marvels which will require the utmost powers of our intellect to grasp.

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HEREDITY AND PERSONALITY[1]

THE fathers of the American Society of Naturalists in their wisdom made the president's address an after dinner speech. What can they have meant by that, save to free him from the shackles of that rigorously scientific procedure which marks our day-light program, to enable him to speak in lighter vein, to discourse of things that as a technical scientist he can not touch; in short, to invite him to leave the solid ground of science, and, following the modern vogue, circle about a bit in the atmosphere above?

And so, in accordance with their prudent provision, I shall neither present to you results of my own experimentation, nor indulge in that favorite present-day pastime of geneticists, so facile when one is far from the material itself, of demonstrating that the experiments of some one else prove just the opposite of what he supposed them to prove. There lacks, alas! no opportunity for disputation in that part of genetics where I am at work, but the problem of pure lines and selection has been at this meeting of the society in more competent hands than my own, and it now needs, not more argument or exposition, but further investigations that shall fulfil the demands of both sides—the analytical experimentation of the pure line worker, the analytical computation of the statistical school—till the two come to some unified result.

So, turning aside from all this, I shall put forth some reflections on the relation of our knowledge of genetics to certain human problems. We ourselves are samples of the material whose rules of action we seek in studying genetics, and one can't help thinking of the bearing of the rules we discover on some of the more intimate questions of human life—even though these reflections may lead nowhere and justify no practical conclusions. Considerations of such a sort are forbidden ground to the man of science in his technical rôle; yet the human being, even though he has been through the scientific mill, is attracted by the forbidden, particularly as an after dinner diversion. We spend our time searching for the practical applications of genetics; it may be a rest from the strain to dally a few moments with the unpractical aspects. I judge that it is clear that what I have to say will have no relation to eugenics.

Genetics is that part of science which deals with the question of how living things have come to be what they are, and with what is to become of them later. Now, these are questions that have long troubled the minds of the living things that make up mankind, with relation to themselves. Shall we lay ourselves open to the charge of audacity, of presumption, even of impiety, if then we try to bring the problems of the origin and fate of human individuals into relation with the science of genetics? Following the admonition of America's philosopher, that we shall do what we are afraid to do, let us venture.

It is popularly held that in the last twenty years genetics has begun to be a science. We seem at last to have gotten hold of some of the threads by which the web unravels, and if the unraveling has not yet gone far, we at least see that the process works; that we make progress at it. It is perhaps no longer an adequate statement of our knowledge to say, as a French author did some years ago:

[1] Presidential address before the American Society of Naturalists, December 28, 1911.

Heredity is a vain word. There are in it no laws to be drawn forth, and consequently no principles that can be stated. There are simply certain curious remarks that may be made, sometimes for, sometimes against, the transmission of virtues and vices by blood. And there are no more cases for than against.

Perhaps we may say that two chief things have been discovered. One is that there is a certain permanency of type in living things, along with a certain dissectibility, as it were, and a capacity for recombination in diverse ways. Certain traits or characters seem to crystallize out, and such crystallized units hold together, and may be moved about, in the processes of generation, according to certain rules, from one individual to another, and combined with other crystals from a diverse source. Or, to change the figure, we find the living world to be a web or net of definite, relatively permanent strands, that interweave, that unite and separate, a given strand passing now into one individual, now into another; each individual presenting a new combination of the strands; a new knot in the web. And we have worked out certain of the rules according to which this interweaving takes place.

The second great discovery is that of some of the intimate material processes of this interweaving. So far as we have gone, we find that the strands which appear in one view as personal characteristics, physical or mental, appear in another as material processes, visible under the microscope; and the rules for the interweaving that we discover by the study of one aspect of the web we find faithfully followed when we study the other aspect. This correspondence seems to that unscientific wondering individual which every man of science conceals, one of the most astounding things in science; it illustrates again the artless ingenuousness of the popular idea that matter is something simple and well known, and that we deprive a phenomenon of its wonder by showing that it takes place in matter. What happens in the personal world finds its parallel, so far as we can see, in the happenings of matter; the wonder of the event is not increased or diminished whether we must call its medium matter or something else equally mysterious and unfathomable; for nothing could be more so.

Our experimental science of genetics is a physiology of the processes by which new generations are produced, comparable to the physiology of metabolism—rather than a study or doctrine of evolution; although we believe, and perhaps we see, that a knowledge of it must precede any correct understanding of evolution. Indeed, the direct attacks hitherto made on the problem of how evolution occurs seem to owe their relative lack of success to the fact that they were not based on a knowledge of the normal physiology of generation; to obtain this preliminary knowledge is now the immediate task of investigation. But this gives us as yet little or nothing that is final on how the strands that make up the living web arise, how they get their unity and permanence, and how they are transformed. Selection, mutation, environmental action, formation of developmental habits—each of these stands before us with a question mark so large as to overshadow the word itself; experimentation finds it equally difficult to confirm any of them.

But the existence and interweaving, according to rules, of these relatively permanent strands, are what remain to us positively. What is the relation of these things to our own existence and personality?

As a material, potentially visible organism, I, like the infusorian, have been in existence ever since the race that devel-

oped into human kind began. And this, for each of us, is not a figure of speech, but the plain literal truth. An unlimited microscopist could have followed with his eyes my course, and your course, down through countless ages, never losing sight of the material organism for an instant, just as our colleague, Dr. Woodruff, follows day by day his thousands of generations of *Paramecium*. I was in actual material existence as a living organism, and indeed thousands or millions of years old, when the pyramids were built, and my unlimited microscopist could give my history from that time to this without a break. What marks has that long history left on my personality and character?

When in England for the first time last summer, I was struck with the familiarity of things strange; by a feeling as if I had returned to my old home. The great things of England seem the working out, the carrying to a limit, as it were, of the tastes that live in me and mine, while the great things of other countries are the revelation of a spirit to me relatively new and foreign. It may not have been an explanation, but it was the truth when I said to myself at that time: I have indeed lived in England many hundred years, much longer than I have lived in America. During the thousands of years of my existence I have had experience of many lands and many people. But of the last thousand years of my life, I have spent all but a couple of centuries or so in England. During that time I have taken part in the growth and development of many an Englishman, and of many an Englishwoman. And who can say that what I have grown into in America has not been partly determined by those habits of growth and development that I acquired in that pleasant English country—so that it is small wonder if things there fit me as if they and I were made together?

True, I was but a cell in the bodies of those many Englishmen, but are we sure that that statement has any real meaning; that the cell—even the germ cell—is in any sense a separate thing from the remainder of the body? Must we not rather conceive the body as a unit, in which all parts share in the developmental processes that occur? In those activities of organisms that are most readily studied, the principle holds that any process gone through repeatedly and under stimulation later takes place more readily and without the original stimulus. There is no reason why we should not expect this principle to hold in development as well as in the other activities of living things. If the body develops as a unit and each cell in the body takes part in that development, we have the basis required for the operation of this principle. After it has developed in a certain way a number of times under the action of certain environmental stimuli, a piece of the body, forming the germ cell, would later develop in the same way without the same stimuli. What we have been accustomed to develop into for the last several thousand years, under the stimulus of our old homes in Europe, possibly we develop into here, so that our old homes fit us as a mold fits the candle that was shaped in it.

The gradual formation of developmental habits seems the only form of the idea of inheritance of acquired characters that is not opposed by any of the experimental facts, that helps us to understand why so many acquired characters are not inherited—since they are not produced by the developmental processes of the organism; that fits all the recent cases which give positive evidence for the inheritance of acquired characters, and that is based

on a law actually known to hold for those organic processes that are most favorable for study with relation to such laws. Can a stronger statement be made for the efficiency of selection or of any other factor, as producing and modifying the characteristics of organisms? There was a time, not distant, when the biologist hardly dared speak of the possibility of the inheritance of acquired characters in any sense, because experimentation was unable to demonstrate its occurrence. But after learning the rules for the interweaving and transfer of characteristics in successive generations, we find as much difficulty in showing experimentally that selection modifies hereditary characters as we do in showing the inheritance of acquired developmental habits, so that the two ideas now stand once more on the same footing. This revolutionary change in the relation of these two possible factors is one of the important fruits of the recent development of genetic science, with its demonstration that most of what had been considered a productive action of selection was in reality not such. If we are reduced once more to judging the two ideas by their relative value for explaining what we find to exist, habit formation in development does not suffer by comparison with selection.

If the formation of developmental habits really occurs, then the fact that each of us has taken part in the development of so many men and so many women, and even, in former times, in the development of so many creatures not yet men and women, helps us to understand many of our impulses, revealed suddenly and unexpectedly to ourselves; helps us realize why we feel that the character and tastes we have manifested in our lives form only one of the types of character that we might have displayed; that perhaps we have displayed in times past.

But however it be with this particular point, I have lived, like the infusorian, in unbroken material continuity for uncounted ages; if the phrase "potential immortality" means anything for the infusorian, it means exactly the same for me, so far as we can judge from past history.

But what then of the future? We have each a singular wish to trace our existence not so much backward as forward; certainly no other problem of genetics has commanded such universal interest as that of immortality.

Many non-scientific theories of immortality have held that we do continue to exist in later generations, in the form of human beings or in other forms, but that we do not remember our previous lives. This last proviso is a relapse into science; it is an attempt to reckon with the facts, for we each observe, upon inspection, that we do not remember a previous existence.

What difference would there be between reincarnation without recollection of our previous experiences—and the actual reliving of our characteristics when a portion of our body develops anew the character and traits that now exist in us? If *you* are a reincarnation of some former individual without the remembrance of his experience—and *I* am a re-development of the characteristics of some former individual from a piece of his body—what pragmatic difference, what difference that experiment or experience could detect, would there be between the two cases?

Thus the fact that we re-live in posterity would seem to constitute all that can be meant by immortality without recollection—if we reproduced as the infusorian does, each for himself, each giving rise to individuals like himself.

But just here we meet that tremendous

complication, which confuses the mind on this point, as it does on so many others. How relatively simple a science would biology be, and how totally different from what it is, if there were no intermingling of individuals for reproduction! The next re-development of *me* is not merely myself—my characteristics, but a combination of my characteristics with those of some one else. And not all of my characters go into the new generation, but only a part of them. And still more perplexing, what I contribute to this new generation often turns out not to be my personal characteristics at all, but those of various and sundry other persons scattered along the line down which I have come, and for which I have served merely as a storehouse, without my knowledge or consent.

And in fact, it turns out that *I* have been merely a sort of focus or knot, in which a lot of strands have been tied together—strands that diverge before and behind me. Cut the knot—the strands separate, scatter and unite with others. Those in my knot have come from a hundred others, and may later unite in a hundred still diverse. Of my characteristics I may say, like Iago of his purse "'twas mine, 'tis his, and has been slave to thousands." Only the scattered parts of me will continue to exist, in diverse persons. And so much is already true; my component parts exist at this moment in many persons now alive, so that if the continued existence of my scattered parts is what we must mean by immortality, then such immortality is the lot of all; it holds as well and in the same sense for him who leaves no children of his own as for the parent. The conclusion of the whole matter, from this point of view, can be only that humanity is but a single organism, merely temporarily separated into pieces, which later reunite, and that we personally must console ourselves (if it is a consolation) with the realization that our characteristics exist elsewhere in humanity and will continue to exist after that particular knot which forms the present self has been untied.

But has not our point of view thus far been after all inadequate for sounding the real depths of our problem? It omits the deepest of all the difficulties; the fact that *I*, the ego, as a feeling, experiencing, knowing self, am identified with only one of these knots into which the living strands are tied; my experiences cling to that one alone. Was it the small boy Huxley (or was it some other one of the famous precocious youngsters that fulfilled their promise) who asked his mother whether she was not overwhelmed by the consciousness of her own identity? And isn't that the most extraordinary of all things, that my experience, embracing in its grasp the universe, is tied down in relations of identity to a single one of the millions of knots tied in this web of strands that have come down from the unbeginning past? For an observer standing to one side, as it were, it is not difficult to comprehend that different combinations of strands should give different characteristics; different personalities in that sense. But that the observer himself—my total possibility of experience, that without which the universe for me would be non-existent—that this should be given only by one particular combination is hard to conceive.

It is the problem of distribution that here seems to call for analysis. Through the operation of what determining causes is my self—my entire possibility of experiencing this wonderful universe—tied to this particular one of the combinations of strands, rather than to some of the mil-

lions of others? And would *I* never have been, would *I* have lost my chance to participate in experience, would the universe never have existed for me, if this combination had not been made?

There seem to be certain facts that bear upon this question. My self, my personal identity, has as a matter of fact arisen in connection with a particular union of two germ cells each bearing a certain combination of the strands that determine characteristics. The essential question is: Could any other combination have produced *my* personal identity?

We find that other combinations are formed in great number, but that none of these do as a matter of fact produce *my* self, not even when they are combinations of germ cells from the same two parents. Suppose that my particular combination of germ cells had never been made, then seemingly those other combinations that *are* made would produce the same results that they now produce, namely, individuals that are *not-I*. And my personal possibility of experience would have been forever non-existent!

On this basis, what are the chances that *I* should ever have existed; that the particular combination which produced *me* should ever have been made? According to competent authorities, one of the two preexisting combinations from which my combination was derived possessed somewhat more than 17,000 germ cells, while the other produced the very considerable number of 339 billions of germ cells. So far as conditioned by the characteristics of these germ cells, any one of the 300 billions might have united with any one of the 17,000; any combination was *a priori* as probable as any other, and the chance that my particular combination should have been formed was therefore but one in five millions of billions![2] Gentlemen, I must congratulate myself on my fortune in being with you this evening!

But this gives but a minute fraction of the real odds against my existence, or your existence, if each of us depends on the occurrence of some particular combination of the strands. We have taken my two parents and their union as given. But the chances were equally many thousands of billions to one against the existence of each of them, and even existing, they might have mated otherwise, absolutely precluding the possibility of that combination to which my identity and experience are attached; and if we go back many generations, applying as we must the same considerations, we see that the system of notation which humanity has devised would be quite inadequate to express the odds against the formation of the combination from which I was derived, or you were derived. The chances were infinite against my existence and your existence.

As an abstract mathematical proposition, you may, if you like, decline to be impressed with this, because the chances were just as strong against the existence of any other persons, and yet some were bound to exist; you and I were therefore just as probable as any one else. While this reasoning is abstractly just, it fails to be entirely satisfying to the self when it is my total possibility of existence that is disposed of in this light way. But this and all our reasoning thus far omits the essen-

[2] If we choose to take into the computation out of the 17,000 ovules only the 400 that actually mature, the chance for any particular combination is one in 120 thousand billions. After reaching the thousand billions, cancellation of a factor of a few hundreds or thousands ceases to produce an impressive difference. The figures here given for the numbers of germ cells are from the "American Text-book of Physiology," 1901, Vol. II., pp. 444 and 454.

tial point, the real tragedy of the situation. If each diverse combination produces a different *self*, then there existed in the two parents the potentialities—nay, the actual beginnings—of thousands of billions of *selves*, of personalities, each as distinct as you and I. Each of these existed in a form as real as your existence and my existence before our component germ cells had united. And of these thousands of billions, but four or five have come to fruition. What has become of the others? A thousand earths might have been populated with those personalities now consigned to limbo. Or, if, as before, we include in our thought other persons, and previous generations, what must we conclude? A real infinity of potential, of inchoate, selves, is cancelled in each generation; a potential and inchoate population sufficient to people all the regions that mythology has invented; all the worlds that astronomy has discovered.

Our instincts and our education impel us to regard a human personality as the highest and most real of entities, having attributes of worth possessed by nothing else; perhaps as being sacred and imperishable. What are we to say of this infinite number of personalities whose existence was foreshadowed and prepared in exactly the way that gave origin to you and to me; who depended only on a chance meeting of germ cells for their full fruition, yet that never advanced farther?

It has become popular, with the advance of the theory of natural selection, to shudder at the tragical ruthlessness of nature, because, according to the very moderate estimate of the poet,

> of fifty seeds
> she often brings but one to bear.

Many a plant produces thousands of spores for each one that matures, and many a fish produces thousands of eggs condemned to premature destruction. Natural selection has therefore been reproached as a tragic and cruel method of advance, since out of the thousands of inchoate existences it brings but one to fruition. An honored former president of this society has tried to show us that nature acts in a kindlier way, through an attempted demonstration that natural selection is not the correct theory as to the method of advance of living things.[3] But the destruction of the uncounted millions was not a part of the theory; it is an observed fact, for which the theory merely tried to give some sort of an excuse. If no purpose is served, no advance made, through this wholesale slaughter, then mere wanton cruelty is substituted for that cruelty whose aim is kindness. But whether with an aim or without, we find that nature plays in the same infinitely wasteful and cruel way, whether with spores of fungi and eggs of fish, or with the potencies and beginnings of human personalities; it is but one out of billions prepared that comes to fruition.

It is not strange that with the instincts and education which we have, men should turn away from such a view of nature, and should attempt to find some alternative that does not lead to such monstrous results. If we have, from studies in philosophy or in other fields, reached the conclusion that the self is the one certain reality, that relation to its existence is the final touchstone for all knowledge; that it is the highest and greatest thing; that it is as it were self-existent, perhaps even imperishable—then this conviction will appear to us a sound argument against the correctness of a view of nature which shows us the existing human selves as a mere chance

[3] Morgan, T. H., *The Popular Science Monthly*, May, 1905, p. 63.

remnant saved from an infinite slaughter. There exists, as we know, an alternative point of view in regard to human selves; one not reached by following the road that leads from the facts of biological science; one that gives the human self a very different position and relation to the rest of the universe. Is that indeed a real "view" or is it a mere refusal to look at the view which is before us? Is that viewpoint one that could be reached in any way from the biological field? Is there any possibility of reconciling it with the data with which we have been dealing? Can we possibly give our own argument a different direction?

With some ingenuity one might find a parting of the ways at that point in our argument where it was set forth that if *I* did not exist, all the other combinations of germ cells that are made would still produce the same result that they do produce —namely, individuals that are not-*I*, so that I would never have existed. It could perhaps be maintained that, on the contrary, *my* existence is in some way one of the determining factors for what shall be produced by other combinations, so that if I did not already exist, some of those combinations might produce a different result from what they do produce; that they might indeed in that case produce *my* self. Granting this, I might have had my personal existence as a self, in connection with some different combination of the living strands, in case the one I am tied to had not been formed.

To work this out in detail, one would apparently have to hold that the human self is an entity existing independently of the living material, and that it merely enters at times into relations with one of the knots of the living web. If one particular combination or knot should not be produced, it would enter into another. Thus each of us might have existed with quite different characteristics from those which we have; it would be only our specific characteristics that were determined by the chance combinations that happened to be made, not our total existence as a self.

We have recently witnessed the phenomenon of a vice-presidential address before a section of the British Association for the Advancement of Science, which set forth that the facts of physiology suggest the existence of an entity or soul that is essentially independent of the body, merely acting through it.[4] Could not those aspects of genetics to which we have called attention be readily converted, likewise, into an argument, convincing for those already convinced, for the independent existence of the self or soul? The monstrous results to which the straight-forward consideration of the data leads us could be held to demonstrate in themselves that we had gone astray; that at the parting of the ways we must follow the other road, leading to views in harmony with our convictions drawn from other fields. Neglecting all difficult details as to when and how and why the temporary union of self and the body is made—how simple and satisfactory to hold (if you can) that there is a limited store of selves ready to play their part; that the mere existence of two germ cells which may (or may not) unite has no determining value for the existence of these selves, but merely furnishes a substratum to which for mysterious reasons they may become temporarily attached; and that therefore there is no cancellation of billions of inchoate human personalities, such as the other view leads to; that nature does not deal with human selves as with spores

[4] Macdonald, J. S., *Nature*, September 14, 1911, pp. 364–365.

of fungi, or as with an infinitely great sum of figures employed in computations amounting to trillions and quadrillions, all to be canceled save a result expressible in units. And what interesting corollaries might be drawn from such a doctrine, as to the farther independent existence of the selves after the combinations to which they are attached have been dispersed!

Certainly I do not wish to be understood as advocating this second point of view. The experiences of scientific investigation do not convert one to that thoroughgoing pragmatism which holds that satisfaction to our instincts is ground for holding a proposition to be verifiable. But I take it that the function of a scientific exposition is to follow wherever the argument leads, and when the road forks, with no signboard to tell us positively which fork to follow, it must chronicle that fact, and investigate so far as it can the regions into which each fork leads, leaving the question of choice to each person as a person. When the man of science leaves the solid ground and takes to his aeroplane, such a rule is doubtless difficult, for all roads become dim, but it still remains the ideal.

Gentlemen of the society, whether you have followed me in any other respect or not, you will admit the truth of my introductory promise that I would give you a rest from things practical and that I would not try to lead you to any conclusion. Looking at some of the elementary facts of genetics in relation to ourselves, we saw that each of us has been in unbroken material existence for countless ages, during which time we have taken part in the upbuilding of many a brute and many a man and many a woman. After speculating a bit as to the marks which these experiences may have left on our characters, we turned our eyes to the future. We found that each of us is but a knot in a continuous web of strands that have, in other combinations, built up many persons, and will, in still new combinations, build up many others. Thus, as we have before taken part in the development of brute and of man, we may hope later to take part in the development of superman. Finally we looked at the relation of some data of genetics to the problems of personal identity and the self. Here the straight path of science, when followed simply and unsuspectingly, showed us nature cutting off budding human personalities by the billion, where she brings one to fruition. Whether this ingenuous and unforeseeing pursuit of the scientific path as marked out by the objective data is the only proper method for the establishment of belief on such a point or whether we are justified in turning off at a certain juncture, because this takes us where, for other reasons, we would prefer to go, is a question which leads into broader fields than the experimental science of genetics.

H. S. Jennings

SCIENTIFIC NOTES AND NEWS

The American Association for the Advancement of Science and the national scientific societies affiliated with it are opening at Washington the tenth convocation week meeting as this issue of Science is sent to press. There are published above the presidential addresses of Professor Michelson before the American Association and of Professor Jennings before the American Society of Naturalists. These will be followed by other addresses and by the proceedings of the meetings.

Dr. K. Von Goebel, professor of botany at Munich, Dr. Aurel Voss, professor of mathematics at Munich, and Dr. Ewald Hering, professor of physiology at Leipzig, have been elected knights of the Bavarian Maximilian order for art and science.