SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

FRIDAY, MARCH 28, 1902.

CONTENTS:

THE INTELLECTUAL CONDITIONS FOR EMBRYOLOGICAL SCIENCE.

II.

NATURAL HISTORY AND NATURAL KNOWLEDGE.

THE definition of science as the analysis and classification of facts leads the philosophical spokesmen of modern science to believe that an embryological account of thinking men is impossible, because it leads them to believe there is a chasm which is intellectually impassable between the facts of physics and the facts of consciousness.

Since the minds and senses by the aid of which we make scientific discoveries are generated from eggs, the progress of embryological science must bring us around sooner or later to the old question: What is science? What is it to know a thing?

In this paper I shall show the fitness of biological science for helping us to reconsider this great question.

1. *May it not be that we understand a thing when we can tell what it means, and use it?*

Philosophers tell us we understand a thing *when we comprehend it,* but it is my purpose to ask whether the progress of biological science may not lead us to think, with Berkeley, that we understand a thing *when we can tell what it means and use it,* and whether this definition of science may

not help us out of the paradoxes of philosophy, and make the way clear for an embryological account of thinking men.

2. *The problem of knowing.*

Our sensations and thoughts and feelings have not taken place anyhow and at random. They have been so related in the past that one has been a sign which has led us to expect others, which have always come about as we expected if our knowledge has been sound and accurate.

When they have thus come about, we have known that *this has not been our doing.* We have known too that it is because it has not been our doing that natural knowledge has been useful to us.

One of the most practical questions that man can ask is this: When, and how far, is our experience a sound basis for confidence in things that we have not experienced—such things, for example, as the animal life of the Cambrian sea, the molecular constitution of matter, and my own embryonic history? Since an answer to this question has been included in past knowing, it must also be included in an account of knowing. It is this question that physical science undertakes to answer by scientific discovery, but the biologist must ask a still more difficult question: How do living beings come to do unconsciously, and without knowing it, the things that are to their advantage? How does a living being get safely through all the chances and changes of life without needing to run its nose into every danger before it avoids it? How do some men learn, from a single experience, what others fail to find out after a lifetime of experience?

3. *Our biological education begins at an early day.*

No institution, no period in the history of science, no stage in intellectual development, can lay claim to the beginnings of biological science. They are to be sought long before our entrance into laboratories; long before the beginnings of book-learning. Even before we learned articulate speech, the teacher whom the poet has called the grand old nurse took us upon her knee and began the wonderful story of nature for our delight and profit and instruction; that story to which there is no end; in which each chapter, as fresh and new as the first, adds new meaning, new usefulness to all we have been told.

Part, at least, if not the whole, of our early education was biological. We laid the foundations of anatomy and experimental physiology when we learned, through repeated scientific experiments, that it is through eyes that we see, through ears that we hear, through hands that we touch, and that it is good to see and hear and handle things. We were no doubt led, slowly and gradually, through innumerable scientific experiments, to the discovery that, among the changes that go on in nature, some are of peculiar interest and importance to us; and we thus come to set apart in our minds, from among the things of which our senses tell us, certain ones which seem, because of their clear relation to our comfort and discomfort, and because of the quickness with which we learn how to make use of them, to pertain to ourselves, and to constitute our bodies, as distinct from the world around us, which we are thus led to set over against ourselves, as a not-self. It seems to me that it is in this way that we lay a foundation, in the conception of a living body, for all later study of biological science, and no naturalist can doubt the great and permanent value of this conception; yet there is no more fruitful source of paradox and contradiction and absurdity than the words in which we attempt, at a later stage, to describe this scientific discovery; for while a scientific discovery is part of the language of nature, our words

are, unfortunately, an inheritance from the language of scholasticism.

4. *Education is often unconscious.*

One may be educated without knowing it. The teacher who guides instead of driving is nearest the method of nature. The best of all training is that which is acquired with least effort, and some of the choicest fruits of intellectual activity have come when effort and self were lost in the inspiration of creative genius.

The untrained muscles of the infant are educated through exercise, but it is not in self-consciousness that the child and the kitten and the colt and the calf delight in frolics and gambols and sports and games. It is only after the human infant has spent weeks in experimenting that it acquires the useful art of moving its eyes together, and of seeing objects single and solid, instead of flat and tremulous. I do not know whether the child is conscious or unconscious of this lesson in the physiology of vision, but it is, assuredly, not through induction from particulars and deduction from laws that the nutritive and nervous changes come about, through which the muscles of the eyeball become coordinated, yet these are educational changes. So far as education is shown by doing the things that are advantageous, and in avoiding those that are injurious, the ancestral rhizopod, which extends its pseudopodia under the stimulus of fit food, and retracts them on the approach of danger, is educated, for our biological education begins long before our birth, and we are born educated. It is this truth, no doubt, which has led some to the strange notion that life is memory.

5. *The things we do most easily, or most naturally, are not always the wisest things.*

The history of our minds, like that of our bodies, has been such that the things we do most naturally are not in all respects the best for our present needs. Just as there are bodily parts which, while fitted for past conditions, are no longer useful, and just as we have natural impulses and appetites which now call for repression, so it is also with our minds; for we are in continual danger of a logical fallacy which it is the peculiar work of natural science to correct, since it is an incidental result of our natural history. This is the fallacy known to logicians as the fallacy of the undistributed middle—the fallacy which consists in mistaking a part for a whole.

6. *The fallacy of the undistributed middle is constitutional.*

Our bodies are so constituted that an action which is at first performed with difficulty becomes easier with each repetition, while departure from established custom at the same time grows harder. It is this peculiarity which fits our bodily frame for improvement by practice and training. In this, our minds are like our bodies, for a path which our thoughts have once traversed becomes easier with each new venture, while it grows harder for us to consider what lies beyond the borders of this path.

The facts of nature do not all interest us equally. Some are more attractive to us than others, and we must specialize to make progress in knowledge, so we are continually and unconsciously fixing attention upon some part of nature, for some purpose of our own, and considering it 'in itself,' to the neglect of that which does not interest us, nor seem to concern us.

Our minds, as they have come to us in course of nature, are so constituted that, when we consider a part as if it were the whole, we are in danger of forgetting that it is but a part and not the whole; and if we make this mistake, we may be led into opinions which seem to be the logical conclusions of sound reasoning when they are nothing more than new illustrations of the

threadbare fallacy of the undistributed middle.

7. *Philosophical agnosticism comes from mistaking a part for a whole.*

When, for some purpose of our own, we become interested in a part of nature, neglecting, for the time, as of no interest to us, its interrelations with other things, we may fall unconsciously, from the very nature of our minds, into the belief that what we have treated as if it were independent of the rest of nature, and complete in itself, is really independent and complete. Thus we come to regard mental abstractions as independent things, and then, finding that our abstractions have no independent being outside our minds, we ask the absurd question whether the real world of nature is anything but an abstraction and a chimera of our fancy, and set ourselves to making systems of philosophy to pull us out of the quagmire of agnosticism into which we think we have fallen.

Berkeley shows that it is because we call all sheep and all crows and all triangles and all numbers by generic names, that we think we can know a generic sheep and a generic crow and a generic triangle and a generic number—that is, a sheep and a crow and a triangle and a number which are not individual and particular sheep and crows and triangles and numbers; and he believes that it is nothing but language which makes us so ready to mistake abstractions for independent things, and then to think that because no real thing exists abstractly we can never know anything as it really is; and he shows that 'we need only draw the curtain of words to behold the fairest tree of knowledge, whose fruit is excellent, and within the reach of our hands.' So firmly rooted in our minds is the notion that abstract words stand for *things as they really are,* that Berkeley, who only asks us to use our utmost endeavors to obtain a clear view of the things we would consider, 'separated from all that dress and encumbrance of words which so much contributes to blind the judgment and divide the attention,' is commonly held to deny the reality of *things,* because he denies that any real thing exists abstractly.

Tyler traces our habit of mistaking abstractions for independent things, and the doubt of the reality of *things* which arises in the mind of the philosopher when he discovers that no real thing exists abstractly to the primitive culture of savages, and it is, no doubt, because there is still much of the savage in us all, that we try to distinguish the appearance of things from those things in themselves of which the appearances are thought to be the ghosts.

May we not trace still farther back the habit of mistaking abstractions for independent things, and ask whether it may not be an unfortunate incidental result of that fitness of living beings for education which is older than the trilobites?

It is not the value nor the reality of generalizations, but their independent, or abstract, reality, that is called in question. A generalization is as real as a pain, and, like a pain, it may have the greatest value, and call our attention to other real and important things which might have escaped notice, and it may thus help us to foresee or direct nature.

If the pain were not my pain it would not be at all; yet, while its being is relative to me, this relation to me is not all the being it has. No fact is more certain than that I do not make my pain, for if it were my doing it could not call my attention to unnoticed things, nor have any value as a warning of danger. Is it not ignorance of this simple truth which has led some to think that our pain is our own doing, and that we need only stop doing it to make an end of it?

All I know about the trilobites and the moons of Jupiter is relative to me; yet the trilobites were real millions of years before any naturalist knew them, and the moons of Jupiter would, no doubt, still be real, even if all life should come to an end upon earth.

8. *Our bodies are real, but their reality is in their interrelations with our environment.*

The child's discovery that its body is of peculiar interest and importance to it, and peculiarly within its control, is a real scientific discovery. Living things are real things, and we can never know too much about them; but their reality is in their interrelations with the rest of nature, and not in themselves, nor in their relations to us. Surely this is good sense and good science. No physiologist who studies the waste and repair of living bodies, no naturalist who knows living beings in their homes, no embryologist who studies the influence of external conditions upon development, can, for an instant, admit that living beings are self-sufficient or self-sustaining, or that their being is in themselves; for the line we draw, for better study, between living beings and the external world, is not one that we find in nature, but one that we make for our own purposes.

The external world of a living thing is as much a part of it as its histological structure. If the environment of its body, or of any cell within its body, were different, neither cell nor body would be what it is, and if they had no environment they would not be at all, for neither eggs nor seeds nor desiccated rotifers exist abstractly. A self-sufficient and self-contained living thing is as fabulous as a griffin or a centaur, but no naturalist thinks for an instant that this truth casts any doubt upon the real existence of living things.

If the being of a living thing is in its interrelations with the world around it, as Berkeley tells us it is, and not in its interrelations with us, as the philosophers tell us it is, is it not clear that we can never hope to know all there is to know about it? But is it not equally clear that, so far as we do know it, we know it as it is?

Does the responsibility for the notion that we can never know a living being as it really is rest upon the shoulders of the naturalist who knows that its being is dependent and relative? Is it not rather to be laid to the charge of the philosopher who believes in its abstract or independent existence, and is led to doubt its reality by the discovery that abstractions have no independent existence?

Locke reminds us that "we see and perceive some of the motions and grosser operations of things here about us, but whence the streams come that keep all these curious machines in motion and repair, how conveyed and modified, is beyond our notice and apprehension; and the great parts and wheels, as I may say, of this stupendous fabric of the universe may, for aught we know, have such a connection and dependence in their influences and operations one upon another, that perhaps things in this our mansion would put on quite another face, and cease to be what they are, if some one of the stars or great bodies, incomprehensibly remote from us, should cease to be, or to move, as it does. This is certain: things, however absolute and entire they seem in themselves, are but retainers to other parts of nature, for that which they are most taken notice of by us. Their observable qualities, actions and powers are owing to something without them; and there is not so complete and perfect a part that we know of nature, which does not owe the being it has, and the excellencies of it, to its neighbours; and

we must not confine our thoughts within the surface of any body, but look a great deal farther, to comprehend perfectly those qualities that are in it.''

9. *The being of things is real, but is it in themselves, or in their interrelations?*

Is it as a self-contained and self-sufficient being, or as part of the universe, that the stone illustrates the law of gravitation?

When Sir Isaac Newton made his speech about the child and the pebble: ''Did he mean,'' asks Dr. Holmes, ''to speak slightingly of a pebble? Of a spherical solid which stood sentinel over its compartment of space before the stone that became the pyramids had grown solid, and has watched it until now! A body which knows all the currents of force that traverse the globe; which holds by invisible threads to the ring of Saturn and the belt of Orion! A body from the contemplation of which an archangel could infer the entire inorganic universe as the simplest of corollaries! A throne of the all-pervading Deity, who has guided its every atom since the rosary of heaven was strung with beaded stars!

''The divinity student honored himself by the way in which he received this. He did not swallow it at once, nor did he reject it; but he took it as the pickerel takes the bait, and carried it off with him to his hole (in the fourth story) to deal with at his leisure.''

10. *May not the notion that our minds are in our heads be due to the fallacy of the undistributed middle?*

Our welfare and our existence depend upon the soundness and safety of our brains, and knowledge of real brains and their functions is of the utmost value and importance, but would it have any value if, knowing only the appearance of brains in our minds, we were altogether put off with false appearances, and could never know brains as they are in themselves?

If the being of a living brain is not in itself, but in its interrelations with nature, we do know brains as they really are when we discover these interrelations; but if the being of a brain is not absolute and independent, but dependent and relative, what are we to think of the notion that our minds are shut up inside our heads? May not this also be an illustration of the fallacy of the undistributed middle? My mind to me a kingdom is, but I find no reason to think this kingdom is a microcosm—a little world set over against the great kingdom of nature. My kingdom is the great universe itself, the starry heavens, and the geological history of the earth, and everything else I know, and my mind grows as more and more of nature becomes mine by right of discovery. So far as I know the Ichthyosaurus and the rings of Saturn, these things are in my mind; and if the things I know were really shut up in my skull, these things would be inside my skull; but there is no room there for real whales and real megatheriums, so philosophers tell me I can never know anything as it really is, because the only universe I can think of or consider is the one I know.

Stone walls do not a prison make, nor iron bars a cage. May we not owe to the fallacy of the undistributed middle—to our useful ability to fix our attention upon a part of nature, and to temporarily neglect that which does not for the time interest us nor seem to concern us, and to the carelessness which permits us to think that what we have considered by itself for our own purposes is really self-contained and self-sufficient—may it not be to this that we owe the notion of a mind shut up in a head, and knowing nothing but the dissected and distorted shadows which the unknown and unknowable real world casts on the walls of its prison through its narrow and grated windows?

11. *Illusions and hallucinations do not show that the world I know is unreal, nor do they show that its reality is relative to me.*

Deceptions and illusions and hallucinations are not unreal. They are matters of fact of which the physiologist and the pathologist and the physician are finding out the meaning, and finding too a way to make use of this meaning, by scientific discovery, while common folks mistake their meaning, just as we mistake the meaning of other matters of fact when we think we know more than we have found out.

Comprehension is the gathering in of generalizations into a hypothesis, but while any plausible hypothesis may satisfy idle curiosity, it has no scientific status unless it leads to the discovery of facts and the control of nature.

When the ignorant man who has lost his foot feels the sensation which he has learned to call pain in his toes, he says his foot is uneasy in its grave. When the learned philosopher tells him his pain is an illusion, he may justly declare that he knows his own feelings better than any one else, however learned. The pain is real, but when he satisfies himself with the notion that his foot is uneasy, he mistakes a hypothesis for a fact, like the philosopher, while the man of science discovers that the sensory nerve is irritated somewhere else than at its endings in the toes.

12. *Instead of showing that we can never know anything as it really is, may not the notion that knowledge is comprehension be a new illustration of the fallacy of the undistributed middle?*

We comprehend things when we know them, but it does not follow that when we comprehend them we know them, for knowledge may be comprehension and something more.

The resemblances between things are summarized by classifying or comprehending them, but Locke has reminded us that knowledge is the discovery of resemblances *and differences.* So far as we know nature, it exhibits universal order in endless diversity; not order here and diversity there, but order in diversity. Can we know any two things are alike without knowing they are different? We may, for some purpose of our own, fix our attention upon the order of nature, neglecting the diversity, but things do not cease to be because they do not, for the time, seem to concern us.

Are the order of nature and the diversity of nature either two things or one thing seen from two standpoints? Are they not rather two narrow and imperfect views of the natural world which lies before our eyes? Have we any way to find out either the unity of nature or the diversity of nature except scientific discovery? May not the notion that while we discover the laws of nature, we deduce from these laws the diversity of nature, and our control of nature, be an illustration of the fallacy of the undistributed middle? Is a scientific law anything more than a summary of past experience, *joined to confidence in the continuity of nature?* Do we ever know that we can foresee or control nature, even in repeating the simplest scientific experiment, until we have succeeded?

13. *Biological science is peculiarly fitted for calling to our attention the diversity of nature.*

While analytical science is making marvellous revelations of the order which pervades the apparent disorder of nature, showing us, by the method of analysis and generalization, the most astonishing proof of order and regularity in the course of events which had seemed to be chaotic, biological science is continually recalling to our attention the diversity of the statistical data, and making equally marvellous

and equally instructive, revelations of the inexhaustible variety of nature. We talk about humanity, but we know and deal with Peter and Henry and Thomas and Black Jim and Yellow John. We need proper names for all the animals that we are well acquainted with. The zoologist tells us about the genus *Equus,* but if he has any practical dealings with horses, he never says one horse is the same as another, or even that a horse is the same to-day as he was yesterday, for even if he be neither sick nor lame nor hungry, he is one day nearer the end of his usefulness.

The botanist talks learnedly of *Chrysanthemum indicum,* but the florist sells golden wedding and ivory and fair dawn and snow queen and hundreds of others. For many scientific purposes it is necessary to give proper names, or designating numbers, to seedling plants, and it may be that if the chemist were dealing with individuals, instead of averages, he might need proper names to tell to others his discoveries about molecules and atoms.

14. *Are identity and diversity absolute or relative?*

To-day's sun is the same as yesterday's, yet the changes which go on in the sun, from day to day, are, no doubt, violent and rapid beyond our utmost means of measurement or expression. We say to-day's sun is the same as yesterday's when we are interested in the dawn and the daylight, and in the flight of time, and in the change of seasons, and in the transit of Venus, and in the stability of the solar system; but we say it is not the same when we are interested in sun-spots, and in the fall of meteorites, and in combustion and the dissipation of energy. When we say the solar system is stable, we do not mean that it is really stable. We only mean that the course of its progress from some past condition to some future condition has no obvious practical relation to our own affairs.

We seldom lose sight of the diversity, or individuality, of familiar living things in our interest in their resemblances. We do not say one horse is the same as another between the shafts. We say he is as good as another, or will serve, or that he is the same *substantially,* meaning, by these words, the *same substantially,* or *the same in substance,* that, while he is not the same, we will accept him as a substitute; but no one with worldly wisdom trusts the strange horse, even so far, before he has tested his opinions, and those of the horse dealer, by scientific experiment and verification.

Biological science has peculiar fitness for guarding us from the fallacy of the undistributed middle, and for teaching us that it is only through verification that guesses become knowledge, because its subject matter lies midway between those 'exact' sciences in which we are told that figures cannot lie, on the one hand, and, on the other, those social and political sciences which show us continually how easily one may lie with figures. When we have verified a hypothesis so often that we are 'satisfied,' we call it a 'law of nature,' and we build as firmly upon it, and trust to it as implicitly, and govern our actions by it as unhesitatingly, as if it were certain, and in all that concerns our conduct we make little or no difference between it and certain knowledge. In this, experience is continually demonstrating our wisdom, but if the discovery that hypotheses have no independent existence leads us to believe that we can never know the real world of nature, is it not time to reexamine our notions?

The laws of nature are real, but their reality is not independent nor absolute, because the unity of nature is unity in diversity, and diversity in unity.

If the views that are here advanced—views that are in no way original with me—are accepted; if the reality of the nat-

ural world is in the interrelations between things, and not in unknown and unknowable things as they are in themselves; does it not follow that scientific discovery is the only way to learn the differences between things, just as it is the only way to learn the resemblances between things? When we say two things are the same, must we not also say what are the relations with reference to which they are the same? When we say they are different, must we not also say what are the relations with reference to which they are different? Is there any way except scientific discovery to find this out?

15. *The biological problem of species.*

Fifty years ago many naturalists thought that all living things of a kind are fundamentally and absolutely alike in certain specific characters, and that it is only in characters that are not specific that they differ; but more exact study has failed to show us, in any living being, any characteristic whatever which does not exhibit diversity from others of its kind, as well as resemblances; for the notion that certain characters are generic, while others are differential, is an illustration of the fallacy of the undistributed middle, as is also the attempt to analyze living beings into *characters*.

After the long controversy between those who asserted the immutability of species, and those who declared that species are mutable, seemed to be happily ended by the scientific demonstration that species have a natural history, there arose a new school of naturalists, who asserted that species have no existence in nature because no two living beings are identical in any respect whatever. At the present day, many naturalists are returning to a modification of the old notion of species, and are teaching that while the mutability of species is due to changes in the interrelations between living beings and the world around them, stability is inherent in the living beings, *as they are in themselves* by birth.

If the view which is here advanced be correct, the specific stability of the individuals of a species is real, and as independent of us as the stability of the sun in the heavens, but when we say the individuals of a species are alike, we must also say what are the relations with reference to which they are alike, for the stability of species and the mutability of species are not two facts, nor the same fact from two points of view, but two narrow and imperfect views of the same fact.

Thus, for example, individual sheep are alike for certain purposes of the zoologist and the paleontologist. They are alike to the embryologist and to the anatomist, and to the physiologist, so far as these scientific students are not concerned with their differences. They are, no doubt, alike to the hungry wolf, and to the geese that graze in the same pasture—to their competitors and enemies in the struggle for existence. They are alike in their sexual affinity, so far as there is no sexual selection. They are alike in the physiology of reproduction, and in their physiological activity in general, so far as they do not differ in fertility and in constitution. On the other hand, they are different to the stock-breeder, and to the shepherd, to the shepherd's dog, to their lambs, and, no doubt, to each other.

As we learn more about sheep, we learn more about their identity and more about their diversity, but this does not show that the identity and diversity are in us and not in nature. It only shows that neither the identity nor the diversity has any independent existence in nature abstracted from the living beings.

16. *Are inheritance and variation two processes, or two partial and imperfect views of the same process?*

If no two individual living beings are alike; if the stability of biological types means that the aberrant have been exterminated in the struggle for existence, and if the modification of a type is an indication of a change in the standard of extermination; are not inheritance and variation two partial and imperfect views of the selective process? When the embryologist seeks in the germ for the material basis of inheritance, and for the mechanism of variation, is he not searching for something which has no independent existence? Must he not seek, in the interrelations between living beings and their environment, and not in the living beings *as they are in themselves,* for that of which he is in search? Do not they who think that natural selection must be supplied with the raw material by a mechanism for variation before it can *do* anything, both personify the selective process and forget the diversity of nature?

17. *Does physical analysis give an adequate account of the organization of living bodies?*

Physical analysis resolves organized beings into organs and tissues and cells and physiological units, but does this analysis give an adequate account of organization?

The bodies of two allied animals are alike in structure. They are composed of organs which are said to exhibit fundamental unity *behind* superficial diversity, for they are practically identical in history, and for most of the purposes of the anatomist and the physiologist and the zoologist. From this point of view, and from many others, they are identical in structure, yet the differences between them do not cease to be because they do not concern us, nor because they escape our notice, for while the identity is real and important and significant, it has no abstract, or independent, reality.

'Were the heart of one man,' says Maudsley, 'to be placed in the body of another, it would probably make no difference in the circulation of the blood, but it might make a real difference in the temper of his mind.' Does not the analogy of nature lead us to ask whether it might not be expected to make a difference in the circulation of his blood as well as in the temper of his mind? If our knowledge of hearts were as minute and individual as our knowledge of men, might we not need a proper name for each heart as much as we need one for each man?

If the interest of the histologist in the resemblances between the tissues of one animal and those of another leads him to lose sight of their constitutional differences, he is in danger of mistaking an abstraction for a reality, for while the scientific basis of histology in the resemblances between the tissues of one animal and those of another is real and significant, it has no abstract, or independent, reality.

"From the morphological standpoint," says Hertwig, quoting from de Vries, "we may properly regard the cell, apart from the organism, as an individual, but we must not forget that it is by abstraction that we do so. Physiologically the cell is an individual only when actually isolated and independent of an organism. From this standpoint, every abstraction is a blunder."

When we say a multicellular organism is a unit, must we not also say what are the relations with reference to which it is a unit? When we say its constituent cells are units, must we not also say what are the conditions with reference to which they are units? Have we any way to find these things out except scientific discovery?

18. *Is cell-differentiation inherent or induced?*

A thoughtful and distinguished naturalist tells us that while the differentiation of

the cells which arise from the egg is sometimes inherent in the egg, and sometimes induced by the conditions of development, it is more commonly mixed; but may it not be the mind of the embryologist, and not the natural world, that is mixed? Science does not deal in compromises, but in discoveries. When we say the development of the egg is inherent, must we not also say what are the relations with reference to which it is inherent? When we say it is induced, must we not also say what are the relations with reference to which it is induced? Is there any way to find this out except scientific discovery?

19. *Are the beneficial effects of practice and training and education and opportunity innate or superadded?*

Can we hope to answer this question, *a priori,* by deduction from hypotheses? Is there any more value in Weismann's demonstration that acquired characters cannot be inherited than there is in Haeckel's declaration that the inheritance of acquired characters is a necessary axiom of the monistic creed?

Such facts as are in my possession seem to me to show that, while we need opportunities to make the best of our natural abilities, no one can do his part in any station in life without natural aptitude. As my opinion is not a deduction from a hypothesis, I hold it lightly, and subject to revision and correction.

20. *May not the biological notion of a living substance be an illustration of the fallacy of the undistributed middle?*

When we say all living things are alike in substance, I cannot discover that we mean anything more than we mean when, admitting some report of a conversation as a substitute for the truth for some purpose that we have in view, we say it is the same in substance as the original conversation.

The modern naturalist is so well aware of the endless diversity of living things that he never—that is, hardly ever—thinks that because one amœba, or one yeast-plant, or one horse, will serve certain purposes of experiment, and demonstration, and instruction, as well as another, they are alike in any respect whatever.

21. *Conclusion.*

As my only purpose is to do what I can to make the way clear for the progress of embryological science, by trying to free my own mind, and the minds of others, from all notions which imply that embryological science is impossible, and not to give a natural history of mind, I have passed by many important aspects of human knowledge without notice. But, before I close, I ask you to take away with you, and to consider, this familiar fact: Philosophers tell us we may come at truth by deducing it from certain first principles which are self-evident to the normal man, and they talk about the normal man as if he were a prominent citizen, the familiar acquaintance of all who have any claim to be considered men of intellect, and a well-known face even to the common herd. The naturalist declares he knows no such person, that all men are individual and particular men, and the normal man a fictitious character, and a statistical average without opinions.

If the naturalist is honest with himself, it seems to me that he cannot fail to come in time to hold his most cherished convictions subject to revision, and to value them only when they are verified by laying them alongside nature, and to regard absolute truth and necessary truth as meaningless words, because the being of things is not absolute but relative to everything else in nature.

The truth that knowledge is not absolute, but relative, is held to be the final and conclusive proof that we can never know anything as it really is, for we are

told that the reality behind the phenomena of sense must be unknown and unknowable, because we can never come at absolute truth. But may not the naturalist be moved to ask whether the conclusion follows from the premises? May it not prove to be only the final transformation of the protean fallacy of the undistributed middle? Instead of showing that we can never know anything as it really is, may not the relativity of knowledge show that nature, as it really is, is relative and dependent—that its being is not in itself? "As no man fording a swift stream," says Huxley, putting into vigorous English a thought that has often found expression; "as no man fording a swift stream can dip his foot twice in the same water, so no man can, with exactness, affirm of anything in the sensible world that it is. As he utters the words, nay, as he thinks them, the predicate ceases to be applicable; the present has become the past; the 'is' should be 'was,' and the more we learn of the nature of things, the more evident is it that what we call rest is only unperceived activity. Thus the most obvious attribute of the cosmos is its impermanence. It assumes the aspect not so much of a permanent entity as of a changeful process, in which naught endures save the flow of energy and the rational order which pervades it."

Every reflective student will, no doubt, feel a responsive chord vibrating in his own thoughts in unison with those of Huxley; but should he not ask himself whether the words, '*flow of energy and the rational order which pervades it,*' mean anything, except that the reality in which the flowing river of nature endures and has its being is rational energy, the energy of a reason, the activity of a mind?

Biological science seems to me to show, with ever-increasing emphasis, that it is in one sustaining mind that we ourselves, and all we know, or can hope to know, have being. Even if this be neither absolute truth nor necessary truth, may it not be that still better truth, a scientific discovery; and the greatest of all scientific discoveries because it has, so far, been verified in every act of knowing?

W. K. Brooks.

Johns Hopkins University.

---

*THE NATURE OF NERVE STIMULATION AND OF CHANGES IN IRRITABILITY.**

As the conclusions of this paper supplement those of Professor Loeb, and as he is unable at present to publish an account of his work simultaneously with mine, a brief statement of the relationship of our work appears to us both to be desirable.

It is well known that Professor Loeb has for the past several years been applying the conclusions of physical chemistry in the investigation of the phenomena of life, as he was convinced that these conclusions would clear up many physiological phenomena. Of the several discoveries which have rewarded his insight there are two of apparently the most fundamental nature. One of these was made several years ago and published in *Fick's Festschrift* in 1899. It consisted in the demonstration that muscle would only beat rhythmically in solutions of electrolytes. This practically established the fact that contractility was in its essence an electrical phenomenon. About two years ago he expressed to me the opinion that other life phenomena were electrical, and not chemical or thermodynamical. A second fundamental generalization was made last summer at Woods Holl and published in *Pflüger's Archiv,* Volume 88, 1901, to the effect that the toxic and antitoxic action of salts was a function of the number and sign of the elec-

* This paper was prepared for publication early in January, but has been delayed in its appearance.