Determinism.

THE wide circulation and attractive style of Sir James Jeans's book, "The Mysterious Universe", will probably mark a step in the crystallisation of ideas towards the rejection of any mechanical system. But many will ask, Why go so far, and go no farther? Why have we dethroned a mechanical system and set pure mathematics to reign in its stead? The essence of a mechanical system, or to give it its more general name, Determinism, requires a single time sequence, proceeding in one direction, and postulates that each state is an inference from any past state, the necessary major premiss being Causation. One immense consequence of Einstein's ideas has scarcely yet been touched,—as the quantum theory undermined Causation, so relativity undermines Determinism and every other ethical theory by abolishing the time sequence.

Pure mathematics differs from this in possessing no time sequence; all its statements are interconnected so that each implies the others, and no statement is made at all other than the original axioms out of which it was evolved. Therefore it assumes the possession of complete knowledge of the theme before it makes any statement at all. If this leads to mysteries in the description of the universe, as well it may, it is hard to see why it too should not be rejected as unsuitable for the purpose, in the same way as we have rejected the animism and anthropomorphism of our ancestors. Pure mathematics is the last thing we would reject—if it goes, number goes, for the logic of pure mathematics depends upon number; and if number and the separation of objects of thought is discarded, all experience merges into one changing whole, incapable of exact description and communication to others. Apparently physical science owes its success to having elected to describe Nature on the lower plane of abstraction, where exact communication is possible. This is the alternative we may have to embrace. We can say with Faust, *Im Anfang war die Tat*, and nothing more. R. A. S.

Edinburgh.

Embryology and Evolution.

I HAVE read with much interest Prof. MacBride's review entitled "The Problem of Epigenesis", and I should like to make a few remarks upon what he says at the end. First of all, I wonder if the following analogy will help him, as it has helped me, to reconcile the conceptions of the geneticist with those of the embryologist. In a modern motor works the cars, so I understand, move along a track past a series of workmen, each of whom has one particular job to do, which is related to what has already been done and also to what is going to be done afterwards. Now if we imagine that all the parts and materials which are going to make up the finished car represent the substances in the developing embryo and that the workmen are the genes, we have an analogy which can be carried surprisingly far. Not only will it give us a picture of normal development, but we can see, by altering one of the parts, how a variation may occur; by altering a workman, how 'sports' may arise; and, by adding a new workman with a new job, how progressive evolution may take place.

There is no need for me to occupy space in working the analogy out, for anyone can do it for himself: what is more important is to point out where the analogy fails. A motor-car is adapted for life on the road, and, until it is completed, it has, for all practical purposes, no environment at all comparable with that which bears upon an embryo throughout its development. So whereas a feature of a car is simply due to the action of the workman on the materials, a feature of an animal is the result of the combined action of the genes and of the environment upon the materials of the embryo. Genes without the appropriate materials can produce nothing; genes with the appropriate materials can only produce a partially developed structure; but genes with the appropriate materials and environment can produce the fully developed functional character. Hence it is that in the development of the frog, for example, the gill-clefts, etc., are full developed, whereas in the Amniota, with the radical change in the environment of the early stages, such structures are only partially developed and the stages, to quote Prof. MacBride, are smudged.

Looked at from this point of view, two other conclusions of great importance are unavoidable. The first is that the recapitulation of an ancestral stage of the evolution of an animal, as distinct from the repetition of an ancestral character, will only occur when the early stage of development is passed in the same environment as that of the ancestor, which environment is different from that of the present-day adult. Only under such conditions will the genes responsible for the adult ancestral characters give rise to them all together without any great admixture of other features; though it must always be borne in mind that such stages in the life history, being larvæ, may evolve on their own account and, therefore, may have features which the ancestor never had. In parenthesis, I should just like to add here that, so far as I know, a larva has never been properly defined: such a definition would be "A free-living stage in an animal's life history which fends for itself and possesses certain characters which it has to lose before it can become a young adult": the possession of *positive* characters distinguishes a larva, not its lack of adult ones.

The other conclusion is reached thus. The appearance of a functional feature is dependent, as we have seen, upon the interaction of three things: the materials of the embryo, the genes, and the environment. Now the facts of Mendelian inheritance give clear evidence that there need be no change in the materials of an embryo for a new gene to modify the form, so, in discussing the origin of a new feature, there is no need to consider a change in the materials as one of the essential factors. The fortuitous appearance of a gene without the appropriate environment would produce a partially developed character, but, in actual experience, we do not find features in a partially developed condition which *have never been functional* at any period in the history of the race. So the genes must, in actual fact, only arise after the suitable environment is present; and the only conclusion to be drawn from that is that there is a causal relation between the two; that is, that the environment is in some way responsible for the appearance of the gene, which is surely nothing more or less than the basis of a new proof of the inheritance of acquired characters. G. L. PURSER.

The University, Aberdeen,
Oct. 29.

I HAVE read with interest Mr. Purser's thoughtful letter on the subject of my review. If he will substitute the term 'race-memory' for 'gene', we shall not be far apart. But the gene of the Mendelian stands out as something that is never functional. "No one", said the late Sir Archdall Reid, "ever heard of a useful gene." When one takes into consideration the fact that the Mendelian genes in *Drosophila* have been shown to increase in their damaging effect on the viability of the organism in proportion to the structural change which they involve, and when further it is discovered that genes can be artificially produced by irradiating insect eggs with X-rays—a