<Further Development 1_3>

Epigenesis and Preformationism

With Malpighi began one of the great debates in embryology: the controversy over whether the organs of the embryo are formed de novo ("from scratch") at each generation, or whether the organs are already present, in miniature form, within the egg or sperm. The first view, epigenesis, was supported by Aristotle and Harvey. The second view, preformationism, was reinvigorated with Malpighi's support. Malpighi showed that the unincubated[1] chick egg already had a great deal of structure, and this observation provided him with reasons to question epigenesis and advocate the preformationist view, according to which all the organs of the adult were prefigured in miniature within the sperm or (more usually) the egg. Organisms were not seen to be "constructed" but rather "unrolled" or "unfurled."

The preformationist view had the backing of eighteenth-century science, religion, and philosophy (Gould 1977; Roe 1981; Churchill 1991; Pinto-Correia 1997). First, if all organs were prefigured, embryonic development merely required the growth of existing structures, not the formation of new ones. No extra mysterious force was needed for embryonic development. Second, just as the adult organism was prefigured in the germ cells, another generation already existed in a prefigured state within the germ cells of the first prefigured generation. The preformationists had no cell theory to provide a lower limit to the size of their preformed organisms (the cell theory did not arise until the mid-1800s).

Preformationism's principal failure was its inability to account for the intergenerational variations revealed by even the limited genetic evidence of the time. It was known, for instance, that the children of a white and a black parent would have intermediate skin color—an impossibility if inheritance and development were solely through either the sperm or the egg. In more scientific studies, the German botanist Joseph Kölreuter (1766) produced hybrid tobacco plants with characteristics of both species.

The embryological case for epigenesis was revived at the same time by Kaspar Friedrich Wolff. By carefully observing the development of chick embryos, Wolff demonstrated that the embryonic parts develop from tissues that have no counterpart in the adult organism. The heart, intestine, and blood vessels (which, according to preformationism, must be present from the beginning) could be seen to develop anew in each embryo. So Wolff (1767) was able to state, "when the formation of the intestine in this manner has been duly weighed, almost no doubt can remain, I believe, of the truth of epigenesis." To explain how an organism is created anew each generation, however, Wolff had to postulate an unknown force—the *vis essentialis* ("essential force")—which, acting according to natural laws analogous to those such as gravity or magnetism, would organize embryonic development.

A reconciliation between preformationism and epigenesis was attempted by the German philosopher Immanuel Kant (1724–1804) and his colleague, biologist Johann Friedrich Blumenbach (1752–1840). Blumenbach postulated a mechanical, goal-directed force he called Bildungstrieb ("developmental force"). Such a force, he said, was not theoretical, but could be shown to exist by experimentation. A hydra, when cut, regenerates its amputated parts by rearranging existing

elements (as we will see in Chapter 24). Some purposeful organizing force could be observed in operation, and it was thought to be inherited through the germ cells. Thus, development could proceed through a predetermined force inherent in the matter of the embryo (Cassirer 1950; Lenoir 1980). In this hypothesis, wherein epigenetic development is directed by preformed instructions, we are not far from the view held by modern biologists that most (but by no means all) of the instructions for forming the organism are already present in the fertilized egg.

[1]As pointed out by Maître-Jan in 1722, the eggs Malpighi examined may technically be called "unincubated," but as they were left sitting in the Bolognese sun in August, they were not unheated. Such eggs would be expected to have developed into chicks.