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Dr. Francis Crick, F.R.S.,
Laboratory of Molecular Biology,
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CAMBRIDGE.

Dear Francis,

I feel very guilty at not having written earlier in answer to your letter about vitelism. I very nearly got around to answering it within a few days of its arrival but then got submerged in other things and it has kept on being put on one side until now when there is a slight let-up around Christmas time.

First on the question of quarks, I quite agree that it is extremely unlikely that the structure of the atomic nucleus has anything much to do with biology. I mentioned quarks only as an example of something which you raise when you discuss your third type of vitelist, the one who thinks that some radically new physical ideas may emerge from the analysis of biological systems. I should have thought myself that this was well on the cards. After all chemists studying relatively simple complexes of atoms had to make use for a long time of the concept of valency, and it was quite a long time later that the physicists got around to finding how to express this in their terms, and in doing so they had to rewrite a good deal of basic physical theory. Is it not at least possible that when one is construing the properties of very large macromolecules one would come across types of bonding, attraction between portions, active states, etc. which simply do not come to notice in other simpler situations? I am, of course, not at all an expert, but it has always seemed to me that the sort of things people talk about - van der Wals forces and the like, are still miles away from giving an explanation of how bodies as big as prophase chromosomes come together and pair ~~other~~ relations between histones and DNA and so on.

Putting the point more generally, I think the usual discussion " vitalism-mechanism" puts the question upside down by asking "if we start with physics and chemistry can we explain the whole of biology?" Whereas the real question should be "if we analyse biological systems shall we come across anything which physics and chemistry cannot eventually accommodate"? This second form of question itself implies of course that physics and chemistry are themselves growing and developing subjects.

This is also at the point I should like to make concerning your second class of vitalists (the biotonic laws). There is a lot of biology which is at present is as far from basic physics as the gas laws are from the dynamics of the individual gas molecules. As you say, the field of natural selection and evolution is one example and I should myself suggest that the morphogenesis of large scale structures such as fores will quite likely turn out in the same category. This means, I think, that new bodies of theory will have to be developed to deal with such phenomena, but this does not imply in any way that the new theories cannot be finally incorporated into an expanded body of physics. Morphogenesis for instance may present us with phenomema as novel as those of low temperature physics or some of the more peculiar solid state systems. Evolution and higher nervous activity may be more analogous to the operations of computers. As I once pointed out some years ago, looking at a few pieces of wire and plastic from the point of view of ordinary physics, I would not easily come to the conclusion that they could beat one at chess. Suitably assembled and programmed they could do so, and their behaviour then is not "non-physical" but is I should say "super (conventional) physics".

Finally about consciousness, I agree I would feel somewhat happier if I had a certain means of physical detection from outside whether someone else was conscious or not, and happier again if I knew that when he was conscious certain things were going on in his higher nervous system, but personally I have sufficient of a metaphysical bent to feel that I would not be satisfied with this. Afterall knowing that when a chap is undergoing rapid eye-movements he is almost certainly dreaming, ~~This~~ is all very nice but it really doesn't tell one enough. Personally I think one has to go back to the beginning of the analysis of the primary experiences into objective and subjective parts. I think Man has always done this by a rather unreflecting application of a system which has been built up by natural selection, which puts into the objective various things which it is selectively dangerous to overlook. It is the theoretical physicists Einstein, Schroedinger, Heisenberg, and so on right up to the most recent

of writers about quantum physics, who have found themselves forced to question this conventional outlook. I think it is possible in future a definitely scientific metaphysics will develop in which the basic physical entities, not being, as they are now, defined in such a way as to definitely exclude such phenomena as consciousness and perception.

With best wishes for 1968.

Yours sincerely,

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