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EVOLUTION AND ENTROPY.

(*being the second prize Langhorne Orchard Essay*, 1942)

By E. H. Betts, B Sc.

THE century which saw the re-birth and re-habilitation of evolutionary doctrines witnessed also the rise of thermodynamics with its two wide-sweeping laws and in particular its Second Law with the involved doctrine of entropy. Darwin's "Origin of Species," which may fairly be regarded as the first attempt to put forward a theory of organic evolution on a basis of wide examination of facts, appeared in 1859 and, in so far as "science is measurement" the First Law of Thermodynamics—the great Law of Equivalence—can be regarded as established by the work of Joule in 1843. Of the Second Law of Thermodynamics the foundation had been laid by Sadi Carnot in 1825 and the formulation made by Clausius in 1850, the term "entropy" having been first proposed by the latter in 1865. Thus in their appearance in scientific shape evolution and entropy were closely contemporary. Here, however, the resemblance ends.

The two doctrines were taught side by side without much suspicion of antagonism between them. Evolution had, as of course it still has, a wider vogue and has now largely settled down to the taken-for-granted stage among the semi-educated, while experts still wrangle about its ways and means of implementing itself. Darwinians, neo-Darwinians, Lamarckians and neo-Lamarckians quite fail to put forward an agreed mechanism. All agree, however, in a vigorous claim that the failure to discover the machinery constitutes no justification for denying the "fact." This may be true. There is, however, a specious fallacy underlying an illustration proffered in support of the argument. "We need not deny the fact," says Dr. Julian S. Huxley, "because we have not discovered the machinery. As an obvious example we are very far from understanding the physiological

and chemical machinery of development by which, for instance, a hen arises from an egg; but that does not cause us to deny the fact that hens do develop from eggs."* The criticism here is obvious. There is a great difference between discovering the machinery and understanding it. In the case of the development of the hen from the egg the machinery needs no discovering. It is patently the physiological and chemical processes which begin with the embryo in the egg and end with the hen and we know beyond a cavil that there is no discontinuity between the beginning and the end. In the case of evolution we not only do not understand the machinery but, as is admitted, it has never been discovered.

But the idea of evolution so captured the scientific. as well as the popular, imagination that it rapidly spread into all departments of thought. We hear therefore not only of organic but of stellar or cosmic, political, social and linguistic evolution. In all these, there is the one underlying and essential idea, namely, that the diversity or complexity to be observed in each sphere of observation is due to the action in the past of natural causes which can be observed still at work in the present. Indeed, according to Herbert Spencer "whose views greatly influenced not only the technical but also the popular use of the word, all the changes in the universe, whether material or psychical, are phenomena either of Evolution or of the reverse process of Dissolution."† Evolution itself thus rapidly evolved. It became more than a scientific hypothesis to explain the origin and diversity of plant and animal species. It engaged itself with the remote past as well as the distant future. It asserted, and still asserts, that all life descended from the lowliest microscopic forms and indeed that "living matter is but a special arrangement of ordinary matter, the evolution of life but a local and peculiar eddy, so to speak, in cosmic evolution."‡ It expanded into belief in the inevitable and endless progress of mankind, engendering the most optimistic expectations of universal advancement and taking shape as a new lay religion, a "firm basis for ethics,"§ dear especially to the heart of the agnostic and the atheist of the late nineteenth and early twentieth centuries.

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* Ency. Brit., 1929, art. *Evolution.*
† New Oxf. Dict., art. *Evolution.*
‡ *Sci. of Life,* Wells, Huxley and Wells, p. 641.
§ *Belief and Action,* Viscount Samuel.

The brightness of the hope of those days of pseudo-scientific optimism is now somewhat tarnished. First of all the great world war of 1914-1919 with its stark revelations of actual and potential evil served the turn of *experimentum crucis* to the hypothesis which had paraded so boldly as a law—the Law of Progress. The modern mind, severely chastened, anxious and even fearful, a fear induced by the dread of a repetition of the great war (since realized) and by the contemplation of the colossal problems of its aftermath, withdraws from its advanced evolutionary positions and hastens to point out that evolution " does not guarantee progress " ;* indeed, that " in evolution, actually it is the exception, and for every case of it there are ten of degeneration."† But the rosy optimism of those days met with a second check—one of a different kind. The Law of Evolutionary Progress found itself confronted with the Law of Increasing Entropy. This asserted very pointedly that the universe, by way of general degradation of energy, was heading for a state of thermodynamic equilibrium in which all physical change must cease—a heat-death, far off, no doubt, but inexorable in its approach and totally contrary in its implications to those of evolution. How men of science and philosophers, not to mention the much misguided ordinary layman, succeeded in ignoring for some sixty years the significance of this great law is no small mystery. On the part of philosophers the cause may have been the notable severance observable at that period between philosophy and science ;‡ on the part of the men of science, departmentation of studies and sectional absorption ; on the part of the general public, lack of education in general and of scientific teaching in particular. That public ignorance of the entropy law has now at last been widely (though still only partially) dissipated is largely due to the brilliant expository powers of such eminent leaders of scientific thought as Sir James Jeans and Sir Arthur Eddington, who by broadcast, book and lecture, both learned and popular, have put the conclusions and the problems of science before great masses of people. Perhaps for the first time in the history of publication, up-to-date accurate science has formed the subject-matter of " best-sellers." And what are the implications of this law of entropy ? In what ways precisely does it impinge on the doctrine of evolution ?

* Viscount Samuel, *loc. cit.*
† J. B. S. Haldane, *Fact and Faith.*
‡ See, *e.g.*, *A History of Science*, Sir W. C. D. Dampier, Ch. VII.

Is there necessarily antagonism between the one and the other ?

Let us first be clear about the nature of entropy and the fact of the law of entropy. Entropy is not a physical condition of a body such, for example, as temperature, which can be apprehended by the senses or measured with an instrument. It is a mathematical concept—a function of the physical conditions heat and temperature—which furnishes us with a measure of the availability of the energy within a body or system for the performance of work or the maintenance of life-process. It is such a function that its increase spells a decrease in the availability of the energy. The Law of Entropy states that *the entropy of an isolated system cannot diminish.* Any change in it must be an increase. In plain language this means that the energy of a finite universe must be "running down"—not disappearing, but becoming less and less available for conversion into work or for the support of life-process ; in short, all energy is degrading itself surely into a homogeneity of heat at one even, universal and probably low temperature level. When, and if, that condition is reached, whatever the temperature, all movement, all work—mechanical, electro-magnetic, chemical, physiological—all sources of power and all life-process will have ceased. So far, the Law of Entropy takes us. Revolt from it as the mind will—and attempts to elude it are numerous—there seems to be no escape ; for it is not the result of speculation but plain deduction from simple observation of universal scope and not, as might be supposed, observation of and deduction from the abstruse, remote or rare. It is no more abstruse as a doctrine than the plain truth that we cannot obtain power from a steam engine by filling its boiler with ice. The accuracy of this comparison will be admitted when it is realized that the law of entropy is merely a mathematical statement of the second law of thermodynamics, which in Planck's form reads thus :—"It is impossible to construct a machine which functions with a regular period and which does nothing but raise a weight and cause a corresponding cooling of a heat reservoir."* If, however, we lend an ear to what *is* rather more recondite, we are told, further, that the same general principles may be applied to the astronomical universe : that however originated, for example, in the hot interior of a star by the breakdown of atoms, energy still "runs

* Max Planck, *Theory of Heat*, tr. Bose, p. 52.

down," that is—it may be pardonable to repeat—while not lessening in quantity, assumes a less and less available form.

This is the degenerative principle which the idea of unlimited and incessant progress had to encounter. It would be absurd, of course, to suppose that it provides a complete refutation of the doctrine of organic evolution. That must come in other ways fairly plainly evident to those with minds *free* to re-examine the orthodoxies of the present day.* What the entropy law has to say bears on evolution and supposed evolutionary progress in two ways, namely, with respect to *beginnings* and with respect to the trend of the changes steadily taking place in the universe.

Considering the latter, we find that there is direct opposition between evolution and entropy. Evolution teaches, or until certain recent changes of front did teach, that the universal trend was upward, from the simple to the complex, from the less to the more highly organised, from the lower to the higher; and it attributed to this alleged progressive process the appearance, in a universe which was once nothing but a nebular mist, of living beings including man, with all his culture, his religion, his thoughts of God. It prognosticated the inevitable progress of our species to perfection. The law of entropy teaches that if there is a universal process it is one of breakdown—of universal energy-degradation; that the universe, far from struggling upward, is running down, irrevocably and irreversibly; and that whatever natural causes are still in operation, the energy at their disposal is on the downgrade. It is hardly necessary to point out that upward progress in the organic and human spheres and degradation in the sphere of energy may co-exist. The two processes do not cancel each other out. But the Second Law of Thermodynamics *is* destined, science tells us, to cancel out ultimately everything that evolution could conceivably achieve and reduce it to the nothingness of a universal heat-death. Thus it was that thermodynamics rang the death-knell of the fantastic hopes based on evolution and preached as a kind of scientific religion by evolutionary philosophers of the last century. Thus it was that evolution in its wider aspects met its first great check at the hands of science.

Incidentally, quite apart from entropy, although in keeping with its teachings, the observed processes in nature and history

* "The severe methodological criticism employed in other departments of biology has not yet been brought to bear against evolutionary speculation." Dr. W. R. Thompson, F.R.S., in *Science and Common Sense*, p. 229.

are rather from the complex to the simple and from the higher to the lower. Radio-activity reveals the *dis*-integration of atoms of high atomic weight and not the evolution of complex atoms from simple ones. Indeed, modern astronomical evidence is showing that there is a uni-directional " evolution " of matter from the state of high atomic complexity to one of atomic simplicity, and a breakdown of matter further into radiation. This process of disintegration may be artificially imitated in an atom here and an atom there, and thus to an almost infinitesimal extent speeded-up, but a reversal of the cosmic process we are not likely to bring about or witness. As to the alleged upward trend in the religion of man, an eminent modern archæologist asserts that a pure monotheism was the original religion and that polytheism was a later pollution of it.* A very eminent modern anthropologist supports this teaching.† Again, civilizations change in character, and change constantly, but not necessarily upward. Many recent finds, for example, prove the antiquity of an advanced state of civilization in Babylonia, Egypt and Assyria, so that no informed person now questions the existence of a state of literary culture long before Moses—facts which are contrary to the evolutionary ideas of human progress from the " primitive " upwards. Thus, not only in respect of cosmic order as revealed by the law of entropy, but also in the spheres of inorganic matter, human culture and human religion, the " law " of evolutionary progress is *not followed.*

And what of beginnings ? Evolutionists do not seem able to face the facts with composure. They have discovered, but will not acknowledge, that their principles fail them if carried to the limit. That a universe which is " running down " must at some time have been " wound up " is a truth which has been expressed many times and has consequently become almost hackneyed in its terms. But it remains robust logic and implies a beginning, and a beginning of a kind which transcends in its action that of any " natural causes now seen to be at work," for it implies a reversal of the irreversible of present science. Boltzmann's identification of the Law of Entropy with the Law of Thermodynamic Probability gives us a fresh statement of the unidirectional running down process in the form that the universe as an energy system " tends to the configuration which offers

* Dr. S. H. Langdon, Professor of Assyriology in The University of Oxford, in *Semitic Mythology.*

† Prof. Wilhelm Schmidt, *Origin and Growth of Religion.*

the maximum probability" ; and this is merely to acknowledge that it must be tending *from* a point of departure the occurrence of which, in this same language of probability, is "infinitely improbable"—apart, of course, from Transcendence. Thermodynamic Probability is an insuperable barrier to any naturalistic explanation of the origin of the universe. The explanation which attributes "to the action in the past of natural causes which can be observed at work in the present" the existence and all the activities of "the whole cosmos including both living and non-living beings"* cannot stand before it. Sir Arthur Eddington takes us to the limit, but is startled by it. "It is one of those conclusions," he says, speaking of the winding up of the universe by God (and allowing that it should be regarded as the working-hypothesis of thermodynamics rather than its declaration of faith), "from which we can see *no logical escape*—only it suffers from the drawback that it is *incredible*."† A revered headmaster of the writer's was fond of reminding dull Latin pupils that "you can lead a donkey to the water, but you cannot make him drink." It is Sir Arthur who is here leading the donkeys to the water, but he is also amongst those who stubbornly decline to quench a thirst which occasionally betrays itself. The stubbornness is manifest. For to him the Second Law of Thermodynamics is at one and the same time "supreme among the laws of nature" and "incredible" in its implications.‡ We are hardly in agreement with him that, as far as thermodynamics is concerned, the "winding-up" of the universe should be regarded as only a working-hypothesis. A conclusion from which there is "no logical escape" is something rather more than that. The inescapable conclusion of science is that the universe must have been "wound up." But at this point, where science reaches its frontiers and can go not a step farther, revelation meets us with the pronouncement, "In the beginning God created the heavens and the earth." There is no discord across the frontier which divides science and revelation.

Not every evolutionist, however, is so honestly refractory as Sir Arthur Eddington. What can we think, for instance, of those who occupy and defend, simultaneously, the three positions set forth as follows ? First, that of the principle of biogenesis, that is that life proceeds only from life. "It is," we are told,

* E. S. Goodrich, *Ency. Brit.*, 1929, art. *Evolution*.
† *Nature of Phys. World*, Ch. IV.
‡ *Loc. cit.*

" one of the foundation stones of the modern doctrine of evolution."* Second, the principle of continuity which maintains that no " causes " should be invoked except natural causes now seen to be in operation.† Third, abiogenesis, taught thus : " But although this principle of continuity applies to all organisms at the present day, which have a long history behind them and have no doubt departed greatly from the initial stages in the evolution of living matter, there must have been a time when protoplasm first appeared. It must be supposed that long ago, when conditions became favourable, relatively high compounds of various kinds were formed.‡ Many of these would be quite unstable, breaking down almost as soon as formed§ ; others might be stable and merely persist. But still others might tend to re-form, to assimilate as fast as they broke down. *Once started*‖ on this track such a growing compound or mixture would inevitably tend to perpetuate itself and might combine or feed on others less complex."¶ It should be noted that the " favourable conditions " here postulated include not merely the sea but a sea of the same composition as at present, for the writer adds : " These first steps in the elaboration of living matter probably occurred *in the sea, for protoplasm contains the same salts as sea-water and in much the same proportions.*"** (Quite incidentally, J. B. S. Haldane imagined the primitive ocean, in which life originated, to have been composed of a hot dilutely soupy mixture of sugars and a vast variety of organic substances formed by the action of ultra-violet light on a supposed previously existing mixture of water, carbon-dioxide and ammonia.†† The two speculators will no doubt easily keep the peace about this, since it has been laid down already that it is by no means necessary to have " discovered the machinery " ; the " fact " is the great thing !) No ! The three positions give us a case of biogenesis *plus* uniformity *plus* abiogenesis. In syllogistic shape it would run thus :—

> Under the natural causes now in operation all living matter proceeds only from living matter.

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* E. S. Goodrich, *Ency. Brit.*, art. *Evolution.*

‡ *Loc. cit.*

† This, it is to be noted, is a process unknown under present natural causes.

§ But this is a process which *is* frequently observed under natural conditions.

‖ Italics here inserted.

¶ *Loc. cit.*

** *Loc. cit.*

†† See *Fact and Faith*, p. 44 of Thinker's Library Edn.

Natural causes now in operation are the only causes that should be invoked.

At some time in the past living matter proceeded from non-living matter.

The logically inescapable fact is that just as the entropy law leads us back to a state of things which is incapable of rational explanation apart from the invocation of non-natural causes,* so does the combination, postulated by evolutionists themselves, of the principle of biogenesis and the principle of continuity. This issue, as has been already remarked, the teachers of evolution cannot face. They tacitly jettison both their principles. Why must they do this? Undoubtedly because evolution is, as has been well said, no science at all but a frame of mind—a philosophy.†

Compare the substantiality of the logical bases of the Law of Entropy with the extreme flimsiness of the imagined evolutionary origin of living matter cited above. Let us take the latter first. It argues that "It *must be supposed*," "relatively high compounds *were formed*" (how, is left to guesswork), they "*might* be stable," "*might* tend to re-form," "once started . . *might* combine or feed." And we find that "when conditions became favourable" merely indicates conditions characteristic of the oceans of our present time in which the *abiogenetic process put forward is unkown to science.* Truly if ever hypothesizing took the bit between its teeth it has done so here! What mere lip-service it is that evolutionists pay to the work of Pasteur!‡ Consider now by contrast the former, the Law of Entropy, *alias* the Second Law of Thermodynamics. Its basis is so secure that anyone who can overthrow it by the detection of a flaw in its structure *can proceed at once to the invention of a machine which would serve simultaneously as a heat engine* (*motor*) *and a cooling machine* (*refrigerator*) *working with the expenditure of no energy and the consumption of no fuel,* all the necessary energy being derivable from the exhaustless stores of heat in the earth, the air and the sea. Such a discovery would be immediately followed by a scientific, industrial and economic revolution of totally unprecedented magnitude. The whole of life would be

* "It could not occur fortuitously," as Eddington says: *loc. cit.*

† See *More Difficulties of the Evolution Theory,* D. Dewar, Ch. XVI.

‡ The discomfort of evolutionists in face of the results of this great investigator's researches is well seen in the unworthy references made to him by J. B. S. Haldane in *Fact and Faith,* chapter on "The Origin of Life."

rapidly changed. Quite conceivably wealth would lose its meaning and labour most of its value. Unfortunately for any would-be inventor, " at present we can see no way in which an attack on the second law of thermodynamics could possibly succeed."* Again, " The chain of deductions from this simple law have been almost illimitable; and it has been equally successful in connection with the most recondite problems of theoretical physics and the practical task of the engineer."† Surely we have here not a hypothesis but an established LAW OF SCIENCE in all truth.

Supporters of evolutionary doctrine who point out that however great and convincing the evidence for the Law of Entropy may be, yet its application to the whole stellar universe is an unjustifiable extension in that " generalizations made from limited observations " should not be supposed true " in wider conditons which are as yet largely undetermined "‡ seem to be strangely inconsistent. They are the people who in support of their own hypotheses, as we have well seen, love to push out into the mists of unknown conditions and the stretches of unlimited time and almost immeasurable space where anything can be *supposed* to happen. " If infinite time is available, all unlikely things *may* happen. Chance concentrations of molecules *might* reverse the action of random shuffling and undo the second law of thermodynamics. Chance concentrations of radiant energy *might* saturate a part of space, and new matter, *perhaps* one of our spiral nebulae, crystallize out. Are we and all our myriad stars *perchance* one of such *accidental* happenings ? "§ It is to be noted how the objection raised to supposition is followed in the same work by a magnificent cluster of suppositions put out by the same writer. The difference in quality between the supposition objected to and the cluster of suppositions advanced by the objector is that the former is based on universal and unchallenged human experience and observation without a negative instance while the latter are without support from experience and contrary to common experience. Sir James Jeans, himself apparently a believer in evolution, tells us that the law of entropy may conceivably fail under conditions of which we have no knowledge but that the majority of serious

* Eddington, *loc. cit.*
† *Ib., loc. cit.*
‡ Citations from Sir W. C. D. Dampier, *Hist. of Sci.*, Ch. V.
§ *Ib., loc. cit.*, Ch. X.

scientists consider this very improbable.* The momentous fact that remains with us is that all experience everywhere and down-to-date, and all recorded observation serves unexceptionably to confirm the law. Accordingly, to cite Jeans once more:

> "Everything points with overwhelming force to a definite event, or series of events, of creation at some time or times, not infinitely remote. The universe cannot have originated by chance out of its present ingredients, and neither can it have been always the same as now. For in either of these events no atoms would be left—save such as are incapable of dissolving into radiation; there would be neither sunlight nor starlight, but only a cool glow of radiation uniformly diffused throughout space. This is, indeed, so far as present-day science can see, the final end towards which all creation moves, and at which it must at long last arrive."†

Attempts to evade the Law of Entropy are fascinating. It is surprising indeed that those who are prepared to strain their logic out of joint to keep out creationist ideas should seek evasion by toying with Clerk-Maxwell's classical demon.‡ Seen in its true light, such a being, able to see and sort individual molecules is but a symbol of the non-, or super-natural; and further, such a demon at work here and there would, as Poincaré has pointed out, merely serve to retard the onset of a state of thermodynamic equilibrium and not prevent it. What is more, such a being must be supposed to be conscious, intelligent and watchful. But to undo the Second Law he would have to be also ubiquitous. Combining then the attributes of consciousness, intelligence, watchfulness and ubiquity, what have we? Surely a Being not for the evolutionist to toy with! To undo the Second Law is akin to "winding up" the universe. In a context relating to entropy in its cosmic bearings, then, Maxwell's demon is either ineffectual or almighty. Evolutionists therefore make a gift of the case to creationists if they introduce "demons." Of course, their attempts to circumvent the law are actuated not from dread of a future extinction due to the heat-death

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* *Mysterious Universe*, Chap. V.

† *Eos. or the Wider Aspects of Cosmogony*, p. 55. Citation given by Dampier, *loc. cit.*, p. 483.

‡ The name seems to have been Lord Kelvin's; the idea, Maxwell's. Dampier seems (on p. 257) to use the idea as an objection to the "extension" of the entropy law. The Swedish astronomer Arrhenius also puts the same objection.

implied by its truth, but from their philosophic horror of an alogical past.

And in this fear of the logically irreducible entropy is not their only *bête noire*. If an alogical past implies creation, the logically irreducible in the present in the sphere of biology implies vitalism or something philosophically closely akin to it. From within their own ranks biologists hear eminent men of science speak of other " surds " in nature than the law of entropy, and of these the most familiar—and the one some most fear—is the great gulf fixed between the " living " and the " not living." Testimonies to this are not few or despicable. " The unity, in the spatio-temporal sense, of the organism, constitutes not so much a problem as a postulate."* " It seems logical to accept the existence of matter in two states, the animate and the inanimate, as an initial assumption."† And, not the least of such utterances, we have : " Life, as simply life, is the reality which must be assumed in biological interpretation."‡ Of course, such confessions, disturbing as they may be to our biological mechanists, are not to be obviated. We are surrounded by the arbitrary, the occult, the logically irreducible. We need not go to the mystery of life or living matter for this. Many " explained " phenomena, subsumed under well-known laws, classical and recent, remain unfathomably profound mysteries. Gravitation had its Newtonian and now has its Einsteinian " explanation," but whichever we dwell on, the unreduced residue is there and however far investigation is carried there must be a residue. Newton asserted that the forces posited in his law of gravitation were not occult but that their " causes " were occult ; and, after all, what " causes " " the curvature of space-time in the neighbourhood of matter " ? It is to be accepted without reserve that the minimization of the alogical core in nature is, as Needham§ states, the proper pursuit of science. It is to be equally maintained, however, that the refusal to admit the logical irreducibility of an order or class of phenomena—to hedge to the point of inconsistency—when scientific investigation points rigorously in that direction is bad

* E. S. Russell, *Interpretation of Development and Heredity*, p. 6, cited by Needham, *Order and Life*, p. 16.

† J. Gray, *Mechanical View of Life*, in *Adv. of Sci.*, 1933, p. 86, cited *ib.*, *loc. cit.*

‡ J. S. Haldane (not J. B. S. Haldane), *Materialism*, 1932 ; p. 66. Cited in Needham, *loc. cit.*

§ *Loc. cit.*, p. 13.

and unworthy philosophy. Of this tendency we have already given instances—for, alas, many excellent and outstanding men of science are faulty philosophers. We shall have shortly to deal with other cases of evasion in connection with entropy and its implications. But there is an important feature characterizing most of these more or less determined attempts at evasion which is particularly well illustrated in the attitude towards the problem of living matter and its organisation exhibited by the biological mechanists, who *entertain, and approach scientific problems with, a pre-determination not to admit the arbitrary in nature although rendering formal homage to it.* Thus we are told that " biological order is a form of order different from that found in physics, chemistry or crystallography, yet not impenetrable by the human mind or ruled by unintelligible entities. Translated into terms of Marxian philosophy it is a new dialectical level."* Now it is submitted that to claim knowledge of what does or does not " rule " biological order, and to assert that the entities, if any, which rule it, are not unintelligible, amounts to a prejudging, in the terms of a philosophic dictum of what is (according to the writer himself) still scientifically *sub judice.* More than this, there is contradiction in the assertion—at least by implication from its context. For the argument is that a form of order different from that found in physics, chemistry or crystallography, is nevertheless to be searched out and revealed by the methods of those sciences. Wherein then lies the difference ? At what point in the development of an organism is it first seen ? What determines the difference ? If the difference is to be equated with a mere change of dialectical (i.e., evolutionary) level, could this sustain the fact that in, say, embryonic " organiser " phenomena living matter must always be there to carry on the co-ordinated activity of structure-forming ? For such is the case whether the " organiser " is itself a relatively simple chemical substance or not. Needham cites K. Sapper with approval to the following effect: " Is it not inconceivable that properties should be found in a material complex which are *not* the result of the properties of the components ? " We will not quarrel with this as a general statement. But used in a discussion concerning the root differences between living and non-living matter it introduces a rank begging of the question by its reference to living matter as a " material complex." Obviously living matter is

* Needham, *loc. cit.*, p. 45.

far more. It is a material complex which displays "active maintenance of normal and specific structure," which, according to Haldane—and we approve—is what we call life. The logically irreducible residuum is whatever *causes* ordinary chemical elements to play a part in the constitution and organisation of living organisms and thus assist in the development of an order different from that of physics or chemistry. Ordinary chemical elements do this only when they are caught up into the whirl of already living matter. An examination of the truly admirable results of modern embryological and biochemical research tends in no way to unsettle this principle. Chemical substances of relatively simple molecular form may exert striking determining effects within the embryo, even changing the "destiny" or part played within its structure of the surrounding areas. But such substances introduced within the embryo can only influence in this way already living matter. Thus we come back, full circle, to something which never has yielded its secret, namely, matter in an animate state, which it seems logical to accept as an "initial assumption"—an alogical core.

Of the objections to and evasions of the Law of Entropy there remain a few pertinent to our subject which should be briefly examined. One type of objection is that which cannot accept the Law because some day something may turn up to oppose it. "There can be no certainty that later discoveries will not reveal some cosmic process, as yet unknown and even unimaginable, which is perenially at work, replacing the energy diffused through radiation. Such a process is not more unimaginable than is an original act of creation."* This suspense of judgment would be commendable if it were being consistently practised. Let evolutionists clear their minds of *all* theories of action which are open to opposition in virtue of agencies "as yet unknown and even unimaginable," and they will carry conviction that it is truth and certitude indeed that they seek! As matters stand the objection is a perfect specimen of that wishful philosophy which sets aside the theoretically ratified and practically verified results of actual observation for something "not unimaginable." It thus provides one more illustration of the remark already made that evolution is no science but a frame of mind—a pre-determination—a philosophy, not beginning, as philosophy should, where science ends, but severed from science and usurping its place. Incidentally, why does the

* Viscount Samuel, *Belief and Action*, Ch. III.

objector attempt to slight creation as being unimaginable ? The process of creation is of course unimaginable. The fact that it took place is *not* " unimaginable." As men of science we think it, in order to escape from the unthinkable. As men of faith we simply apprehend it. This type of objection merits no further comment except that it reveals a certain discomfort set up by the law of entropy in the minds of evolutionary thinkers. Bosanquet is one of those philosophers who cover a similar discomfort with a show of indifference. " For a philosophy that knows its business," he says, " the law of degradation makes no difference." Pringle Pattison agrees with him, for " entropy has ceased to trouble philosophers." W. R. Inge's comment is caustic and sufficient : " A theory which threatens to destroy the universal validity of the mechanistic hypothesis is, one would think, worthy of serious attention by metaphysicians."*

Eddington, face to face with an *impasse*, seems to seek escape in a form of idealism by insinuating that " entropy is of a much more subjective nature than most of the ordinary physical qualities." Entropy is an " appreciation " of arrangement and organization, he says. It certainly is a measure of it, or—preferably—a measure of *dis*organization—but that Eddington here really is in a state of confusion as to physical entities and our knowledge of them seems to be indicated by his next analogy : " entropy is subjective in the same way that the constellation Orion is subjective. That which is arranged is objective, so too are the stars composing the constellation, but the association is the contribution of the mind which surveys." This is not so. The stars are arranged in space. They are spaced about in a pattern or " association " which has physical existence. There is in the mind which surveys an answering " association " or pattern. If Rigel and Betelgeuse converged on to the " Belt " there would be a different association in the surveying mind only because of a different physical association in actual space. It is precisely the same in the case of entropy. It is a mental picture or " appreciation " of molecular groupings corresponding to the physically existent groupings, and the correspondence is one of close linkage. Maximum entropy, for example, is an " appreciation " of the physical grouping entitled fortuity. Consider thus the thermodynamic equilibrium of a small closed system. Would the state of final inactivity and inertness thus

* *God and the Astronomers*, p. 21.

characterized consist in a mere subjective "appreciation" of something, or would the total disorganization or randomness of the particles exist objectively? Even Professor C. E. M. Joad criticises such philosophies of the universe in these terms: "What, I cannot help feeling, eminent scientists misconceive is the nature of the act of knowing and the nature of its relation to the object known."* But Sir Arthur Eddington and Sir James Jeans are certainly not led into these falsities by any revealed falsity in the science of which they are such eminent exponents, but by a philosophy which constrains them both to a pre-fixity of view of the universe and which led the former of them, as we have seen, to speak of one law as both "supreme among the laws of nature" and "incredible."

Finally, there are those who accept the Law of Entropy and admit the validity of its application to the universe as a whole, but repudiate, even as a working hypothesis, the idea that at some date in the past the universe was "wound up" by God. In other words they deny any act of creation. In its stead they substitute blind chance. Their hypothesis is—to borrow the illustration used by Sir James Jeans (after T. H, Huxley)—that just as the random and unintelligent strumming on typewriters of an army of monkeys would, *given time enough*, produce all the books in the British Museum, so the shuffling of the atoms from infinity of past time would, sooner or later, produce the ordered universe. Here we recognise the Epicurean theory of the origin of the world by a "fortuitous concourse of atoms." Such a theory of a blind, chance-play origin of the universe could only spring from a desire to eliminate God from our thoughts. Not only would it thus leave us infinitely poorer but the argument itself is very poor. It eliminates reason just as much as it eliminates God. For it attributes to the same causes both the present irreversible process of degradation of energy and the original organization of the energy of the universe. "Does anyone really think that printer's pie might be shaken up till *Hamlet* emerged complete?"†

In this attempt at evasion of the full implications of the Law of Entropy we see evolution and entropy in complete opposition. The theory of a fortuitous origin of the universe is evolution in its quintessence. Creation by God at some date in past time

* *Philosophical Aspects of Modern Science*, p. 122.
† W. R. Inge, *God and the Astronomers*, p. 227.

is, even by the grudging admission of evolutionary physicists,* the working hypothesis we are compelled by the Law of Entropy to adopt.† Thus, confronted with the necessity of admitting creation or suggesting an alternative, what is the reaction of evolutionary theorists ? It is this :—" Let us make two colossal assumptions—the eternity of matter and the infinity of " shuffling," and let the Laws of Probability account for a configuration which is grotesquely improbable ! "

In conclusion, it is clear that even a cursory comparative survey of the logical foundations of evolution and entropy, respectively, provides a contrast so striking that the rationale of evolution is seen to be in a condition of decrepitude, while entropy is so well founded that to upset it would entail a revolution in both thought and life. To recapitulate, evolution puts forward as a scientific explanation of the diversities as well as of the origin of life the workings of an unknown mechanism and claims that apology for not knowing it is unnecessary. It reasons in a circle, basing evolution on geology and adjusting geology to suit evolutionary teachings. It puts forward as of fundamental importance the principle of biogenesis and, when faced with a fundamental problem (the origin of life), immediately jettisons this principle. It makes solemn pronouncements about the supreme importance of a law of science,‡ and refuses to follow it to its just conclusions on the score of their incredibility.§ It postulates as the cause of cosmic *organization* natural processes observed to be those of irreversible *degradation* of energy. It repeatedly resorts to the unknown and the unknowable in the form of infinite time and immeasurable distance in appeal against the known course of action in nature while all the time doing lip service to a principle of continuity. It propounds imaginary favourable natural conditions under which, it claims, life may have originated spontaneously, but totally fails experimentally to reproduce either the conditions or the life out of them : in excuse it postulates a need for unlimited time for nature's successful experiments.

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* Eddington : " I am an evolutionist," *Nat. Phys. World*, Chap. IV, last paragraph.

† Jeans gose further and says : " Everything points to a definite event . . . of creation," *Eos or the Wider Aspects of Cosmogony, loc. cit.*

‡ " If your theory is found to be against the Second Law of Thermodynamics can give you no hope." " It is supreme among the laws of nature." " The chance against a breach of the Second Law can be stated in figures which are overwhelming." Eddington, *Nat. Phys. World*, Ch. IV.

§ " No logical escape—only . . . it is incredible," *loc. cit.*, same chapter.

In its philosophical aspects evolution exhibits unphilosophical prepossession by a bias—the strong predetermination at all costs never to admit an actual instance of the arbitrary or rationally irreducible in nature, while compelled, of course, to profess general belief in the existence of the arbitrary.*

To exclude the arbitrary is to exclude that into which or beyond which human knowledge cannot penetrate. In effect it is to exclude God. It is therefore in this philosophical, or, more truly, *un*philosophical, trait that the peculiar anti-religious character of evolutionary teaching consists. It is important not merely to point this out but to stress it and particularly to have it noticed that this attitude towards the inexplicable residuum in nature is the result of predetermination and not of investigation. For evolution has long posed, and still is posing, before the public eye as a scientific *discovery* having certain philosophical and religious results. *It is nothing of the kind.* On the contrary it is a philosophic bias giving form and direction to doctrine alleged to be scientific but resting on evidence and using methods which are, as we have seen, of the most shifty, inconsistent and evasive kind—evidence that in any British court of law would be ruled out as invalid and methods that would merit condemnation in any schoolboy.

* "That there is arbitrariness in the universe cannot be disputed. Why the universe has the nature it does have, and not some other nature, is not a question to which any scientific answer can be given." J. Needham, *Order and Life*, p. 12.

Written Communications.

Lt.-Col. L. M. Davies, D.Sc., Ph.D., F.R.S.E., F.G.S., wrote: I welcome this paper, which is ably written and much to the point. It is clear that, while working on different lines, the author emphasises similar facts to ones which I have tried to bring out as a geologist. His criticisms of the fallacies and inconsistencies of evolutionary reasoning are true and timely. I suggest comparison between his concluding remarks and the whole burden of my paper entitled "Darwinism" in the current (January, 1944) issue of the *Nineteenth Century*, pages 27–36. For the doctrine of organic evolution is a piece of natural philosophy masquerading as natural science; and, as Mr. Dewar and I have recently demonstrated, even its foremost propagandists—men like Professor D. M. S. Watson,

F.R.S., Dr. Julian Huxley, F.R.S., Dr. Joseph Needham, F.R.S., and Dr. H. B. Cott, F.R.S.—refuse to meet competent critics when their broadcast assertions or published works are radically attacked by a series of articles in a leading secular review. The promptness with which these gentlemen go to ground when faced by well-informed opponents shows how well they know the indefensible nature of their propagandist claims on behalf of "science, falsely so called."

Mr. JOHN EVENDEN wrote: The author writes (page 14): "Evolution is no science, but a frame of mind—a predetermination—a philosophy, not beginning, as Philosophy should, where science ends, but severed from science, and usurping its place"; he develops this thesis in his paper. For reasons stated below I would submit that the theory of evolution is not a mere philosophical idea, but a scientific theory that in its day met the facts and was to be held tenable until disproving facts should arise. That it is no longer tenable does not mean that it is not a scientific theory as well as a philosophy.

On comparing physics to biology it will be seen that the relative importance of various factors is vastly different. For instance, mathematics plays a very big part in physics, and thus physical theories are often subject to the rigid proofs associated with mathematics; in biology mathematics is of far less importance. Again, classification plays a very big part in the biological sciences, whilst though important, in physics it plays an altogether different rôle.

Now when the systematic study of fossils became established as a science the method of classification was applied, as in other branches of natural history. It was found that the classification could be co-ordinated if it was assumed that each form of life was created not from inanimate matter, but from other life. Thus, it was thought, the higher animals developed from the lower, during geological history. This is, notice, a scientific hypothesis, based upon reasonable foundations, and is subject to either proof or disproof. Darwinism, Lamarckianism, etc., are theories designed to account for the mechanism of change from one level of life to another. It is the original idea, coupled with this suggested mechanism, that constitutes the scientific theory of evolution, a theory which philo-

sophers generalised into a philosophy that was in turn to colour the science. The point to notice is that at first the theory of evolution was a scientific theory, later becoming a philosophy.

I agree with the author that evolution has been used quite wrongly in philosophy. I cannot think, however, that it is just a worthless "frame of mind." Philosophically it is, in its proper place, a description within a prescribed limit. Thus a certain development can be said to be evolutionary, implying continuity of development within the limits of the discussion, and it is most important that one should be able to do this. The point may be illustrated by considering a staircase; whilst one would normally say that it is continuous, a carpet-maker would point out the steps; upon his agreeing, however, that it was the steps that were continuous a microscopist would point out the fluff on the carpet, and so on. In other words, it is most valuable to deduce general principles of evolution, so long as they be applied only within the limits of the problem concerned, just as geometry is useful even though pure mathematical curves seldom if ever occur in nature.

Rev. Principal H. S. CURR wrote: I have thoroughly enjoyed the perusal of Mr. Betts' essay. In its lucidity, literary grace, and learning so lightly carried, it is a model for papers such as those presented at this Institute.

A principle of far-reaching significance is mentioned when reference is made to Sir W. C. D. Dampier's reminder to the effect that generalifations which are based on limited observations should not be regarded as universally and eternally true in view of their possible incompatibility with conditions which have not yet been fully investigated. The same truth is stated by Sir James Jeans in a sentence which is summarised in the same paragraph. In illustration, one need only refer to the discovery that this planet is not a flat surface, but a globe, or, again, to the Copernican theory in astronomy which displaced the Ptolemaic. Indeed, Sir W. Dampier's dictum may be regarded as the keynote of scientific progress.

With regard to its bearing on the Second Law of Thermodynamics in connection with evolution, it may be said that the same difficulty inheres in the acceptance of the latter. There may well be conditions in which and on which evolution becomes clearly untenable.

What is sauce for the goose is sauce for the gander. The overwhelming majority of arguments in all departments of human knowledge are sharp, two-edged swords, and the man who uses them must be careful lest he injures himself with the weapon which will overthrow his opponent. In logic there cannot be one law for the rich and another for the poor.

Another observation which may be made is that the rigid application of Sir W. Dampier's words would result in the undermining of confidence in all scientific deliverances. We would be certain of nothing except uncertainty. In practice, of course, we are all guided, learned and simple, by the conscious or unconscious acceptance of Bishop Butler's famous words that probability is the guide of life. By probability Butler meant anything short of a mathematical demonstration. Faith is the foundation of science as well as of religion.

The most effective solution of the difficulty seems to lie in the direction of considering the foundations on which the theory of entropy rests. Are these inherent in the very nature of matter and energy ? In other words, is it inconceivable that matter and energy could exist except in a form which was inevitably amenable to the principle of entropy ? John Stuart Mill once observed that it is possible to conceive a world where two and two make five. The only remark to be made on that statement is that, in the world in question, two must mean something different from what it must denote in the scheme of things with which we are most familiar. In the same fashion, matter and energy would cease to be what they are known to be if the doctrine of entropy was no longer applicable. If that be a correct train of reasoning, then it may be said that the Second Law of Thermodynamics admits of no exceptions save such as this : " And the angel of the Lord appeared unto him in a flame of fire out of the midst of a bush ; and he looked, and behold, the bush burned with fire, and the bush was not consumed. And Moses said, I will turn aside now, and see this great sight, why the bush is not burnt " (Exodus iii, 2–3).

Mr. E. W. BATTERSBEY wrote : The lecture on " Evolution and Entropy " by E. H. Betts, Esq., B.Sc., was admirable in that he dealt ably with an extremely difficult subject. His exposition was

lucid, and he stuck to the main points of their relationship without getting entangled in side issues.

Perhaps the following passage from " Outline of Modern Belief " (edited by Prof. J. W. N. Sullivan and Walter Grierson, " The Enquiring Layman ") will illustrate how unwilling modern scientists are to take the step from the ultimate results of their investigations into the realm of a faith that is being corroborated both through knowledge and intimate experience : " At some time in the past the universe must have been in its highest possible state of organisation. How did this state come about? It can be shown mathematically that the odds against its coming about by chance are entirely overwhelming. Was it, then, evolved by the operation of natural laws from some primitive state ? No ; that would be impossible as we have seen that the whole tendency of a universe such as ours is towards disorganisation. A less organised universe could not evolve into a more highly organised universe. The only possible alternative would seem to be that the universe was suddenly created. We are to suppose that in some definite moment in the past this universe in a state of perfect organisation sprang into existence at one blow or had steadily been becoming more and more disorganised ever since. This conclusion is incredible. It certainly seems to follow from the law of increasing entropy, which is one of the best attested laws in science, but we simply cannot believe it. No explanation could be accepted as scientific which involved such a breach of continuity." (Part XIII, p. 730.)

The only " breach in continuity " is that of a number of scientists who refuse to accept the conclusions of their premises. Additional proofs to the perfect organisation of the universe at the time of Creation are: (*a*) Linguistic evolution. Recently I read that a philologist could reduce all languages to three, or even one original one. (*b*) Disintegration of atoms, *e.g.*, Ætherium. A becomes Ætherium B in two-thousandths of a second, whilst uranium becomes lead in some millions of years. (*c*) The original religion was monotheistic and later developed into pantheism. I believe that Prof. Delitsch had proved this. (*d*) Moral dissolution through the emancipation of women and the use of contraceptives ; and (*e*) entropy, of which Sir James Jeans writes : " For every ton of the sun's weight which existed at its birth only a few hundredweight remain to-day."

Rev. W. B. MONAHAN wrote: This paper expresses my conclusions on a subject of lifelong interest, viz., Evolution, which long ago I showed to be utterly out of place if applied to revelation, except in a dialectical sense. That is to say, there may be a growth in expression from the less clear to the clearer; and at last a clear definition of the fact revealed which itself is not subject to any process of evolution.

I want to thank the author of this paper, the best I have seen, and one which ought to have a very pronounced effect on all genuine thinkers. It is splendid.

Prof. ARTHUR P. KELLEY wrote: Mr. Betts is entirely correct in stressing the "evasion" of evolutionists who refuse to submit to the logical deductions of the "law of entropy." Evolution, on the part of evolutionists, is simply a stubborn retention of dogma. One of my university students once said to me: "We are determined to believe evolution, not because it is true nor that we believe there is any evidence for it, but because it has become the symbol of our Liberalism." What point is there in arguing with people whose minds are totally closed to argument? I have recently been thinking of the inertia of the human mind. Harvey is said to have lost his medical practice for announcing circulation of the blood—no one wanted such a crack-brained doctor; but within 30 years his discovery was accepted by the universities. Hobbes ironically remarked that Harvey was perhaps the only man who ever lived to see his doctrine accepted by his own generation. But what can be said for these brilliantly superior evolutionists who not only needed 30 years to adjust themselves to a reception of Gregor Mendel's discoveries, but required 40 years more to understand that the Mendelian Laws which they so naively accepted and so widely published actually knock the very under-pinning from their house of cards, Evolution?

AUTHOR'S REPLY

There is little for me to say in reply to my kindly critics beyond thanking them for their remarks, which in several instances reinforce or more aptly illustrate important points. I emphatically agree with Rev. W. B. Monahan that revelation is not evolutionary in

character. It should be apparent to any careful student that its progress in clearness of definition and in fulness to its culmination in the out-shining of the light of the gospel of the glory of God in the face of Jesus Christ, was by well-marked, discrete stages.

I have read, and I rejoice in, the articles referred to by Lt.-Col. Davies and so ably written by himself and Mr. Dewar which have appeared in recent issues of the *Nineteenth Century*. The fact that an editor should esteem such mental food to be suitable for and acceptable to the readers of a successful modern review is to be regarded as a hopeful sign of returning public sanity.

Mr. E. W. Battersbey's notes strengthen the impression that certain men of science, who boggle at the very findings and implications of their own science, are entirely " without excuse " (Rom. I, 20).

Rev. Principal H. S. Curr has placed his finger on a pertinent point of the greatest import, which was perhaps too lightly touched upon in my essay. It is, of course, true, from the very nature of inductive reasoning that no scientific laws whatsoever have any certain application that is both universal and unchanging. It follows from this, with equal truth, that such laws *are not and cannot be valid against satisfactorily attested miracle.* These points need emphasis and insistence, *pace* Sir Arthur Eddington and others who seek by a tour de force, mathematical in character, to represent the laws of science as deductive or as " truisms." Such representation is entirely illusory and must be exposed and strongly resisted. However, it being the chief business of my essay to compare the doctrines of evolution and entropy in their logical foundations rather than to assess their absolute values, I was content to allow each of them its widest conceivable application in order to give full effect to the comparison.

Mr. Evenden's points I can only partly allow. *Formally* such a theory as Darwin's is a scientific theory. But this admission gives it no logical status beyond that of a more or less informed guess. Until it is shown to " fit the facts " it remains a *mere* guess. Any opprobrium attached to such a label is more thoroughly merited by Darwin's hypothesis than by the majority of scientific hypotheses, for his main " guess " as set forth in " Origin of Species " was buttressed by some seven hundred subsidiary guesses taking the form

" we must suppose " or " it may well be supposed " or something equivalent. And the methods of his modern continuators J. S. Huxley, J. B. S. Haldane, E. S. Goodrich and many others are equally steeped in wholesale guessing, as I have also indicated in the essay. That both the main hypothesis and the multitude of subsidiary hypotheses are not merely untenable, but grotesquely so, has been demonstrated again and again.* To insist on and reiterate such farcical and exploded theories is, I must maintain, not science, but " a stubborn retention of dogma," the result of a predisposition to see things in an exclusively naturalistic light. Professor Kelley's comment, for which I thank him, instances a perfect specimen of this in the determination of a student to believe in evolution " not because it is true nor that we believe there is any evidence for it, but because it has become the symbol of our Liberalism." " The symbol of our *atheism* " would be equally correct. The very word " evolution " has become odious to lovers of truth because it bears a permanent weight of evil connotation. Not the least evil feature is the insolent attempt to account for origins to the detriment of revealed truth. I suggest to Mr. Evenden that his own sentence, viz., " a certain development can be said to be evolutionary, implying continuity of development," would suffer *no* loss if simply given as : " a certain development can be said to be continuous "—unless he wishes to thrust in suggestively some flavouring of evolutionary teachings. For this is what has been done in magazines and popular science books for three quarters of a century, and is still being done. It is a practice which conveys to the easygoing thinker and the thoughtless the impression—intended, no doubt—that evolution is in itself a firmly founded doctrine available for general service in the illustration of other notions of inferior clarity. What a travesty of truth it all is ! I do not know what " general principles of evolution " may mean ; much less can I imagine how they can be " deduced." In his last paragraph Mr. Evenden speaks of " evolution " but means simply " continuity." Finally, Mr. Evenden states that " physical theories are often subject to the rigid proofs associated with mathematics." *This is simply a delusion.* Mathematics

* See, as a specimen of a recent exposure, *The Man from Monkey Myth*, D. Dewar, B.A., F.Z.S., *Nineteenth Century*, April, 1944, also reprinted as pamphlet by the Evolution Protest Movement.

can be used to elaborate a physical theory and to explore its consequences, but never to prove it. The only certain proof of a physical theory is the experimental one. Rigidity in the proof of a mathematical theorem consists in the absence of all assumptions except those explicitly given. If there is a physical theory which can be said to be certainly and unshakably proved it must be true of such theory (i) that it " fits the facts." and (ii) that it is the only theory that will do so. Much more could be said on this topic and, in these days of the extravagant esteem of mathematics, it badly needs saying. But it must be reserved for another occasion.