THE PHILOSOPHY OF A BIOLOGIST[1]

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WITH the progress of science we become more and more aware of the undiscovered, and of our feebleness to visualize or express what is dimly known to us. Geologists estimate that man evolved some 1,000,000 years ago on an earth which astronomers say is some 2,000,000,000 years old. Caution is required in accepting such figures, for we must remember how far out Lord Kelvin was in estimating the age of the earth—before the discovery of radium. Man has been civilized for some 5,000 years, and Galileo, with his telescope and revolutionary ideas, lived some 300 years ago. There may be, we are told, a million million years before the sun grows weak and the earth becomes farther from the sun so that all life freezes. Long before this man may use up the metals available for his machines, and those ready sources of energy now so wastefully used, by which he at present multiplies and swarms in cities. In such case he will return through birth control or famine, or both, to a simple, uncrowded, pastoral existence. There is little likelihood of his being able to use atomic energy, other than that which reaches the earth as sun radiation and is available directly or as energy stored in water-power, wood, coal, and oil.

Research in the laboratory is based on simple relations between cause and effect, and the scientific knowledge so gained hour by hour is vastly extending inventions, only by means of which men swarm in cities.

At the present time we have among us great astronomers and physicists, and every new experimental observation is tested as to whether it can be explained by existing theories; and if not, to find the modifications necessary to include it in the general theoretical scheme of natural processes. The formulæ of modern science are judged by their capacity for describing the phenomena of nature with simplicity, accuracy, and completeness. It does not matter whether the formula corresponds to ultimate reality, for all progress is made and tested by experimental operations. "The essence of a physical theory," says J. J. Thomson, "is that it should be expressed in terms of concrete quantities of which we have experience, and transcendental space is not one of these." An attempt is made to form a model which will supply a mental picture of what is taking

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place in the physical phenomena under consideration. Faraday was so guided; there is not an algebraical symbol in his *Collected Researches*. The admitted incapacity of scientific men to grasp reality does not, therefore, justify anyone turning to table-rapping, spookery, and other modern witchcraft. Theory—regarded as a tool, not a creed, and based on operation and observation—has led astronomers, physicists, and biologists over and over again to fresh operation and observation and new discovery. Spookery and telepathy have added nothing to human knowledge.

"That which captivates their reasons and leads men of sincerity blindfold from common sense," says Lock, "will, when examined, be found to be some independent ideas of no alliance to one another, by education, custom, and the constant din of their party, so coupled in their minds, that they always appear there together; and they can no more separate them in their thoughts than if they were but one idea, and they operate as if they were so. This gives sense to jargon, demonstration to absurdities, and consistency to nonsense, and is the foundation of the greatest, I had almost said of all, the errors in the world." "Let custom from the very childhood have joined figure and shape to the idea of God, and what absurdities will that mind be liable to about the Deity."

While the Assyrians some four thousand years ago accurately noted movements of the heavenly bodies, and the Greeks laid the foundations of mathematics and even conceived the motions of the solar system and an atomic structure, the recent discoveries of electricity, X-rays, cathode rays, radio-active elements, the perfected methods of observation afforded by the modern telescopes, microscopes, spectroscopes, electrometers, and amplifying valves, etc., have, with the help of mathematical equations such as Maxwell's, which were, be it noted, founded on a model, so widened knowledge that we are the first to have evidence of an infinitely large and an infinitely small universe. The astronomers have evidence of the existence of two million nebulæ, each spinning a universe similar to our own galactic universe; in this alone there exist some millions of stars. Light travelling 186,000 miles a second, has taken 140 million years to reach us from some giant star just visible in the most distant nebula. Bigger telescopes will reveal more and yet more nebulæ. If a circumference be set to this universe containing unknown millions of nebulæ, probably only about 20 per cent. so far are visible, may not this universe be but a unit in something bigger? We are told that the number of the stars in the whole of the two million nebulæ is such that if stars were grains of sand, the grains would cover the whole of England hundreds of yards deep. Our earth is one millionth part of one such grain, and we bother ourselves over questions of social rank. In estimating his position in the universe, man, says

Jeans, "had been guided mainly by his own desires and his self esteem; long fed on boundless hopes, he had spurned the simpler fare offered by patient, scientific thought . . . henceforth he must reconcile himself to the humbler position of the inhabitant of a speck of dust and adjust his views on the meaning of human life accordingly." Some astronomers tell us that radiation of the sun and stars is produced by the formation of helium out of hydrogen and by the annihilation of atoms, that heat can only do work by becoming colder, and the energy of the universe is running down, and so vast are the cold regions of space that in the end energy will be dissipated into a universal increase of temperature negligible in amount. The argument is then that the present matter of the universe cannot have existed for ever; an upper limit of its age has been assigned at some 200 million million years. But, as J. S. Haldane points out, a greater and greater part of the energy of matter will not be dissipated as the temperature falls.

It is conceivable that radiation of shorter wave-length and higher availability than any known in the present universe might have created such a universe by the running down of energy, and might have crystallized into electrons and protons and finally formed atoms. Out of a chaos of radiation came the nebulæ, and out of these the stars by condensation of whirling gaseous matter. "If we want," says Jeans, "a concrete picture of such a creation we may think of the finger of God agitating the ether," or be content to say creation is unknowable. It is conceivable that there is an infinite supply of short wave-length radiation in internebular space which is evolving into matter, that the finger of God continues, and will continue for ever, to agitate the ether. Millikan and Lodge have suggested that scattered star radiation somewhere reconstitutes itself into matter. If so, the evolution of the universe may be without beginning or end. We are told that the planets were not, as Laplace conceived, formed, with the sun, out of a whirling nebula, but out of a tidal stream of gas drawn out of the sun by the near approach of another star; a phenomenon so rare in the empty vastnesses of space that the earth, with the atomic structure and restricted conditions possible for life, may be, and perhaps is, unique.

All matter is now conceived of as resolvable into atoms, each comparable to the sun with its planets, but so small that the size of an atom bears the same relation to a drop of water as the drop to the earth. Atoms of all elements more complex than hydrogen are, it is thought, composed of a highly condensed nucleus positively charged, consisting of hydrogen units or protons together with some negatively charged electrons, and containing nearly the whole mass; around this nucleus spin other negatively charged electrons in various fixed orbits. Every atom can be activated by radiations coming from

the sun and universe, but when not excited, each atom of the lighter elements common on earth sinks in time to a state in which its electrons occupy orbits of lowest energy, one in each, and then continue in these orbits without dissipation of energy. It has been shown that the various wave-lengths of radiation are endowed with various quanta of energy. On collision with atoms the energy of any quantum which is in tune with an electron is given up to it and this electron is then emitted—the photo-electric effect. There is emission of electrons only when quanta of the right value are available. When electrons return to their orbits in the atoms radiation is emitted, and here again the emission is only by complete quanta. The pathways of alpha particles and electrons emitted by radium and the result on these pathways of a collision of an alpha particle with an atom have actually been photographed. By photographing the behaviour of a hydrogen atom or proton penetrating, or reflected by, a calcite crystal, Dempster has been able to show that it is in a state of continuous motion at tremendous speed. The theory of atomic structure is so far confirmed by observation.

Different methods of experimental observation have led to the conclusion that both matter and radiation exhibit, on the one hand, the properties of undulatory phenomena, and on the other, those of particles. Electrons are not merely point charges of electricity, but carry a train of waves with them and these allow them to spin in certain orbits of a simple numerical relation and in no other; only one electron can occupy each orbit; an electron can jump only from one of the possible orbits to another; to effect the jump, a certain quantum of energy is required, neither less nor more will suffice. When the train of waves is taken into account, the classical theory of dynamics gives the requisite distribution of orbits in the atom (J. J. Thomson). We have been told that it is probably as meaningless to discuss how much room an electron takes up as it is to discuss how much room a fear, an anxiety, or an uncertainty takes up; that the quantum theory succeeds in keeping the universe in existence as a going concern, but it is difficult to form even the remotest conception of the realities underlying all these phenomena.

The train of waves determines the pathway the electron travels and the form of the waves is determined by events happening at a distance and propagated through space in the form of waves.

However far from reality be such conceptions, we know that electrons are given off by the hot filament of the wireless valve, and that the forces in the oscillating circuit control their motion, that electrons are set free by light in photo-electric cells which make television and "the talkies" possible. They have become articles of commerce and the foundation of great industries.

We are told that when protons and electrons fall together and

radiation is produced in the stars by the annihilation of atoms, the energy produced is "so great that the annihilation of one drop of oil would suffice to drive the *Mauretania* across the Atlantic."

"The atoms in a room," says Eddington, "are rushing about in all directions with a speed of a fifth of a mile a second; if the temperature could be raised to 20,000,000° C. they would be going at 50 miles a second. In the very core of the sun and stars the temperature is twice as high, and the substance consists of stripped atoms or ions with vast quantities of free electrons. The electrons of atoms forced off by X-rays combine again, to be forced off once more, and so on. An X-ray on forcing out an electron is absorbed; when the electron combines again the X-ray comes out. Radiation of all wave-lengths finally reaching the surface through the screen of atoms is emitted into space. It is conceived that the main mass of the central region of the stars consists of immensely heavy liquid supra-radio-active atoms with atomic numbers just above those of the known radio-active elements.

"Primeval matter," says Jeans, "has gone on transforming into radiation for millions of millions of years until, by the rarest accident, gas consisting of the lighter and most inert atoms was torn out of the sun and condensed into a planet whereon the physical conditions became such as to make life possible. There is nothing to favour the view that life reached the earth from elsewhere, and we know nothing of the primeval physical conditions which led to its formation, but we do know that life is only possible in complexes of atoms which are relatively quiet and stable and shielded from excess of radiation, and that all life is kept going by the radiant energy of the sun, either directly received or absorbed in the food. Electrons are forced out of the atoms of living cells by light and ultra-violet rays, by X-rays, and by gamma rays of radium which come out of the soil and which are now used in concentration to kill cancer cells. Unfortunate girls who painted clock-dials with luminous paint containing a radium salt and sucked their brushes have died owing to the radium which, once absorbed, never left the body and ceaselessly continued to give off its destructive rays. X-rays can be used for sterilization and in smaller doses for producing mutations in germ cells. There are still shorter wave-lengths probably produced by cosmic annihilation of atoms; some of these have the power to penetrate through 16 feet of lead. Coming from inter-nebular space these cosmic rays knock electrons off millions of atoms in our bodies every second with what physiological result we do not know. They must help to create a fresh configuration of the living cells from instant to instant, and possibly are one cause of mutations which spring from germ cells.

Photo-electric effects produced by the action of ultra-violet rays

on the most superficial living cells of the skin is the cause of sunburn. A substance called ergo-sterol, existing in these cells in minute amount, when activated by the right wave-length and intensity forms a vitamin necessary for growth and prevention of rickets. Exact measurement has shown that as little as eleven quanta of radiation of green light suffice to stimulate the retina and provoke vision. If this amount of energy were turned into heat and conserved without loss it would take some hundred million years to heat a gramme of water one degree centigrade. If telepathy were possible, why should nature evolve an organ with such extreme sensitivity?

"Life," says J. S. Haldane, "depends upon the maintenance of a balance of molecular exchanges between the cells and their environment. If the balance is disturbed so that, for instance, too many or too few water molecules and potassium, calcium, and sodium ions are passing from the blood to the tissues, or *vice versa*, life is imperilled. The case is exactly similar with oxygen molecules or with hydrogen and hydroxyl ions."

Between the cells and fluid medium of the body there goes on a ceaseless interchange of ions, that is, of molecules in an active state through loss or gain of electrons. Potassium salts, radio-active and emitting electrons, are present in living organisms. The healing power of certain natural mineral waters are now being ascribed to the active state of their constituents. Electrical currents due to movements of electrons accompany every form of vital activity such as conduction of nerve impulse, muscular contraction, and secretion. We all know the importance of the body temperature for maintaining active the processes of life. The brain cells soon cease to function when the molecular dance is lessened by cooling or increased too much by heating. Continued monotonous warmth produces sterilization in the male. In living processes, then, there is ceaseless play of radiation quanta or photons, electrons and molecules, but this play must not be too violent.

The physicist tells us to multiply the diameter of an atom by two thirds of the way to the sun, it would then become about two miles: the protons would be almost invisible specks, the electrons the size of sixpences, and the whole nucleus the size of a cherry. The structure of a speck of dust sufficiently magnified might appear as the midnight sky, supposing the nuclei of the atoms and their planetary electrons were luminous. So open is the atomic structure that if all protons and electrons of the atoms in the body of a man could, with the wave of a magician's wand, be packed together, the man would shrink to a speck.

A microscope magnifying a thousand times reveals the organism of suppuration called staphylococcus as a mere dot. Such a microbe

contains millions of atoms, and each of these electrons with trains of waves, and waves of what? we do not know. A non-filterable virus is too small to be seen under the microscope, and yet we know that if we take one drop of blood from an animal infected with a virus disease and dilute this ten million times and then take one drop of this dilution and inject into another animal and so dilute it to a very high degree, this injection may cause the disease. It is worth noting that in the very best vacuum which can be made there are estimated still to be some million million molecules per cubic centimetre, and that the purest water possible to distil fluoresces in the ultra-violet rays and so shows impurity.

We know that all substances are resolvable into one or more of 92 elements and that these form a series of increasing complexity of atomic structure from hydrogen (one) to uranium (ninety-two). Two of the elements have disappeared from the earth. A few elements, such as silicon, aluminium, and oxygen form most of the earth. The atomic number of each element is given by the number of electrons spinning round the nucleus, the positive charge of the nucleus being of corresponding value. Bombardment of atoms by rays given off by radio-active elements causes transmutation—but the dream of alchemists has not come true, there is no gold to be so made; the radio-active elements themselves transmute, undergoing an evolution into other elements; in doing so radium emits 3·6 million million particles per sec. per grm. The physicist has succeeded in making this count. Each emission is spontaneous, cannot be predicted, nor any cause for it assigned; it can neither be stopped, nor controlled.

The difference of substances depends on arrangements of atoms, their grouping into molecules and these again into complex particles such as form crystals and colloids. The ceaseless play of radiation keeps up a never-ending dance of all atoms, not only in each living cell, but in every particle of dust. The smallest particles under the microscope ceaselessly dance in the fluid medium; the molecules of a gas ceaselessly bombard the vessel containing them. A speck of dust or a drop of water is then to the seer neither less nor more marvellous and mysterious than the blue sky and sailing clouds, the flower, the nightingale and its song.

We know that the chemical elements are genetically related and fall into families; isotopes of the elements have been discovered which are comparable with individuals of a species. A pair of electrons together form something different from two electrons separately; on division something would be lost which could only belong to the whole (Eddington). Atoms repair themselves no less than organisms. An atom of copper which has lost an electron is no longer copper, it must be replaced. Loss and replacement ceaselessly go on

both in living and dead substances. If the organisms of a species show individualism, so do atoms, for chemical and physical constants are merely statistical averages of an infinite number of individuals summarizing a variable population. Atoms, no less than organisms, may retain their identity in spite of ceaseless change. If a central control is ascribed to organisms, it cannot be denied to atoms.

"Scientific determinancy," says Eddington, "has broken down, and that in the very citadel of its power—the inner structure of the atom. Matter has lost its fixed, rigid, and formal character." "Modern physical investigation," says J. S. Haldane, "of the atom and molecules seemed to be endowing them with something very like an individual life." "The similarities in behaviour," says Boycott, "between a hydrogen atom, an amœba, and a cat are, perhaps, really more significant than the differences." Smuts' holistic conception of life as a unity, which maintains and asserts itself, no less applies to the atom.

It has been asserted by a vitalist that crystals of a substance of the same size resemble each other completely, and grow by additions without change of chemical nature or release of energy, and that a drop of water is the same as any other drop, while individual organization and purpose are characteristic of organisms. But each atom is a complex, active, unknowable in ultimate nature as is a living cell. Each instant activity of either atom or cell is creative, the identity swings about a mean and is never the same for two moments. H. W. Carr says "a material thing has no evolution, and Science not only cannot discover, but cannot even represent the origin of life," to which Science answers that the whole universe is in evolution, and that it cannot discover or even represent the origin of matter. Carr says "there is present in the living thing an active principle organizing it to carry out a set of self-interested purposive actions." Science answers, "Can we deny self-interested purposive action to the spontaneous emission of alpha particles of radium and the play of quanta and electrons?" We do not know.

It must be borne in mind that individualism is not a general characteristic of organisms, for just as electrons form atoms and atoms form molecules—and these crystals or other complexes—so there are innumerable species of lower animals which at times coalesce and break again into several or form colonies. There are the slime fungi exhibiting an astonishing rythmic flow in canalized sheets of protoplasm; worms which segment into chains of worms, the last link separating as the newest one forms. Plants can be propagated by cuttings and by pieces of root, or grafted together. Two-headed babies, Siamese twins, and other monsters are born, and can easily be made by grafting embryos together; what about their personalities?

The discovery of X-rays has meant to physicists what the discovery of the microscope meant to biologists, geologists, and chemists, for the use of these short wave-lengths has increased the range of observation ten thousandfold. The molecule, large relative to the wave-length, has its characteristic shape imprinted by scattered rays on a sensitive plate. From this imprint a picture of the molecule can be constructed by measurements and calculation. "The crystal," we are told, "shows all the exhilarating unexpectedness of an organism, subject as it is to principles of periodicity, attraction, repulsion, growth, and structurally disciplined function." There is a persistent tendency of nature to arrange her molecules in ordered fashion. This obtains not only in bodies, hitherto called crystals, but also in cellulose, wool, hair, silk, nerve, and muscle.

While the doctrine of spontaneous generation finds no support, there are not only viruses which produce diseases, but bacteriophages which destroy bacteria too small to be seen under the microscope, and question has arisen as to whether these really are living organisms or more of the nature of vitamins which promote growth, but having the opposite action. Then, again, it is generally agreed that inherited qualities are transmitted by the chromosomes of the nuclei of the germ cells, and that the chromosomes are made up of units called genes, small molecular complexes, each of which divides into two when the chromosomes divide, a half going to each daughter cell. It is suggested that viruses and bacteriophages may be of the nature of genes, and these be the most primitive form of life. It is worth noting here that the study of specific immune reactions shows us that the spatial arrangement of the groups in the reactive part of the protein molecule may determine the specificity of the entire complex many hundred times its own size.

Let us look back to the simplest units of life evolved in sea-water under conditions of the world which no longer pertain. We can conceive of this life substance persisting and spreading through hundreds of millions of years, guided by the environment into myriads of structural adaptations which persist so far as they help in the persistence of life. The cells of our body form a part of that continuum of living cells which in the past gave origin to the laying down of vast limestone and coal strata and now forms the lovely child, the robin redbreast, the ravening shark, the poisonous viper, the lily of the fields, the horrid parasite, and the microbe of pestilence. The adaptability of the living cell is shown by the existence of salt and fresh water and of ærobic and anærobic organisms, of fish in the vast depths of the sea which withstand a pressure of hundreds of atmospheres of water and secrete oxygen in their swim bladders at a pressure which kills all surface organisms. The history

of evolution and the relation of man to the primates are shown in the stages of development of the human embryo.

Few realize that the subconscious life of the cells of our bodies exceeds the conscious by some million million times or more, for the unconscious living cells of the body are myriad in number. In every tiny droplet of blood there are some five million red cells. Think of the myriads in the organs such as the liver, kidneys, etc., of the myriads living in the skin and alimentary canal, and forming the muscles. In the brain, the seat of consciousness, there are some nine thousand million neurons. Think again of the millions of atoms in each cell and the electrons and train of waves in each atom. A single living cell is as complex as a large organism, for these are made up of multitudes of cells arranged in organs, in each cell of which the life processes while conforming with those of the single-cell organism, specialize in other functions for the good of the whole. And the cells of our body die in myriads and are replaced by others in the course of life. Immunological reactions enable us to detect blood relatives from the rest of a species, so that an individual difference stamps all the cells of the body of each of us. Cell subconsciously influences cell by chemical messengers, so that all are kept developed and balanced and serve the common end. I can pause only to give two striking examples of the call of cell to cell which determines effect. First, an optic vesicle, when transferred from the head to beneath the back of an embryo tadpole, causes a lens to develop in the skin there. Secondly, a growing tip, brought close to the stump of a rootlet which is placed horizontally, causes the rootlet to grow downwards.

In forming a philosophic view of life, it is noteworthy that cells can be cultivated outside the body and, suitably fed, continue to multiply as if immortal; further, that ova can be fertilized artificially by changing the salt-content of the medium, or by the prick of a needle. A feminist writer has even looked forward to attainment of immaculate conception and the expulsion of men as useless drones.

We must take into account so curious a fact as that the female mantis bites off the head of the inattentive male before fertilization takes place. The reflex, undisturbed by the higher senses of the male, then results. There is the habit also of the female scorpion eating the male after fertilization has taken place; and of the male living as a small parasite in the female of certain deep-sea fish.

While the myriad cells of the body by chemical messengers through the medium of the blood help to preserve the life of all, the evolution of a central nervous system made possible quick responses to the environment for maintaining posture, securing food, escaping injury, and promoting sexual propagation; but let us take note that

the first fundamental phenomena of sensation, response, and memory are observable in a unicellular animal such as an amœba or paramœcium. Such take in useless granules at first but soon come to reject them. It is very noteworthy that in the evolution of the brain of species of fish one or other part develops in size in accordance with the sense used by that species for securing food.

While a dinosaur, big as three elephants, feeding on swamp vegetation had a brain the size of one's thumb, in the number of neurons and complexity of pathways, the nervous system of man, who has to live by skill, far exceeds that of the stations and wires of the whole telephonic and telegraphic systems of the world.

The amplifying valve has enabled Adrian to record the electrical variation which accompanies a nerve impulse coming from a single sensory nerve ending. He has shown that greater intensity is conveyed by greater frequency. So, too, with the muscles, while the number of fibres involved is the coarse adjustment the frequency of excitation is the fine. While the nerves merely conduct more or less frequent impulses, it is in the relay cells of the brain that integration takes place, the summation of excitation and inhibition, and the storing of memories and consciousness; these cells are most sensitive to fatigue, blood supply, drugs, etc., and while disease of them leads to dementia, their non-development results in amentia.

The researches of Sherrington and Magnus have very greatly advanced our understanding of the reflex working of the central nervous system. We know that bodily actions are co-ordinated and effected without consciousness. While consciousness acts as accelerator and brake, the bodily engines carry out actions controlled in the central nervous system by a ceaseless stream of afferent impulses from muscles, tendons, joints, otolith organs, etc., of which we have knowledge only by laborious research, unconscious impulses which excite these and those muscles, and inhibit these and those others.

Particular attention must be given to the recent epoch-making researches of Pavlov on conditioned reflexes. He has devised experimental methods of studying behaviour and shown how conditions of neurosis may be set up. Thus the conditioned reflex was established between the sight of an oval and food and of a circle with no food. Then the oval was made more and more like a circle, and in the end the dog became nervously disturbed and took long to recover. An insoluble difficulty, on solution of which food depended, upset its stability. So too with us. Every action of a civilized man is guided by an endless chain of previous conditioned reflexes established by up-bringing and education. How much lower is the level of the stone-age man is shown by Darwin's description of the Fuegians. Stunted, naked, filthy, and greasy, with long streaming and entangled hair,

their voices discordant and their gestures violent; with no religion, government, or chief, but tribe fighting with tribe for the wretched means of subsistance. Sleeping like hares in forms in the inclement climate, living on shell-fish and putrid bodies of whales and seals; each, if attacked, instead of retiring, endeavouring to dash out your brains with a stone, as certainly as a tiger would tear you; their skill comparable with instinct of animals, not improving with experience. When one was given a piece of cloth it was torn into shreds and distributed; when a pistol-shot was fired close by, one merely looked astonished and rubbed his head, the sensation being no more relevant than a motor-car is to a lion in the bush. And yet if that infant at the breast, which the father snatched away and dashed on to the rocks because the mother dropped a basket of eggs, had been rescued and educated it would have become a useful civilized man. "We must remember," says Wood Jones, "that awareness results only when a stimulus is relevant." Thus the blind-worm is aware of drops of rain and of the movements of the brown slug, its food. The blast of a motor horn or a symphony concert provokes no response in it.

We must bear in mind, too, the profound alteration of personality as the fertilized ovum develops to the new-born infant, and this to the child, the adult, the aged. What alteration, too, is made by drugs, alcohol, insufficient oxygen, excessive fatigue, illness, and injury to the brain. The dancing dervish gains his vision through fatigue or by hasheesh, similarly the Buddhist or Christian who keeps vigils and fasts; by brain-cell exhaustion is the so-called freedom from domination of the external world obtained. The symptoms in order are—impairment of finer motor adjustments, *e.g.* seeing double and disorder of speech, impairment of attention, loss of inhibition, increased emotion, loosening of social habits, hallucination, and delirium.

"I have had," says Gissing, "one of my savage headaches . . . memory, reason, every faculty of my intellectual part is being whelmed in muddy oblivion. Is the soul something other than the mind? If so, I have lost all consciousness of its existence . . . my being is here, where the brain throbs and anguishes. A little more of such suffering, and I were myself no longer; the body representing me would gesticulate and rave, but I should know nothing of its motives, its fantasies. The very I, it is too plain, consist but with a certain balance of my physical elements which we call health."

Without the internal secretion of the thyroid gland a child is a cretinous idiot. Feeding with thyroid makes it into a normal being. Too much pituitary gland makes a child grow up a stupid giant. Tumour of the supra-renal gland causes sexual precocity, producing in a young child the maturity and appetite of a man.

By the removal of sex glands and transplanting of opposite ones sex characters are changed.

A decerebrate animal is an inconscient reflex automaton. It stands statuesque: tilt the head up, and it sits and looks up; tilt the head down, and it assumes the posture of feeding from a dish.

Take the case of the baby boy who stirred and cried only when hungry, thirsty, or soiled, whose eyes appeared turned up whenever the lids were opened, who never smiled or made any response to his mother's voice. He lived for $3\frac{3}{4}$ years, breathed, swallowed, digested, excreted, kept warm; his brain was found to be a mere bag of fluid. Who can justly doubt, then, that personality is bound up with the cortex cerebri?

Take again the case of a man with superficial injury to the left parietal region in the vicinity of the supra-marginal gyrus. The wounded man had no difficulty in expressing by words his ordinary deeds, but often appeared to have lost the connection between what he had said and what he wished to say. He read aloud correctly and understood the significance of words and short sentences, if they did not contain a command. He wrote very rapidly as if he feared to lose the idea. He counted and named coins, but could not solve the simplest problem in arithmetic, and he had been an accountant. Unable to draw or to sum in any manner the relative position of objects in a familiar room, he yet could point to any object in the room with his eyes closed. He could not find his way about or play games, as he could not foresee the consequence of his next act.

Evidence shows that the brain acts as a whole but that certain regions are associated with entry of one or other sensory pathway. Hence the localization of effects of injury.

Dr. William Brown recently told us that "mind is an active, dynamic synthesizing force, creative, carrying on activities which even the greatest conceivable extension of our physiological knowledge would not enable us to infer from observing the brain," to which modern science answers that the activities of mind are neither more nor less unexplainable than those of matter. "The packing of all the potential properties of a species in one tiny reproductive cell, the gradual transformation of one species into others much more complex and having consciousness and memory," these mysteries of life are neither greater nor less than those of radiation quanta and electrons. The finger of God in stirring the ether endowed matter also with the potentiality of evolving mind through a particular play of environment.

"When I use my pen," says J. S. Haldane, "the light in which I see it is not merely that of an electric lamp, but of all my other experience. When I write with the pen the movements of my muscles are determined by the actual presence to me of innumerable past, present, and anticipated future events in both my own individual

history and that of mankind. The past events are not simply past and done with, like events interpreted physically or biologically, but they, and not their mere effects, are still present and active . . . I am living and acting in a spiritual world for which separation, not merely in space, but also in time, has none of the meaning which it possesses for the world interpreted physically or biologically. Along the years and across the oceans action and reaction are direct in this spiritual world. It is evident that in conscious activity we are face to face with facts that neither physical nor biological hypotheses are capable of interpreting. Yet conscious activity manifests itself in connection with the same beings that seem also to live and breathe as mere organisms, or to consist of nitrogen, hydrogen, oxygen, carbon, and other atoms leading a wild and undefinable dance."

By those words of Haldane, "actual presence to me," the conscious guidance of the pen by all that innumerable past seems clearly suggested. I venture to suggest, firstly, that the movements of the pen are determined by a pattern laid down in the brain with its ten thousand million neurons and infinite myriads of atoms and electrons and their train of waves a pattern laid down by past experience and education acted on by present sensations. It is only little by little that a book is written, through consultation of authorities, copying, altering, and adding a little to the work of and picking up hints from others, thinking out one point after another over weeks of time, writing of rough drafts and gradually improving these, and so on. Secondly, I suggest there is evidence that along the years and across the oceans action and reaction ceaselessly continue in matter no less than in living organisms; further, that the past is not done with in events interpreted physically and biologically, that there is no wild dance in matter, and that consciousness is neither greater nor less than matter and energy, the ultimate nature of which physical and biological hypotheses are not capable of interpreting. "The universe," says Haldane, "is a spiritual world and not a dualistic universe of matter and mind." Yes, in so far as "the stirring of the ether by the finger of God" results, among all other phenomena, in consciousness which is determined, like all other phenomena of living or non-living organisms, by an evolutionary reaction to the environment. The effect of the environment is conditioned by the inherited quality of the organism, and the reaction of the organism is conditioned by the environment. Thus personality is socially formed: by inhibitions and reinforcements, habits, and consistency of conduct result. Actions are determined by all previous experience, upbringing and education are paramount in patterning the brain and so bringing about the formation of right or wrong moral and intellectual habits in each person born with certain inherited qualities.

We are told that energy can exist in a number of forms and can

change endlessly from one form to another, but cannot be destroyed, or created. That all existing energy must have existed from all time, although possibly in some form entirely different from its present form. That all the life of the universe may be regarded as manifestations of energy.

Energy has then attributes ascribed to God, unknowable, eternal, in all and through all, and modern science has reached a conclusion compatible with Deism. In every atom, just as in every complex of atoms forming a living cell, there may be the purpose of God; every atom may be dynamic, not only moulded by the environment, but determining it.

Hume says: "I ascribe to matter that intelligible quality, call it necessity or not, which the most rigorous orthodoxy does or must allow to the will."

Of one thing there is certainty, *viz.* that scientific knowledge can extend life and happiness by education and prevention of disease, by recognizing and avoiding adverse forces of nature, by inventions for securing means of subsistence, utilizing and conserving sources of energy and controlling the birth-rate and so putting an end to war. Science relieves us of superstition and fear of punishment after death, and leads us to devote ourselves to the improvement of conditions on earth.

We have to reckon with inevitable natural forces. A meteor, such as the one that struck a hole almost a mile wide in a desert of Arizona, may destroy the city of London in the twinkling of an eye; volcanoes and earthquakes destroy cities, and tornadoes and floods and pestilences work destruction on good and evil alike; some criminals succeed and good people suffer; monsters and idiots are born; men have tortured, burnt, and waged war in the name of religion.

Nature creates and destroys, indifferent to our prayers. Inscrutable, omnipotent, endowing us with joy in sky and sea, trees and flowers, the fruits of the earth, running waters, song of birds, the play of animals and children, the love of a mother for her child, and kindly acts.

"We are not living in the world to discover final truth," says Lord Haldane, "there is no such truth. What we find is always developing itself and assuming fuller forms. Of knowledge we can at best master only a fragment. But if that fragment has been reached by endeavour that is sufficiently passionate, the struggle towards it yields a sense of quality, of quality in the very effort made, which stands for us as being what we care for beyond everything else, as being for us truth, whatever else may not be certainly truth. And so life is not lived in vain, though in the ends attained it may seem to have failed."