly fail to recognize, because we are unable to describe and explain them in the mechanical terms to which some would restrict the vocabulary of science.

#### PARALLELS BETWEEN HEREDITY AND MEMORY.

All are aware of the power to recall and reproduce before the mind impressions of events long passed. It is also a matter of common knowledge that impressions may be temporarily lost, beyond the control of the conscious, voluntary memory, though still retained by the subconscious memory. We know that we have met the man and heard his name, and are sure that the impression remains in the mind, though momentarily unable to reproduce its original surroundings.

Of all the multitude of impressions stored in the mind only two or three can be brought simultaneously into consciousness, for comparison or expression. To have fre-

quent occasion to recall a fact gives facility in reproducing that particular impression, but impressions may also remain unrecalled for many decades without being lost or weakened. They may come back vividly in dreams or in abnormal mental states, after years of absence from the conscious mind, or even when normal consciousness is entirely unable to recall them.

Parallel phenomena abound in the field of heredity, the organic memory of descent. The failure of an ancestral character to be expressed in a particular plant or animal is no indication that this character will not be transmitted to subsequent generations, and regain expression in some of them, even very remote.

When the crossing of two varieties of domesticated plants or animals yields something different from either, but more like the wild type of the species, we call this a reversion, a turning back on the ancestral pathway, though hundreds of generations may have intervened since the primitive character last came into visible expression. Thus Darwin found that the crossing of two white varieties of pigeons might result in blue hybrids, like wild rock pigeons. Similar results have been reported with many animals and plants. The mingling of varieties may recall characters long omitted from expression, but still preserved in transmission. Other reversions occur spontaneously, without crossing, sometimes when external conditions remain uniform, but more abundantly with change of conditions. If the diversities of the ancestral stocks are unknown to us we are led to suppose that new characters are produced in mutations and hybrids, but many of these have proved to be reversions, and the rest may be of the same nature.

CHARACTER TRANSMISSION DISTINCT FROM CHARACTER  
EXPRESSION.

To find that transmission is distinct from expression does not solve the problem of heredity; it only enables us to state our questions to better advantage. To be aware that our equations contain two kinds of unknown quantities, instead of one, may be quite as helpful as in algebra in determining the missing factors. Comparison of heredity with memory is useful if it enables us to distinguish better between the two kinds of facts which we have been attempting to explain by one kind of heredity.

Heredity, like memory, is a complex of two distinct groups of phenomena. Transmission inheritance corresponds to the subconscious memory, expression inheritance to the conscious memory. The subconscious, involuntary memory is the faculty which receives and retains impressions of all that passes before the senses; it is quite independent of the other process of voluntary memory, the recalling of past impressions, illuminated by the searchlight of consciousness. The catacombs of the mind are only partially wired for this voluntary illumination; of the other records we have only casual glimpses, often when we least expect them.

An event can not be remembered unless the necessary impressions have been received, but it is not the lack of impressions which so narrowly limits our field of knowledge. The impressions we receive vastly outnumber those we can recall, just as the transmitted characters greatly exceed those expressed in any individual plant or animal. The coming of a character to visible expression in an organism is a process distinct from the transmission of characters. Transmission implies only the basis of expression, the passing from one generation to another of the power to produce a certain characteristic. Whether

the possibility is realized or remains in abeyance, depends on other factors, on internal expression relations and sometimes on external conditions.

Current theories of heredity do not take into account these two distinct processes, transmission and expression. Diversity among the offspring of the same parents is now ascribed to differences of transmission; the germ-cells are not supposed to convey full complements of the parental characters, according to the theory of Mendelism.

It often happens in crosses of varieties with definitely contrasted differences that the character of one parent remains entirely in abeyance in the first generation, while the other character gains exclusive expression, but the abeyant character reappears in about one-fourth of the second generation. Mendel sought to explain the proportions of the contrasted characters in the second generation by his theory of alternative transmission by pure germ-cells. Units representing the characters of the two parents were supposed to be separately conveyed in equal numbers of the germ-cells produced by the first generation. About one-quarter of the chance matings among two kinds of pure germ-cells would result in bringing together germ-cells containing the unit of the abeyant character, and this would explain its reappearance in one-quarter of the second generation.

For mathematical purposes the doctrine of pure germ-cells leaves nothing to be desired, but the biological facts are not equally accordant. Mathematical problems are usually capable of a considerable variety of solutions, so that a simple numerical coincidence can hardly be accepted as proving the nature of Mendelism, and still less as demonstrating the existence of character-unit particles and their alternative transmission in pure germ-cells, as general principles of heredity.

Biological facts warrant a different conception of the

facts of Mendelism and other phenomena of descent. Each normally produced germ-cell can be thought of as receiving and transmitting the characters of both the parents, as well as those of more remote ancestors. Transmission inheritance may be thought of as inclusive, complete and permanent, like the subconscious memory. The assumption of character-unit particles and of their separate transmission becomes entirely unnecessary as soon as we associate the Mendelian phenomena with other well-known facts of reversion, which prove that characters can be transmitted without being brought into expression, not only for one generation or a few, but for large numbers of generations.

The facts of Mendelism do not prove that the germ-cells are pure, in the sense of being able to *transmit* only one of the contrasted characters. They indicate only that the germ-cells have different *expression relations*, half of them tending to express one character, the other half the contrasted character. Alternative expression accommodates the facts of Mendelism better than alternative transmission, for it is frequently found that the germ-cells supposed to be "pure" have in reality transmitted the contrasted character, to reappear unexpectedly in some later generation.

#### DIVERSITY OF CHARACTER EXPRESSION A NORMAL PHENOMENON.

Though the formal distinction between expression and transmission remained to be drawn, the facts have long been recognized in connection with sexual characters. Darwin and others have appreciated that peculiarities of the secondary characters of one sex can be inherited through the opposite sex, without being brought into expression. Sexual diversity, like Mendelism, is a phenomenon of alter-

native expression of contrasted parental characters. Diverse parents produce equally diverse offspring, and in equal numbers. Sexual diversities are usually very much greater than those of the contrasted characters of the Mendelian hybrids. Mendelism shows that alternative expression is not limited to sexual characters, but appears in connection with many kinds of differences, including those which distinguish varieties of domesticated plants and animals.

The accurate balancing of the Mendelian proportions may not be frequent in nature, for natural species commonly show more numerous alternatives of expression. They are seldom limited to the Mendelian condition of contrasted pairs of characters, but have a rich diversity of combinations of alternatives and proportions, so that no two individuals are exactly alike.

Diversity, even among the simultaneous offspring of the same parents, should not be thought of as abnormal, and does not require us to predicate diversity of heredity, in the sense of transmission. Individual diversity in the expression of characters is like that of the many eye-witnesses of an event who give widely varying accounts from memories of closely similar visual impressions. The conscious memory often supplies only dim or disconnected outlines, allowing details to be elaborated by the imagination, in accordance with interest or prejudice, or capricious associations of other ideas. Imagination may even prove stronger than direct perception, as when one substitutes words and changes constructions in reading from the printed page.

Likewise with organisms, expression seems never to coincide completely with transmission. Fluctuation of expression relations is a principle of normal descent. Members of a species are alike only in comparison with members of other species; among themselves they are end-



lessly diverse. Individuals do not show the same combinations and proportions of characters as any of their ancestors or relatives. Each represents a new selection of details from the transmitted history of the evolution of the species.

#### ENVIRONMENTAL ALTERNATIVES OF EXPRESSION.

There is no completely fixed individual inheritance, no absolute predetermination in the germ-cells of the characters which shall be brought into expression in adults. When germ-cells of different varieties are united in conjugation, characters may be brought into expression which neither of the partners would have shown if joined with a mate of its own kind. And long after the germ-cell stage is passed it is still possible for one pattern of construction to be substituted for another, either as a regular incident of development or through change of conditions of existence during the growth of the individual.

All the characters developed by an insect during the larval period may be thrown aside at the time of metamorphosis to bring into expression an entirely new equipment, adapting the reorganized creature to different habits of life and a different place in nature. Young junipers and eucalypts produce for several years one kind of leaves and then change suddenly to the very different foliage of the adult type. Some amphibious plants have two distinct forms of leaves which alternate with each change of habitat, from land to water or from water to land.

External conditions can influence the expression of characters in individual organisms, but need not be reckoned as agencies affecting transmission heredity. External conditions do not cause the characters of organisms. Change of weather may cause umbrellas to be substituted for parasols, but we do not say that weather makes um-

brellas and parasols, or the wit to use them. Characters are changed to adjust organisms to different environments, but such accommodations are not imposed from without, but are put forth from within. They represent alternatives of expression, brought out from large stores of transmitted ancestral diversities. Expression inheritance, like the needle of a compass, is susceptible to external influences which do not affect the dial of transmission heredity.

All the characters of organisms can be thought of as transmitted by like processes of heredity, and as having been acquired by like processes of evolution. Yet characters differ greatly in their expression relations, not only in different species and varieties, but even in the same individual, under different conditions, or at different times in its life-history.

Mutilations and direct results of environmental limitations or accidents, do not represent characters of organisms, and have nothing to do with heredity, but all characters which organisms bring normally into expression appear to be capable of transmission. Character-alternatives subject to environmental influence are not less truly characters of the species than those expressed in all individuals. Alternative characters represent a more specialized and useful form of expression inheritance, and enable the species to exist under a wider range of conditions. A plant able to change readily the size and texture of its leaves may thrive both in sun and shade, while a less versatile species may be restricted to one condition or the other.

If all alternative characters had relation to environment the theory of external causation would appear better justified, but the fact is that the sexual and other non-environmental diversities among the members of a species are often much greater than the variations they show in

accommodating themselves to external conditions. Expression inheritance is unlike the needle of the compass in having power of independent motion, without external interference. Internal expression relations have to be recognized as able to maintain alternations of characters, without reference to environmental conditions.

#### CHARACTER REVERSION LIKE MEMORY FATIGUE.

The conscious memory becomes fatigued through long-continued exercise on one set of impressions. The impressions are not destroyed by this fatigue, but the recalling of them becomes distasteful. An increased amount of voluntary attention is required to prevent the wandering of consciousness to other kinds of impressions. Recreative diversity of interests is a principle of psychological hygiene. A fixed idea, the persistent direction of consciousness upon one fact or group of impressions is an abnormal mental state, soon leading to still more definitely pathological conditions.

On the side of heredity, similar fatigue phenomena may be recognized. Selective narrow-breeding renders organisms more and more uniform. One set of characters is repeated in the successive generations of the selected stock, and the other alternative features left in abeyance. Uniformity in the expression of one set of characters may increase the agricultural value of the variety, but the restriction of expression to a narrow range of characters results in a weakened vitality, and a lessened rate of increase.

Limitation to one set of characters brings, in other words, an expression fatigue. Even the uniformity is seldom complete, but continues to be broken by reversions, that is, by the occasional production of individuals in which the former alternatives of expression reappear. Re-

versions are often more vigorous than the narrowly selected parental stock, and may serve to originate new agricultural varieties, especially when they "come true" from seed, as in the plant reversions now often described as mutations. Reversions become more and more abnormal as the expression fatigue increases and the natural freedom of alternatives of expression is gradually lost.

Expression fatigue also brings a gradual narrowing of the range of conditions under which the variety remains normal and uniform. With many closely selected varieties of plants seed has to be raised in one particular locality. Even a slight change in the expression of the environmental characters is likely to disturb the processes of descent and reveal their degenerate state. Sometimes the removal of selected varieties to new conditions calls forth large numbers of degenerative variations, and sometimes a notable change occurs in a whole planting, as though a simultaneous mutation of all the individuals had taken place.

The fixing of characters within too narrow limits, like the fixing of ideas, leads ultimately to the derangement of the structure, by the loss of the normal alternatives of diversity. Variety is not only the spice of life, as the adage says, but it is a necessity of normal existence, not for man alone, but for the whole organic world. Stability of characters in organisms is not normally maintained by "identity of form and structure" among the members of the species, but rather by a natural tendency to vary and alternate along a specific range of diversity. This range of normal diversity represents the true evolutionary characters of the species, rather than the peculiarities of any single individual or of some narrowly selected group.

## EVOLUTION OF MEMORY THROUGH INSTINCT.

Heredity, instinct and memory represent a truly evolutionary sequence of specialization. Structural coordinations of organisms with their environments we ascribe to heredity, while coordinations of activity are called instincts, but there is no essential difference. Instinct is a part of heredity which determines functions, even after structural development is complete. Structure-building by heredity, and muscular contractions determined by instincts, depend alike on internal activities of cells.

Heredity adapts the mouths and muscles of embryonic mammals for sucking, and it also supplies the wholly unconscious new-born young with instincts to use these complex milk-extracting appliances. Instinct does for the infant what memory does for the adult. Instincts not only resemble memory, but share the same functions; they have been aptly described as the memory of accumulated ancestral experience. The memory-organs, like other parts of the body, are formed through heredity, and doubtless represent a specialization of some of the functions of primitive cells. Heredity itself is the primitive cell-function which memory most nearly resembles, and the instincts afford the connecting link between heredity and memory, indicating a developmental relation.

Though more helpless at first than the lower animals, man is able to remember and compare his experiences, and thus develops gradually an adaptive judgment more effective than the most complex of animal instincts. The individual animal acquires from experience only a slight addition to the highly-specialized instincts already supplied by heredity. Memory of individual experiences remains relatively useless among the animals because their actions are still under the almost exclusive control of the hered-

itary instincts, and are not readily accommodated to particular cases.

Instinct, like reason, is a form of intelligence, but a less adjustable form. The special senses and natural cunning of animals often exceed those of their human competitors, but man more than makes up in resourcefulness what he lacks in instinct. Perhaps there were limits to the number and complexity of instincts which germ-cells could transmit. In any event, an alternative form of intelligence was attained through the postnatal development of specialized memory functions. The unconscious memory which sufficed for the guidance of inherited instincts was eventually supplemented by the conscious memory, needed for recalling and comparing impressions in the making of reasonable inferences. In advanced civilizations conscious memory and rational inferences may completely overshadow the instincts, but criminals and victims of diseases or drugs often show the instinctive cunning of animals and savages. Conscious memory is thus traced back through unconscious memory to find its prototype in the inherited instincts.

#### CONSCIOUSNESS NOT A GENERAL PROPERTY.

The details of such a process as swimming may be developed by frequent repetition from a conscious memory into an unconscious, instinctive action. From such facts it has been inferred that the subconscious instincts of man and the lower animals began as conscious voluntary actions and developed gradually into unconscious hereditary instincts. Eminent biologists have argued that consciousness must be reckoned as a universal property of protoplasm, because organisms of all kinds are capable of purposeful instinctive acts.

This reasoning reverses the probable course of evolu-

tion. That conscious actions may become instinctive through repetition does not prove that consciousness was developed before instincts. It may show only that the original relations of the two phenomena are sometimes reversible. Animals with the most highly specialized instincts show no traces of the consciously adaptive intelligence required by the theory.

Consciousness is evidently a product rather than a cause, something superposed upon heredity, instinct and memory. The human personality exerts a voluntary control and coordination of activities which in all other organisms remain instinctive and largely mechanical. The wonder is not that conscious acts sometimes become unconscious, but that unconscious acts ever become conscious.

#### PLACE MEMORY LIKE HEREDITY OF CELL ARRANGEMENT.

Some of the most specialized forms of memory are the least conscious, such as those enabling animals to preserve their geographical relations and return to places whence they have come. Birds traverse continents and seas and return the next year to nest in the same tree. Accurate unconscious memory of time and place are also human talents. We may be able to recall only a few of the more striking objects encountered in a day's wandering in the forest, but by the unconscious record we can retrace all our steps and find the lost object or secure more specimens of the rare plant or animal. From the standpoint of consciousness such phenomena are quite as mysterious as the hereditary return of the offspring through structural wanderings, to the organic status of the parents.

To what extent place memory may be joined, like the instincts, to the hereditary memory, is not yet known. The memory function of brain-cells may represent, after all, only a specialization of the heredity functions of the germ-

cells, just as muscle cells represent a specialization of the primitive power of contraction. Our bodies are built of specialized germ-cells, in which primary reproductive functions have been replaced by accessory reproductive functions. Our genealogy as organisms is not to be traced back to the inferior types which are formed without conjugation or in the intervals between conjugations. The bodies of the higher plants and animals are conjugation products in another and more thorough sense of the words, for they are formed while conjugation still continues, by subdivision and specialization of the united germ-cells.<sup>1</sup>

The descent function of the germ-cells appears more complicated than the functions performed by other cells and tissues of the body, but it is a primitive and general function, rather than special or local. The new body is built up through a series of subdivisions of the conjugating germ-cells. The heredity function is not confined to the germ-cells, but is passed along down all the lines of cells till the final product, the adult body, has been built. There is no reason to suppose that the new organism is preformed in the germ-cells. Nor have we any indication that the germ-cells contain any special substances or mechanisms not to be found in other cells.

The matured body-cells of the highest organisms still have enough of the generative power in reserve to repair injuries. Among the lower animals and plants larger parts can be restored, and even complete bodies reproduced from small fragments. This power of regenerating lost members marks a primitive state, rather than an adaptive condition developed through natural selection. Adaptive specializations of cells, as among the higher organisms, tend away from regeneration. From historical and evolutionary standpoints the germ-cells do not appear more special-

<sup>1</sup> Cook, O. F., and Swingle, W. T., 1905. "Evolution of Cellular Structures," *Bul.* 81, Bureau of Plant Industry, U. S. Department of Agriculture.



ized than the body-cells, but less specialized. Studies of body-cells and their relations may prove quite as significant for heredity as studies of germ-cells.

#### SPECIALIZATIONS OF HEREDITY IN HIGHER ORGANISMS.

As we ascend in the scale of organization the cells of the body become more specialized and their power of giving rise to new sex-cells is more restricted. In the highest types the original reproductive function of most of the body-cells is lost. They have no longer a complete biological existence, since they leave no offspring of their own. Like the sterile worker bees of the hive, they function only as parts of an organization.

The fact that conscious memory is not inherited does not destroy the analogy with heredity, nor lessen the possibility of common origin. Memory and consciousness, like physical strength, are functions of the specialized cells which no longer serve for reproduction, but must develop anew in each individual, through proper nourishment and exercise. The instincts are carried along and repeated in each generation, but the record of memory is furnished only in blank. The heredity memory provides brain-cells for the personal memory, but leaves them without the ancestral equipment supplied with the instincts. The power to remember and act upon individual experiences thus appears as inversely related to the power to forget and disregard the ancestral experience; it substitutes the memory of recent impressions for instincts relating to the past.

If memories were transmitted as effectively in man as the instincts are in the lower animals, we would be in the same plight as they, for the nonadjustable instincts of the animals are often worse than useless outside the conditions in which they were developed. The memories would

not pertain to the existing conditions and would have less value as the basis of judgment than those we individually accumulate. We would be burdened with useless historical details, like the primitive peoples whose educational efforts are spent in the memorizing of genealogies, rather than in training in the arts of life.

Even the most civilized nations have yet to put behind them the superstitious notion that minds must all be subjected to some particular system of training, or that there is some particular body of knowledge with which all brains must be stocked. Our young people no longer memorize genealogies, but most of their educational activities are applied in directions as little related to the life of the community. In the world of ideas we still waste much in efforts to preserve useless relics of the past, like the savages who have not learned the art of burial, but drag their dead about with them, to the detriment of the living.

#### CONSCIOUSNESS AND EVOLUTION.

Man is by no means so deficient in instincts as our conceit often leads us to claim. Instincts are the background of consciousness. Pleasure can be defined biologically as the satisfying of instincts, and vice as the perversion or unbalancing of instincts, by which they cease to serve their natural purpose in the economy of life, or become unduly developed, to the detriment of other tendencies and functions.

The highest power of the personal will is to choose among the instincts, to determine which are to be served and developed, which to be avoided, deferred or suppressed. Judgment is weaker and more fallible than instincts, but when instincts are in conflict judgment can call them into court to compromise their differences, instead of surrendering the interests of all to the blind slavery of a single

usurper, whether in the form of superstitious fear, or of some more obviously physical gratification. Animals, children and savages often enjoy being frightened. Fear is a normal and useful instinct which seeks occasional exercise, but interferes with evolution if too much indulged.

Instincts of the utmost utility to savages may become useless or even harmful for civilized man, and tend toward elimination. Other instincts of small significance in barbarism are being developed with the better opportunities afforded by civilization, such as the instinct of causality, the basis of scientific investigation. Right proportions among the instincts are quite as important as in the physical body, if the organism is to accomplish its normal functions. Heredity bears upon human welfare through the instincts even more than through the bodily features, for the range of variation in instincts is far wider, and they are equally heritable.

As the lower forms of memory serve only for the recognition of something actually present, so the lower forms of instincts and of consciousness deal with facts only from the standpoint of the narrow selfishness of the individual. Finally, a higher stage of personality is reached, and the range of interest gradually widens to include all human relations. Evolution passes to the conscious plane. We seek to know the good and evil of existence, to avoid its limitations and to realize its possibilities.

In more complete consciousness lies the only security of human progress. We must appreciate our human birth-right, and open the eyes of our understanding upon the problems of our own existence. Thus far human institutions and societies have developed by the same unconscious evolution as plants and animals, and with the same high percentage of fatalities from over-specialization in wrong directions, economic, social, educational and religious. It is not sufficient that sages and reformers shall frame sys-

tems good for their own ages and generations, and establish them by arbitrary regulations. The spirit of true progress seeks to assure its steps in the light of full, scientific knowledge. Virtues of one age may become vices of another, if they set limits to evolution.

It is this larger consciousness that now gives a practical value and a pressing importance to the study of evolution. The motive is no longer a mere curiosity to know whence we have come or whither we are tending, but the realization that acts may determine the fate of tendencies, not only for individuals, but for nations and races. Consciously or unconsciously, evolution is a process of choice. We have now reached the stage of development in which the choice can be made conscious.

With every advance in the scale of development the problems of existence are vastly multiplied, and the chances of further progress decrease. The mere multiplication of species or elaboration of local differences, such as those distinguishing tribes of Indians and other primitive peoples, may signify little in evolution. Thousands of species and tribes are sacrificed and extinguished for one that develops a new talent and attains a higher stage of existence.

Of all the millions of species that have inhabited our earth only one remained on the path that led to the attainment of consciousness, the rational appreciation of the purposes of our acts. Of all the millions of men who participated in the ancient Oriental and Mediterranean civilizations only one effectively perceived the more fundamental laws of human personality, and opened the way toward possibilities of higher development—possibilities we have scarcely begun to realize, after nearly two thousand years.

## ASSOCIATION IN HEREDITY AND IN MEMORY.

A final analogy between heredity and memory is found in the fact that both are phenomena of association. As the mind grows by the accumulation and combination of ideas, so does evolutionary progress toward higher types of structure depend upon the maintenance of a network of interbreeding which binds the members of a species into a social and physiological unity.

Multiplicity of alternative characters strengthens heredity, just as the association of many impressions renders memory more effective. The more we know about anything the easier it is to acquire additional details. The more numerous the characters transmitted, the greater the efficiency of the hereditary processes, even though many of the characters remain unexpressed. As bicycles and gyroscopes require to be in motion in order to maintain their equilibrium, so organic stability depends on change. The existence of a species is not maintained by uniformity, but is supported by diversity, by free alternations between many characters. This enables us to understand the otherwise useless diversities found everywhere in nature. A very large proportion of the characters by which related organisms differ have no environmental or other value, unless it be this physiological benefit of multiplying diversities.

The heredity function degenerates with narrow breeding, just as the memory becomes enfeebled if associative contacts cease. A species is an organization of plants or animals, just as the intellect is an organization of remembered impressions. Evolution is a progressive improvement of the descent-fabric of a species. The causes of evolution are not in the environment, nor in the individual organisms, but in the species. A synthetic, constructive

process goes on in heredity no less than in the associative intellect.

The combination of characters derived from different lines of descent contributes to the progress of heredity, but no amount of mere combining of primitive characters would fully explain the continued advancement of organisms in series of new types. New characters arise and new functions develop by progressive modifications, just as the mind attains new ideas and standpoints, significant for intellectual and social progress.

That evolutionary constructions are unconscious is no evidence against their reality. The most effective synthesis of mental impressions also takes place unconsciously. We return to a task which has received no conscious attention for days or weeks, to find that new and vivid associations have been formed, or that a more orderly arrangement of ideas is ready for expression. We can not voluntarily imagine anything new; otherwise there would be no delay in scientific discoveries. New ideas, like other new characters, are reached by unconscious evolutions and associations, coming as accidents and surprises, even to the deliberate investigator. Originality is the power to recognize the truth of these unconsciously formed associations, even when they diverge from current opinions. The principal element in originality is lively interest in the facts, quite apart from any question of novelty.

The claim of psychologists that thought is impossible without words overlooks a distinction like that between transmission and expression. Words we must have to express our thoughts, but the essence of practical and scientific thinking is the comparison of impressions, and this is continually going on in the mind, without words and without volition. Formal metaphysical thinking can not be done without words, any more than chess can be played without a chess-board before the mind. The game of

metaphysics is to arrange abstract terms with logical consistency. Each player lays out his own problems and solves them for his own satisfaction. Schools teach this word-wrought metaphysical thinking, but it is not the only kind, nor the most effective.

Words and forms of speech also represent unconscious evolutions. Philologists assume that languages must have been deliberately contrived because much conscious ingenuity is needed in describing and comparing the endless complexities of linguistic forms and structures. Among primitive peoples it becomes evident that speech grows quite as unconsciously as plants or animals. Its development depends as little upon formal grammar as organic evolution upon botany and zoology. Instead of consciousness being the cause of language, articulate speech was one of the potent factors in the evolution of consciousness. Language and consciousness are evolutions of memory. They are characters which each individual acquires anew from its environment, by the aid of hereditary organs and instincts.<sup>2</sup>

Words are symbols by which ideas are expressed, but it would be a mistake to say that ideas are composed of words, or that languages originate from words. In order to serve the purposes of expression words have to stand in relations with other words. In naturally developing languages words always come from the modification or combination of older words, just as characters come from other characters, gradually changed and compounded, but not added as new units, like bricks to a house.

It is equally misleading to say that organisms are composed of characters, or to suppose that characters have any existence apart from the organisms, or that they constitute distinct entities inside of organisms. Characters have significance only in their relations to other characters.

<sup>2</sup> Cook, O. F., 1904. "The Biological Evolution of Language." *The Monist*, XIV, 481.

Words determine the meanings of sentences, but at the same time sentences determine the meanings of words.

Species precede and give rise to characters, just as ideas and languages generate new words. After being developed and brought into use, words and ideas are capable of ready recall and repetition. Likewise, the alternative characters of a species can return abruptly into expression, but this does not prove that either characters or species are suddenly evolved. Only the formal species or concepts defined in systematic monographs can be said to consist of characters. The physiological and evolutionary species is made up of organisms related to each other in a gradually changing network of descent.

#### CONCLUDING SUMMARY.

All the forms of memory, instinct and heredity, represent, we may believe, the workings of organic mechanisms, though we know nothing of the nature of such mechanisms: It has not been determined whether they pervade all the protoplasm of the cells or are confined and specialized in particular parts or particles in the cells. It is likewise uncertain whether they are formed of solids or liquids, solutions, enzymes, or other colloids. They may also depend upon electrical or radiant conditions of matter, or upon other states or properties with which we are still unacquainted.

Of the nature of heredity, as a substance or mechanism for the predetermination of characters, we gain no suspicion. We are free to use any comparison or apply any analogy that helps to illustrate or associate the facts. We have learned that the phenomena of heredity are not all of the same kind, but fall into two groups, like those of memory. There is a more comprehensive and permanent transmission heredity, independent of the expression in-



heritance of successive generations. Characters can be transmitted without expression, just as sense-impressions can be retained in the mind without being registered or recalled by the conscious memory.

Transmission inheritance is not limited to the characteristics of one individual any more than memory is restricted to the small group of impressions which can be called before the mind at one time. Uniformity of transmission does not interfere with diversity of expression. As memory may preserve the whole experience of the individual, so heredity may cover the whole evolution of the species.

The details of structure, arrangement and coordination of all the cells of the body, and of their countless variations, are transmitted by a single microscopic germ-cell, so infinitely compact is this capacious mechanism of descent, of whose nature our clumsy imaginations fail to frame any conception.

Facts are not limited by our power to understand them; it is our understanding which remains limited if we fail to recognize the facts. Theories of heredity which lead us to neglect ascertained facts of descent are worse than useless. We do not yet know what heredity is, but we should not refuse to perceive what heredity does, nor neglect to associate it in our minds with other familiar facts. Memory and instinct present phenomena of like complexity, and are related to heredity in evolutionary sequence.

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