The Origin of Variations.

By Sir OLIVER LODGE, F.R.S.

ARTICLES in NATURE have the advantage that they are addressed not merely to experts in the same line of work as their writer—these have to be placated rather than informed—nor are they specially addressed to the school-educated general public, who are more likely to recognise the etymological character of the terms used than to appreciate their physical or biological significance. Articles in these pages are, I suppose, primarily intended to reach workers in other branches of science, thereby putting them into touch with modes of thought differing from but akin to their own. Our relations with each other are somewhat like those of politicians in alien countries: the problems are different, the methods dissimilar, but the general aims are alike.

International exchange of views is sometimes valuable; international conversation at Geneva has become possible: and long may it be before NATURE is subdivided into delimited areas labelled A and B. Seldom, however, does a member of one group feel entitled to intervene or say a word concerning the business of any other group. If he does, he runs the risk of being regarded as a trespasser and treated with contumely. That of itself would matter little. What usually deters him is the doubt whether anything he has to say is likely to be of the smallest use: he might be merely airing his own ignorance. Well aware of that likelihood, he may nevertheless occasionally venture to intervene, with all due diffidence and dependence on the charity and better understanding of those whose knowledge is so thorough that they can afford to pardon crudenesses of expression, and be willing to give favourable interpretation to presentations from another point of view.

These remarks are introductory to some comments on this year's Joseph Hooker Lecture before the Linnean Society, by Dr. E. J. Allen, on "The Origin of Adaptations", as partially reported in NATURE for June 1, page 841; and without further apology I would thank him for this concise summary of opinions on so interesting a subject—first explicitly treated, so far as I know, by Bateson many years ago.

Take then the question of heredity, on which so much turns. Certain truisms may safely be laid down. The only material transmitted to descendants is the germ-plasm (using that term comprehensively as including germ and sperm). No portion of the soma is transmitted, and therefore changes in the soma can only be inherited if they are such as to modify the germ-plasm. We know, however, that that substance is modifiable by slight changes in the environment, and hence it would appear quite possible for body changes to have their due effect. Such change may be imperceptible; except when tested by the actuality of inheritance, they might otherwise escape observation: hence only experience can tell us what is heritable. The body is the organ which gains experience of surrounding conditions and adapts itself to them; whether it can transmit any part

of such adaptation to the germ-plasm can only be effectively tested by observation of the descendants. If no such transmission occurs it is difficult to see how racial experience can contribute to progress. I gather that observation shows that evolution proceeds in such a way that descendants are on the whole better adapted to their surroundings than their ancestors; and further, that improvements do not proceed as if executed in accordance with some preconceived set plan, but that they are flexible and able gradually to follow unexpected changes in the environment which could not have been foreseen. Inheritance of modifications may be slow, but changes or adaptations of an individual may be quick, as when a flat fish rapidly and surprisingly adapts its coloration to suit the background on which it is placed. In other words, adaptability of a somatic kind exists in the individual as a fact of observation, so that there is no question about the possibility of individuals adapting themselves to circumstances. The question is how more serious adaptation, to permanently changed surroundings, can be conveyed to descendants.

The first *vera causa* suggested is natural selection and survival value. Permanent modification may result from the improved chances of life for those individuals who happen to be born with some approach to the favourable variation or mutation; subject to the added proviso that such innate peculiarity is transmissible by inheritance. This doctrine, though apparently true so far as it goes, obviously does not explain how the variation arises: it only acts as a lock to secure its continuance in the race when it has arrived. The problem of the origin of the variation is deeper than that. The survival of the fittest or the elimination of the unfit, alone, is little more than a shipwreck experience.

I will now make a quotation or two from the article referred to; and as it is so accessible, and this is not a controversial epistle, I will not hesitate to introduce into my quotations words in square brackets that are not in the original. In the second column of page 843, I read:

"That evolution proceeds according to laws of the same character as other [known] laws of Nature, is the common basis of all modern evolutionary theory, and was held perhaps more strongly by Darwin, Huxley, and Weismann than it is by some writers of to-day."

The word "known" which I have thus introduced is surely important, for if it be omitted I do not see how anyone could doubt the statement. Every event must happen in accordance with laws of Nature in the widest sense. But as to whether at any given period those laws are all known, or rather whether the laws known to a particular generation are sufficient as a basis from which to explain every recognised phenomenon, may very well be doubted. That, I presume, is the only point on which modern

writers can differ from what may be called the Huxley point of view—or, to make it impersonal, say, from the view that the fundamental knowledge of Nature already acquired by humanity is sufficient to account for all observed phenomena. Those phenomena have been added to since the middle of last century, and everyone who knows anything of Darwin and his great protagonist must realise how eagerly the newer experimental results would have been assimilated and utilised by them.

GUIDANCE AND CONTROL.

The question which still remains open, as worded by Dr. Allen, is “*how the soma influences the factors in the germ cell*”. Well, that is one way of putting it, from the material point of view: and an interchange or circulation of hormones has been suggested as a material method. For paternal inheritance this particular method may possibly lack cogency, but doubtless some machinery will be found; one can scarcely expect to see changes produced in matter without *some* appropriate mechanism! But that alone does not solve the problem. There is about the process a suggestion of purpose, as if, like all other mechanism, it were constructed for a definite object, and designed so as to work in a particular way. A random circulation of hormones, or of anything else, could scarcely be trusted to effect the precise changes which, having originated in the soma and possessing survival value, ought to be transmitted to the germ-plasm so that they may be inherited. Hormones may, for all I know, constitute the material means of conveyance; but how do they exercise that function? And what initiates or controls their activity? So much is left unexplained even when the machinery is discovered.

Material mechanism is just what can be followed by those whose business it is to study the physical basis of life, but mechanism is never self-explanatory. The most automatic mechanism ever constructed must have mind behind it, not indeed in its contemporary working, but in its design and purpose; and if the result of mechanical working simulates the effect of purpose, it may be wise to keep our minds open to the possibility that after all there may have been some purpose, or so to speak intention, in the change that is being observed and in the adaptation of the means. The mechanism whereby a flat fish (to go back to that merely popular illustration) changes its pattern when greater concealment can be thus secured, has I believe been made out: certain pigment cells swell, while others contract. That the animal knows what it is doing is quite unlikely: the mechanism presumably works automatically. But surely biologists scarcely feel that they have got to the bottom of the problem when they merely point out the mechanism!

Some biologists apparently realise that a statement in terms of automatic working is not ultimately satisfying, and are said to have introduced “the idea of some psychic or psychoid influence, controlling and regulating the processes of metabolism and organic growth”; which idea is

deprecated by Dr. Allen, in common I suppose with many others, as too like “the animisms of primitive man”, too suggestive of conscious purpose, “such as we know only in ourselves, or by analogy assume in higher animals”.

Purposive action and planning, however, do after all exist in the universe, and therefore may have to be taken into account in ways of which we at present have no suspicion. It is true that the higher animals who thus act for the future have “an elaborately differentiated nervous system”; but that is only part of the mechanism for the forming and carrying out of a purpose. A machine does not really explain the rationale of its own action: no machine is able to do that. The most elaborate machine is a mere executive.

Suppose we revert to an earlier position and ask, How do we know that germ-plasm may be influenced and modified or adapted to new and unexpected conditions? Doubtless we know it in several ways, but among others by the direct experiments mentioned by Dr. Allen in the second column of page 842, where we are told “that the germ-plasm itself can be acted on by physical and chemical forces in the environment in such a way that mutations are produced”. For

“Harrison has shown quite clearly that the germ-plasm can be changed by chemical substances contained in the food of an animal, or in more general terms that the germ-plasm can be altered by the environment”.

Here, then, is a change which has been produced through proper physical and chemical means and has resulted in a mutation. But surely Dr. Heslop Harrison may be not impolitely called “a psychic or psychoid influence, controlling and regulating the processes of metabolism and organic growth”; and H. J. Muller, by finding the correct dosage of X-rays for mutation production, seems to be another of those influences. An imaginary observer able to watch the processes, but from whom the operator was concealed, might feel impelled to infer him. But indeed we need not appeal only to recent advances. The long-established procedure of breeders, and even of gardeners, long ago showed that mental operations—put into effect by a nerve-muscle system—were able to guide and direct the ordinary forces of Nature so as to produce variations almost at will. The beneficent progress of discoveries in agriculture, from which ultimately we hope so much, is an outcome of this purposive activity of a “psychic or psychoid influence”. Such an influence is therefore another *vera causa*, which may be more widely operative than at present we imagine.

CONCEALED INFLUENCES.

It will be said, however, it is quite unfair to bring in the operations of a highly organised product of evolution, and use that as an analogy for what occurs in connexion with low organisms without any trace of psychic or even nervous development. How is it possible for anyone who wishes to adhere closely to the laws of Nature to think of any other

influences than those displayed by the organisms themselves? How can we detect concealed influences? If we attend only to matter, and to those laws which have been already ascertained, I admit it may be impossible. But a physicist is not limited to the contemplation of matter. He regards the behaviour of matter chiefly as a sign or indication of what is going on in space. Faraday showed that the phenomenon of electric charge would never be properly understood by attending to matter alone: he traced the electric field to a property of space. Charged conductors are only the boundaries or terminals of an electric field existing *in vacuo*. Similarly Poynting showed that an electric current is not propelled by anything occurring in a metallic conductor, but by an influence reaching the conductor through space. The energy of the sun reaches the earth in that sort of way. Atoms act on each other across intervening space; and it is to space that modern physics turn for explanation of cohesion, elasticity, and of what used to be called 'gravitational attraction'.

In fact, it may be said that modern physics attends very much to space and its properties, and utilises matter mainly as an index, demonstration, or manifestation of those properties. The very electrons of which matter is composed are spatial peculiarities, and seem to have more affinity with waves than our scientific ancestors suspected. An electric current, considered materially, is a procession of electrons; but the driving power is not an end-thrust like that of water through a pipe: the propulsion is a lateral propulsion exerted by electromotive forces which reach the conductor through the surrounding medium, along paths which can be mapped out.

Undoubtedly we are dependent on matter for every observation; we cannot study even ether or radiation without it; occurrences in space are concealed from us, they have to be inferred. For example, a magnetic field is an etheric or space phenomenon, and yet, admittedly, it is by aid of the properties of matter that we explore and investigate such a field. But matter after all is secondary; it displays and locates the phenomenon: it helps us to deal with it and make experiments upon it; yet an actual magnetic field is turning out more like a circulation in space than anything else. Before the discovery of electric currents, the only magnets known were natural magnets and those which had been propagated from them by regulated movements. One magnet could produce any number of others, without being itself weakened, and there was no magnetism without antecedent magnetism. The parable is obvious.

The progress of science in that department, however, led on to the production of artificial magnets, electromagnets, whereby fresh magnetism could be generated by setting electricity in motion. Yet, even so, 'generated' is scarcely the correct term. The act of magnetisation seems to be only the utilisation and opening out of circuital relations which already exist, so that instead of being shut up into infinitesimal configurations they are dis-

played openly and made manifest. Pre-existing but imperceptible magnetism could be incarnate in matter and exhibited. All matter has close relations with the space surrounding it. Radiation is a constant means of communication, not only obviously, but also secretly, in ways only recently discovered. An atom under certain conditions can emit energy into space, and can receive energy from space; and all material activity is the result of this interchange of energy. In space, the energy is what we call potential: in matter, it is what we call kinetic. The one form is continually passing into the other, and back again.

It must be admitted that analogies prove nothing, but they are sometimes suggestive. My suggestion is that life is something which primarily exists in space, though we only know of it when it is associated with and displayed by matter. I venture to say that we shall never understand life so long as we attend to its material manifestation alone. We must always use matter as our index and means of exploration, because it is matter alone that appeals to our senses; but the reality may lie beyond or behind matter, and may only interact with it for a time. We should never have understood the laws of an electromagnetic field, and the nature of radiation, by theorising as if matter were supreme. Even now we scarcely understand the nature of gravitation, though we can apply its laws with considerable success to the motions of material bodies. Similarly, the nature of life is unknown, though a vast amount has been learnt about living bodies.

I would ask biologists to consider whether they could not, as a working hypothesis, begin to contemplate life as something existing in space as in a sort of infinite reservoir, out of which it could under appropriate stimulus enter into association with molecules of sufficient complexity to enable it to catch hold and become as it were incarnate. They might go on to suspect or infer concealed mechanism, not of a perceptible material kind, but still possibly of a physical nature, activated by something at present unknown. I suggest that concealed powers have put the organism together, in a specific form, out of such materials as came to hand. When the machine goes out of order the controlling powers cease to be able to display themselves: the instrument of manifestation is spoilt. But we need not jump to the conclusion that when they related themselves to matter they came into existence, and that when they leave matter they cease to be.

Few of the controlling powers can have attained an individual or personal existence, but we know that matter, in its more complex and higher protoplasmic forms, has been the means of individualising those concealed activities; and consequently, as developed personalities, we ourselves are able to testify and help the explorers. If they made use of all the information available they would have a wider scope for contemplating the apparently purposive movements of live things, and might realise that in studying as they do the material basis of life, they are studying the influence of some

controlling entity—perhaps etheric, perhaps psychic, probably both—by aid of the material mechanism which it utilises.

CONDITIONS FOR VITALITY.

There are certain narrow conditions which have to be satisfied before live things can appear—a certain narrow range of temperature, the presence of chains of carbon atoms and perhaps of oxygen and liquid water—all of which are commonly called the conditions necessary for life to exist. I would rather call these the conditions necessary for vitalising or animating matter—the conditions for vitality; in other words, the conditions enabling life to enter into association with matter. I admit that it is the peculiar behaviour of organised cells that we commonly designate by the term 'alive', but we must not be too much hampered by our use of terms. Animated matter displays life, and the display or manifestation of life we might call vitality. When vitality ceases we are apt to imagine that life has gone out of existence. But we do not think that electricity has gone out of existence when a body is discharged, though it is no longer electrified; nor need we think of magnetism as going out of existence: it can become concealed and go out of our ken. Nor do we think of electricity as ever coming into existence—at least not under observation; it can be localised so as to display itself by material effects. Animated matter behaves in a curious way, and so does electrified or magnetised matter. A compass-needle points north and south, as if mysteriously cognisant of those regions; but everyone knows that it is only acted on by the peculiarities of the space near it.

Similarly, if we try to understand apparently purposive action in animated matter, we may fail unless we realise more clearly that something is

controlling and being itself displayed by that matter. An electrician uses a compass-needle or a filament to display or manifest an electric current; but he would not understand much about the current if he limited himself to a discussion of its material manifestation. Nor do I think that we shall understand much about heredity, and the other strange occurrences dealt with by the biologist, so long as we attend only to the material vehicle or instrument of life. Life enters into a nascent organism gradually, as its cellular constitution is enabled to receive it; and when, in the long course of evolution, an organism has attained sufficient complexity, the higher stages or aspects of life, called mind and consciousness, enter or are manifested too. But a study of the mechanism alone will never detect more than an indication of our thoughts, plans, hopes, and aspirations; nor can we thus explain consciousness and our power of understanding what is going on in the material explored.

One more quotation from Dr. Allen in conclusion, with which, I need scarcely say, I heartily agree, especially if extended by the words in square brackets:

"In whatever direction we look problems bristle, problems open to successful attack; and the old qualities, insight, patience, and determination, will get them solved. But we must not limit the outlook, and all aspects of biological research must proceed hand in hand. Botany, zoology, palaeontology, the work of the systematist and of the field naturalist, the study of structure and the study of function, the work of the embryologist and of the experimental physiologist, of the geneticist and of the statistician [aye even of the physicist and the psychologist], all are necessary, and none can succeed without the others."

The Joint Meeting of the French and British Associations at Havre.

IN 1914, while the British Association was meeting in Australia, the delegates of the Corresponding Societies were invited as guests at the conference of L'Association Française pour l'Avancement des Sciences, then being held at Havre. Those who were present will remember the hospitable way in which they were entertained at the Hotel Frascati, at the meetings and excursions, though as day by day passed there seemed to be something mysterious going on; the hotel gradually emptied, there were signs and whisperings, the members were impressed by the enormous accumulation of food-stuffs in the warehouses, and before the meeting was closed the declaration of war explained a good deal. The members had to find their way back to England as best they could, and those who had the experience will never forget it.

The French Association, towards the end of July this year, again meets at Havre, and as the principal members of the British Association will then be at South Africa, our French colleagues have again extended the courtesy of inviting the other members of the British Association to attend its conference at Havre without any extra fee beyond the ordinary

subscription to the British Association, which would be paid in any case.

In addition, the French Association has invited the delegates of the Corresponding Societies to hold their conference during the Havre meeting, and in connexion with this a sub-committee was appointed consisting of the president of the Conference of Delegates, Dr. F. A. Bather; the secretary, Dr. C. Tierney; and the acting secretary for the Havre meeting, Mr. T. Sheppard. Sir Henry G. Lyons was also appointed the official representative of the British Association and chairman of the organising committee referred to.

At the Glasgow meeting of the British Association, Dr. A. Loir, whose courtesy was so much appreciated in 1914, was present and gave an official invitation to the General Committee of the British Association and was prepared to do the same for the Conference of Delegates, but apparently that body was too fully occupied to spare the necessary time. Mr. T. Sheppard has recently visited Havre and met the chairman of the Local Committee (the English Consul, Mr. H. C. Swan), Dr. Loir, and others interested in the local arrange-