Reprinted from "Of Microbes and Life," J. Monod and E. Borek, eds. Columbia University Press, N.Y., 1971.

Festschrift for A. LWOFF

To, Marcel, philosopher, with the compliments of the Author

Nov 15, 197

Aristotle–totle–totle

M. DELBRÜCK

THE LOGICIAN: *Let us take another example. All cats are mortal. Socrates is mortal. Therefore, Socrates is a cat.*

THE OLD GENTLEMAN: *And has four feet. Indeed, I do have a cat named Socrates.*

THE LOGICIAN: *There, you see. . . .*

THE OLD GENTLEMAN: *Then Socrates really was a cat!*

THE LOGICIAN: *That is what Logic reveals to us!*

E. IONESCO, *The Rhinoceros*

During the past 20 years André Lwoff—*mon cher collègue et ami*—and I have been carrying on a casual correspondence about Aristotle, inspired by a remark in a public lecture by another dear friend and colleague, who claimed that Aristotle, *more than 3000 years ago,* had said such and such a thing about Life. It stands to reason that a prenatal quote from Aristotle, centuries before his birth, is something special and precious, whatever its content. Dr. Lwoff and I, therefore, endeavored to find other, possibly still earlier utterances that might shed light on the intellectual development of the great sage from Stagira. And we did not labor in vain. Indeed, in one of Dr. Lwoff's most recent letters to me he was able to communicate a quotation dating back more than 4000 years, adding, justly, "The more you push him into the remote past the more impressive the man becomes."

Unfortunately, I am not in a position to publish here these metahistorical studies, since this would have required the consent of Dr. Lwoff. The rules set up by the editors of this book explicitly forbade

such an approach. Thus it must be left to future historians of science to dig out the fruits of our labors from the appropriate archives. As far as Dr. Lwoff's letters to me are concerned, I can throw out the hint that they will be deposited in the Archive of the Millikan Library of the California Institute of Technology.

My letters to Dr. Lwoff should be in his files. I must confess that I tried to obtain copies of these letters by stealth. I wrote to Jacques Monod, suggesting that Gisèle might be able to find them. He expressed enthusiasm and vowed cooperation. But, as we all know, Jacques is undependable. "At lovers' perjuries, they say, Jove laughs." He laughs at Jacques's perjuries, too. I never heard from him again.

Nevertheless, while we are talking about Aristotle, I should like to utilize this opportunity to state the conjecture that this wonderful man discovered DNA. Let me explain.

To consider Aristotle not as a philosophical system but as a human being subject to development is an idea of this, our twentieth century. Werner Jaeger (1925) was the first to pursue this approach, with a vengeance, thereby ushering in a new era of Aristotelian studies. Now it so happened that Jaeger knew next to nothing about biology. He lived before the double helix had hit the news and could not see anything of interest in either the biology of his own day or in Aristotle's five major biological books (*Historia animalium, De partibus animalium, De motu animalium, De incessu animalium, De generatione animalium*). In fact he considered these books as something compiled by Aristotle in his old age, illustrative applications of his general views on natural philosophy and metaphysics. Scrutiny of the internal evidence by a host of later students has modified this view to the extent of placing some of these books in the period of Aristotle's travels with Theophrastos on Lesbos and in Macedonia, before his return to Athens and the founding of his own school, but definitely after his formative period of 20 years in Plato's Academy. Nobody can fail to be impressed with the wealth of biological observations, and Ingmar Düring (1965) points out the intensity, variety, and subtlety of the speculative arguments. He, too, however, puts these studies after the main philosophical opus, and especially attributes *De generatione animalium* to Aristotle's late period.

This chronology may well be correct for the books we have. However, I would like to conjecture (and I would not assume that I am

the first to do so, having assimilated only 10^{-3} of the relevant literature) that biological studies constituted the decisive early intellectual experience in Aristotle's life, imprinting *telos* on him as his most pervasive concept. Where Plato sees the world as ideas of which static objects are the shadows, Aristotle sees striving and development towards goals and motions governed by permanent plans.

The following passage from *De partibus animalium* (I, 5; 644b21–645a37) contrasts the eternal world of astronomy with the seemingly ephemeral one that surrounds us on Earth:

> Of the products of Nature some are eternal, not subject to generation and corruption, others grow and perish. Of the former, grand and divine as they are, we have less insight since they offer few aspects for our perception. From these scanty data we can explore what we care to know about them. In contrast, for the perishable things, plants and animals, we are given a great wealth of information since they are close at hand. If one makes the effort, much can be learned about each kind. Both sciences have their charm. Even though our understanding of the eternal things is more limited, they fascinate us more than the things of our own world because of their grandeur, just as our imagination gets more excited by even a glimpse of a beloved person than by the close observation of many other and even important things. However, the perishable things are to be preferred as objects of science because of the wealth of knowledge we can gather about them. I will speak about the nature of animals and to the best of my ability not overlook anything, may it seem large or small. Also with those less appealing creatures, nature grants indescribable pleasures to those with a scientific bent, by revealing her creative power to their scientific scrutiny. Indeed it would be absurd were we to take delight in artistic reproductions, admiring the craft of the artist—as we do with paintings and sculptures—and should not take delight in the original creations of nature, especially when we can achieve some measure of understanding of their structure. Therefore one should not childishly recoil from the study of lower animals. All creations of nature are miraculous. When strangers were visiting Heraklitos and found him warming himself by the oven they hesitated to enter. He encouraged them to approach, saying, "The Gods are here, too." Just so one should approach the study of any animal with reverence, in the certainty that any of them are natural and beautiful. I say "beautiful" because in the works of nature and precisely in them there is always a *plan* and nothing accidental. The full realization of the plan, however, that for which a thing exists and towards which it has developed, is its essential beauty. Also one should have it clearly in mind that one is not studying an organ or a vessel for its

own sake but for the sake of the functional whole. One deals with a house, not with bricks, loam, or wood. Thus the natural scientist deals with the functional whole, not with its parts, which as separate entities have no existence.

This famous passage could be entitled "A Biologist Looks (Somewhat Defensively) at Physics," and it is not the only one in which Aristotle is anxious to point out that the world of creatures has its kind of eternity, too. In *De generatione animalium* we find (II, 1; 731b, 32–39) this sentence: "Since it is impossible that creatures should be eternal, these things which are generated are not eternal as individuals (though the essence is in the individual) but as a species."

Anybody who is familiar with today's physics and biology, and who reads Aristotle's writings in these two fields, must be struck by the aptness of many of his biological concepts, in contrast to the tangled inconsistencies of his physical and cosmological analyses. And, indeed, nobody would deny that Aristotle's physics was a catastrophe, while his biology abounds in aggressive speculative analysis of vast observations on morphology, anatomy, systematics, and, most importantly, on embryology and development.

Aristotle does consider it remarkable, and a fundamental aspect of Nature, that human beings beget human beings, and do not beget rabbits or an ear of corn.[1] What strikes the modern reader most forcibly is his insistence that in the generation of animals the male contributes, in the semen, a *form principle,* not a mini-man. He argues, contra Hippocrates, that the semen is *not* a secretion, in which each part of the body is represented by a contribution from that part, pointing out:

(a) The resemblance of children to parents is no proof of part-for-part representation because the resemblance is also found in voice and in way of moving (GA I, 18; 722a, 4–7).

(b) Men generate progeny before they have certain parts, such as beards or gray hair (722a, 8–9); similarly with plants (722a, 12–14).

(c) Inheritance may skip generations "as in the case of the woman in Elis who had intercourse with an Ethiopian. Her daughter was not dark but the daughter's son was" (722a, 10–12).

[1] See (and hear) the 5-minute lecture (with *guitarre*) on molecular genetics by Joel Herskowitz, entitled "The Double Talking Helix Blues," a phonograph record published by The Vertebral Disc, 913 S. Claremont, Chicago, Illinois 60612.

(d) Since semen can determine female children, it clearly cannot do so by being a secretion, in a man, from female genitals (723a, 31–32).

From the foregoing it is clear that the semen does not consist of contributions of all parts of the body of the male (as Hippocrates had taught), and that the female's contribution is quite different from the male's. The male contributes *the plan of the development* and the female the substrate. For this reason the female does not produce offspring by herself, since the form principle is missing, i.e., something to begin the development of the embryo, something that will determine the form it has to assume (GA I, 21; 730a, 24–30).

The form principle is likened to a carpenter. The carpenter is a moving force which changes the substrate, but the moving force is not materially contained in the finished product.

The semen contributes nothing to the material body of the embryo but only communicates its program of development. This capability is that which acts and creates, while the material which receives this instruction and is shaped by it is the undischarged residue of the menstrual fluid (GA I, 21; 729b, 5–8).

The creature produced from them (the form principle in the semen and the matter coming from the female) is produced like a bed comes into being from the carpenter and the wood (729b, 17–18).

The male contributes the principle of development, the female the material (730a, 28).

The male emits semen in some animals and where he does, it does not become part of the embryo; just as no part of the carpenter enters into the wood in which he works, . . . but the form is imparted by him to the material by means of the changes which he effects. . . . It is his information that controls the motion of his hands (GA I, 22; 730b, 10–19).

Quite a few quotations in a similar vein could be added. Put into modern language, what all of these quotations say is this: The form principle is the information which is stored in the semen. After fertilization it is read out in a preprogrammed way; the readout alters the matter upon which it acts, but it does not alter the stored information, which is not, properly speaking, part of the finished product. In other words, if that committee in Stockholm, which has the unenviable task each year of pointing out the most creative scientists, had the liberty of

giving awards posthumously, I think they should consider Aristotle for the discovery of the principle implied in DNA. It is my contention that Aristotle's principle of the "unmoved mover" originated with his biological studies, and that it was grafted, from here, first onto physics, then onto astronomy, and finally onto his cosmological theology.

I should like to suggest, furthermore, that the reason for the lack of appreciation, among scientists, of Aristotle's scheme lies in our having been blinded for 300 years by the Newtonian view of the world. So much so, that anybody who held that the mover had to be in contact with the moved and talked about an "unmoved mover" collided head-on with Newton's dictum: Action equals reaction. Any statement in conflict with this axiom of Newtonian dynamics could only appear to be muddled nonsense, a leftover from a benighted, prescientific past. And yet, "unmoved mover" perfectly describes DNA: it acts, creates form and development, and is not changed in the process.

Indeed, let us go one step further while we are in the mood, *mes très chers collègues et néanmoins mes amis,* and consider the fact that the re-entry of Aristotle into Western thought occurred through scholastic Christian theology. Let us assert that, by the irony of history, the vast historical impact of Aristotle on Western thought is the result of an almost accidental appropriation of the most secondary and misguided aspects of Aristotle's speculations, and that it is due to this bizarre twist that we are encumbered today with a total barrier of understanding between the scientist and the theologian, from St. Thomas Aquinas till today, Catholic, Protestant, and LSD mystic alike. Thus a new look at Aristotle the biologist may yet lead to a clearer understanding of the concepts of purpose, truth, and revelation, and perhaps even to something better than mere coexistence between us natural scientists and our colleagues from the other faculties.

REFERENCES

Düring, I. (1966). "Aristoteles. Darstellung und Interpretation seines Denkens," Heidelberg, Carl Winter Universitätsverlag.

Jaeger, W. (1923). "Aristoteles. Grundlegung einer Geschichte seiner Entwicklung," Berlin; *Nachdruck,* 1955.