Le hasard et la nécessité

Essai sur la philosophie naturelle de la biologie moderne

J.Monod

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According to a faded receipt I bought the book in Grenoble. This limits the occasion to the spring 1995 or the fall 1999. I suspect the latter. I recall the introductory pages to have been quite interesting to me, asking,as they did, for the criteria of demarcation between the artificial and the natural. However, I did not get much further in the book, at least judging from the position of the receipt; maybe the French, in spite of being straightforward and devoid of literary flourishes furthermore furnished with a limited but precisely employed vocabulary, just as in mathematics, was too much of a strain? But such excuses can no longer be made.

Indeed it is an interesting question, and the verdict is that it is really inadequately posed. True, the obvious distinction between the artificial object and the natural is that the former has been designed, i.e. being part of project. The forces of nature are blind and devoid of any premeditation, whatever meditation can be assigned is but a retroactive creation imposed by the mind. Monod speaks about *teléonomie*[1]. However, when you think about it more deeply, the distinction between man-made things and natural things becomes more and more tenuous. The real distinction in the universe is between material things and living things (*êtres vivants*). The latter are indeed strange entities and their emergence and 'living' seem to go against the basic laws of physics, such as the second law of thermodynamics. There are a number of reactions to this. The first is 'vitalism' which did not make sense until the emergence of modern materialistic science. The author distinguishes between *vitalisme métaphysique* and *vitalisme scientiste*, the first denies the possibility of a scientific explanation whatsoever of life, the second that the present ones are incomplete, that something is missing, that in fact there is both dead and live (vital) matter. As a proponent of the first he chooses Bergson, who in his time had quite an influence. Bergson is very seductive in his arguments, and his idea of *l'élan vitale* has an immediate appeal as the guiding principle of the universe, the understanding of which is only accessible to intuition transcending mere rational reasoning[2]. The author has

[1] A term of fairly recent coinage (Pittendrigh in 1958) meant to be related to the teology of Aristotle and his final causes. The concept of purposefulness as applied to biology in general, was, according to Haldane, to be thought of as the mistress of biologists, whom they could not live without, but were reluctant to be seen in public with.

[2] Not even mathematicians may be immune to its charms. After all the basic axioms of Euclidean space and logical reasoning seem to transcend (by necessity) logic and ultimately based on intuition. And a mathematician may give more credit to intuitive understanding than mere logical manipulation which seems more to be some formal justification after the fact. There is much (intuitive?) truth to that, but involves a far-reaching discussion too long and involved for a mere footnote.

very little patience with Bergson or at least his style of reasoning (if you can talk about reasoning) and declares himself incapable of commenting on him, but is careful to point out that does not mean that he holds him to be an insignificant figure, after all profound criticism of rationality is a signature of our present age, the author indicates, but he cannot read him. The scientific vitalism on the other hand has a lot of support from distinguished scientists[3] and he mentions in particular Elssser[4]. But prior to the scientific revolution, in fact going back to the origin of mans cultural development, we have *animisme* the idea that there really is no division between nature and man, that both have a purpose and a plan, as in the philosophy of Aristotle, that every material body in the universe is, so to speak 'animated'. In such a view there is nothing strange and paradoxical about living things[5]. While, as I suspect, vitalism can be seen as intellectually dishonest, a 'cop-out' animism is much more fundamental and connected with mans natural attitude towards the universe in which he finds himself. In fact modern science, as say instigated by Descartes and Galileo, makes a clean break with 'animism' by objectifying nature. Cartesian dualism reduces the physical world to a machine, i.e. objectifying it as its workings are in principle accessible to the intellect, while reserving the notion of spirit to the soul of man exclusively. Monod rejects both vitalism and animism, the former on pragmatic grounds, only by rejecting it can we freely pursue a material investigation of nature, and the latter on metaphysical grounds, because the way to pursue science unsentimentally is to grow up and transcend your biological biases; yet one suspects, that he has some sympathy for the Cartesian dualism if you extend the soul of man to encompass all living things. But animism is not entirely dead, the author brings up Marxism as a throwback to animism, with its assumption that history has a purpose, that it is evolving according to some plan, which may intellectually be seen as an implication of Hegel and the evolution of the world spirit, ideas which at different times, have had a strong emotional appeal[6].

The remarkable thing is that all living entities share the same bio-chemistry. The latter is in principle simple, although the details are subtle and the consequences unpredictable and unsurveyable. The smallest living unit is the cell. All living things are made up by cells, even if still most are only made up by one. The cell is an incredible efficient chemical machine, whose purpose is faithful reproduction without which evolution would not be possible. There are two types of chemical compounds nucleic acids and amino acids.

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[3] He incidentally implicates Bohr

[4] (1904-1991) a physicist doing fundamental work in geophysics, known in biology mainly for his idea that the physics and chemistry of a living cell is too complicated to analyze from a purely causal angle and in particular not amenable to any precise predictions, thus calling for biology to pursue other avenues of research.

[5] vestiges of that idea can be found among certain modern philosophers who claim that even an atom has a rudimentary consciousness.

[6] It would be interesting to trace the idea of evolution in philosophical thought. Some of it figures in Hegel, obviously ahead of Darwin, but the idea was of course also present in Lamarck. No doubt it can be traced back to the old Greeks, although Hegel was the first to exploit it as a philosopher. Hegel's vision of evolution is of course animistic, while the pure form of Darwin is not, although it is so seen in the vulgar mind, seeing it as having a goal, namely man.

Of the former there are only four kinds [7] referred to by their initial letters as A,T,G,C. They make up, in practice arbitrarily long sequences, which are given a geometrically fairly stable configuration, the well-known helix structure, invariant under rotation and translation, and hence in the nature of a crystal. Those are the famous DNA molecules. Basically they are chemically fairly inert, and partake in meaningful chemical interchanges with other molecules in only two ways. One is through reproduction the other through protein synthesis. As to the former the helix is split up into two strands, one the 'mirror' image of the other. More specifically A and T are paired, so are C and G. Occasionally the strands are split apart and then spontaneously each nucleic acid bounds up with is complementary acid, supposedly swimming around in a soup, thereby creating a mirror image attached to it, and thus a replication of the original DNA, and normally the same thing for the other stand, thus producing two copies of itself. The process is conceptually simple and elegant, congenial to a mathematical mind. What is noteworthy here is the spontaneous creation of order against the principle of increased entropy characteristic of physical systems left to themselves, a phenomenon occurring over again in the chemical processes of a cell. Why is that? Monod refers somehow vaguely to the acids functioning as Maxwell's demons. Once the right kind of nucleic acid turns up in the immediate vicinity of one they both so to speak lock together automatically, by virtue of their stereo-metrical shapes. Does it take energy to do that? The author gives an exploratory explanation, which I have to admit is not entirely transparent. The other way interactions occur is in the production of proteins, which goes through a somewhat round about way. A DNA molecule can be described as a sequence of the basic letters A,T,C,G, and every block of three letters code for a specific amino-acid. There are twenty of the latter, so any strings of DNA will code for a string of amino-acids. Now the amino-acids are attached to a skeletal frame making up long molecules, so called proteins in analogy with the nucleic acids of the DNA, but their structures will not be as simple and rigid as that of DNA, but very contorted. Their very stereo-metric structure will determine how they will interact with other molecules, and thus interactions will be much more complicated and unpredictable than those engaged by the nucleic acids, in fact partake in the complicated chemical dance of a cell and ultimately in the construction of the phenotype of organisms, a process purely understood in any kind of detail, thus providing a huge gap in understanding between the DNA sequences and the actual macroscopic effects as manifested by their phenotypes and the way those work. Now the construction of proteins is somewhat complicated by the fact that it is not done directly on the DNA strands but through the intermediaries of so called messenger RNA, which are also made up of nucleic acids in structures very close to the DNA, but with the difference that the T-acids are replaced by the U-acids, so the genetic code, meaning how to convert the 64 different types of triplets to the twenty types of basic amino-acids are used using 'U's instead of 'T's.

There are a few things to stop and ponder at this stage. First the process is characterized both by simplicity and elegance, as well as what seems totally arbitrary, such as the genetic code dictionary (supplied, along with other technical information, in appendices), as well as the round about way through RNA[8] and the inexplicable substitution of

[7] As we will see one of them comes in two versions

[8] similar to DNA, except consisting of only one helical strand, not two mirror-images as in the DNA

T by U in the latter. Mathematicians are typically excited about the simple features, as being somehow inevitable, and turned-off by the arbitrariness of other features[9]. Now the different nucleic acids make up letters in a small alphabet. The shape of letters are usually irrelevant, as long as they are mutually distinguishable, what matters is the information they help do encode, but that is from the point of view of a conscious intelligence manipulating them. Now there cannot be any overarching design as how they are deployed. First they are very small involving a rather limited number of atoms, hence they are more compact than any macroscopic letters we can design. Also their very shapes are essential in the way they are being combined. So the natural question is, can there not be other basic nucleic acids (nucleotides) playing a similar role, in particular why to the U-acids not get hooked onto the regular DNA strings, after all they seem to replace the T-acids[10]. More radically, why not a different chemical basis? Could it be that the real bottle-neck is the chemical[11]. The biosphere contains an incredible variety of life forms, be they all microscopically very similar, could it be that there can only be one kind of chemical basis for life, or that the emergence of suitable molecules to support life is so improbable that it might only have occurred once in the history of the universe. As the author claims, life is not deterministic, it is only compatible with physical laws, and not necessarily determined by them. There may be billions of planets which would allow life to develop, but that is not the same thing that life will appear. It is not sufficient if all the necessary conditions are fulfilled.

It is noteworthy though that Monod emphasizes that while information is transmitted from the genotype (the DNA) to the phenotype, indirectly through protein synthesis, information does not go the other way, part of the dogma of genetics. DNA is of course being perverted through a form of increased entropy through external damage and misreproductions, so called mutations, but those are usually weaned out due to the impairment of the phenotypes that will typically follow. This goes to the heart of the difference between Darwinism and Lamarckism; Darwinism is simpler as it only has to account for one direction.

Now most mutations are deadly and are thus filtered out, others are indifferent and form the basis of so called genetic clocks, which was not yet really thought of at the time that Monod was writing, and would anyway been peripheral to his main theme. Occasionally though mutations are advantageous, and due to that species evolve and often

[9] Before the determination of the actual codes there were some very clever mathematical ideas of how such a code could be canonical. It turned out to be irrelevant, turning off the mathematicians for venturing further.

[10] The same question could be asked about proteins. Are there only twenty possible amino-acids? And those amino-acids are they synthesized on location or are they imported wholesale into the cells? Monod's book is not intended to be a textbook on the nitty-gritty details, and besides during the half century which has since passed much more technical knowledge has been adduced. According to a Wikipedia article there are 172 theoretically possible amino-acids although only twenty are produced by DNA. Thus many more proteins could be manufactured than are naturally synthesized.

[11] S.E.Luria in his MIT textbook 36 lectures in Biology (1975) speculates that there might have been alternative biochemical processes initially but the one we know has taken over so successfully that no traces of alternatives have survived.

become more efficient and sophisticated. But the source for those changes are entirely by chance. What is meant by chance, Monod stops top ask? To throw a pair of dice is not really chance, the dice obviously follow the laws of physics, and follow a deterministic path, but we do not know the necessary details in order to be able to predict the outcome ahead of time, nor can we throw with such precision as to achieve anticipated results. But true chance has to do with long chains of events accidentally intersecting, as an example he takes the doctor hurrying to attend to a patient being hit by a falling hammer, accidentally dropped by a plumber on an assignment of roof-work, and dying. Two chains of events having nothing to do with each other. This is the kind of chance evolution thrives on, it is not deterministic only compatible with the laws of physics complying with them without being determined by them. Yet one is able to see certain trends in evolution, as if it had a plan. The feet of horses have become more and more specialized until they now only run on one toe, while the less developed mammals (such as primates and bears) run on five. The point is that speed of flight is crucial to the survival of horses, hence high survival value are placed on whatever improves its speed. It is unlikely that horses will split up in speedy horses, and horses with very strong and sharp teeth to defend themselves. As the paleontologist Björn Kurtén put it. Horses have entered an evolutionary dead-end, all they can do is to become more and more 'horse'. This if anything would qualify as a general plan. Man, on the other hand, is far less specialized. As an animal of its size it is remarkably weak and stands defenseless against any good sized predator; also its sense of hearing and smell is far less developed than most mammals, but being a primate it has good eye-sight, although it cannot compete with birds of prey. One may also speculate that when it comes to cognition, involving memory and such things, it is not remarkable, but its survival skill is tied to its sociability, which combines individuality with the herd instinct, and probably can only be compared to wolves[12], as well as its manual dexterity. Both are assumed to have been crucial in the almost explosive development of the brain[13]. The evolutionary fate of man is hence to develop its brain capacity. One crucial aspect of it being language, and here Monod is much in sympathy with the ideas of Chomsky claiming that the ability to quickly learn and use language is innate, thus diverging from the empirical tradition of classical British philosophers with their 'blank slates' [14].

Ultimately what is the point of it all? Meaning our human existence in a universe which could not care less about us?[15] Morality cannot be based on knowledge, as already

[12] The social life of elephants is also rather sophisticated

[13] Most tangibly through its growth in size, with the pelvic of women not keeping pace. Thus human infants are born prematurely, but nevertheless the passage out of the uterus is fraught with danger. In fact the human population at some time almost went extinct, thus humans are genetically much closer to each other, than primates in general.

[14] Traditionally animals, especially lower animals, are thought to live by instinct, while higher ones learn their skills through experience. But how do you learn to learn, or for that matter learn how to learn to learn? Man is in fact much more driven by instincts than ordinarily thought, and more and more skills turn out to be innate. Chomsky for one thing also thought about making sense of vision being an innate quality, explaining how we so fast acquire the skill to see.

[15] Similar sentiments have been expressed by Steven Weinberg, who notably claimed that the more we get to know about the universe, the more pointless it appears.

Hume emphasized. How can we form values which are not only pragmatic, i.e. subservient to some perceived end, but are actually pure in the sense of existing independently of any ulterior agendas. Monod proposes that the seeking of knowledge is by itself an expression of a moral stand. To seek and expand knowledge has thus a value independent of any practical applications, and it presupposes honesty and a willingness to share in a purely disinterested way. Thus this very pursuit of knowledge, and the moral values it entails, can be thought of the basis of a human value system[16].

One always looks for the popular science book addressed to the intelligent layman. One seldom encounters it, but in my view this book is an exception. It treats a scientific domain of knowledge through a philosophical overarching view. This is not done as a condescension to the reader but is the fruit of an honest reappraisal by an expert. The book is indeed an essay in the sense of evolving during writing guided by an honest as well as passionate attempt to see the familiar from a new and fresh point of view. The author does not primarily teach nor instruct or simply pass on information, although aspects of that is of course inevitable, but shares his experience of discovery with the reader, who is then treated to be on the same level. The author may have superior technical knowledge, and this is what makes the book exciting as well as edifying, but he claims no superior metaphysical knowledge, such knowledge is to be seen as the end product not as the basis.

August 11, 13, 2019 **Ulf Persson:** *Prof.em, Chalmers U.of Tech., Göteborg Sweden* ulfp@chalmers.se

[16] C.S.Pierec has expressed similar view, claiming that logic as a basis for accurate thinking belongs to moral philosophy, as opposed to mathematical logic. which I would agree to be a species of applied mathematics. One may also argue, as I am found of, that the deductive system in mathematics is the foundation for political democracy. Namely that the value of an argument rests entirely within the argument itself and who happens to formulate it is irrelevant. In this view everyone has a right to be heard and also expected to participate in discussions.