Darwin's Germ Theory of Heredity

In 1867, engineer and polymath Fleeming Jenkin published an essay criticizing *Origin of Species* and the implications of its assumption that biological inheritance involves a simple mixing of the characteristics of each parent (Jenkin, 1867). To express his concern, Jenkin posited the following dilemma. Imagine a shipwrecked British seaman washed ashore on a tropical island. Faced with only the native population, how could Darwin's theory avoid calamity for our poor seaman's hereditary line. While he could obviously kill off all of the native males, how could the children he had with the native women avoid hereditary degradation? The following year Darwin published what may justly be called his germ theory of heredity which offered a potential solution to Jenkin's dilemma. In earlier times, the word 'germ' had long been understood in terms of biological growth and reproduction, as in 'wheat germ' and 'germination'. However, the then recent reports of Louis Pasteur and others that specific forms of bacteria give rise to specific forms of disease sent political shock waves around the world. The rapidly expanding and often squalid industrial cities of the nineteenth century had become major breeding grounds for a wide range of deadly communicable diseases, and the prospect of having established a basis for understanding and potentially treating these diseases was truly electrifying. Arguably, no previous scientific discovery had ever so rapidly captured such widespread attention among the general public as that of Pasteur's germ theory. Henceforth, 'germ theory' would be understood in terms of a potentially existential threat. Soon, Darwin's theory of pangenesis would feed a similar level of dread.

While in *Origins of Species* Darwin had laid down the general premise that the environment acts upon the individual organism to induce inheritable changes, it was in his *The Variation of Animals and Plants under Domestication* (1868) that Darwin presented his theory on how environmental influences are translated into inheritable traits. In contrast to the traditional divine design doctrine in which each species is created de novo perfectly designed for the environment in which it exists, according to Darwin's theory biological change can only occur as the result of environmental change. "[I]f it were possible to expose all the individuals of a species during many generations to absolutely uniform conditions of life, there would be no variability" (Darwin, 1868, p. 255). Darwin used this logic to deduce the thoroughly inaccurate conclusion that domesticated species exhibit far more genetic variability than do species that live in the wild. "Under nature, the individuals of the same species are exposed to nearly uniform conditions, for they are rigorously kept in their proper places by a host of competing animals and plant." In contrast, domestic species "are treated differently, so that they rarely remain during any considerable length of time exposed to closely similar conditions. In conformity with this, all our domesticated productions, with the rarest exceptions, vary far more than natural species." (Darwin, 1868, p. 254).

Regarding the question of how environmental changes could result in causing an inheritable trait within an organism to become changed, Darwin invoked the nebulous concept of 'fluctuations'(Darwin, 1868, p. 352):

"But a far more frequent result of changed conditions, whether acting directly on the organization or indirectly through the reproductive system being affected, is indefinite and fluctuating variability"

In contrast to the standard view of transmutation in which the hereditary material of an organism undergoes an abrupt change in one generation that is then transmitted to the next generation, Darwin proposed that his fluctuations act via a cumulative effect over a number of generations before resulting in a stable inheritable change (Darwin, 1868, p. 270):

"There is good evidence that the power of changed conditions accumulates; so that two, three, or more generations must be exposed to new conditions before any effect is visible."

How were these quite consciously ill-defined 'fluctuations' to be transformed into inherited traits? Darwin's explanation (pangenesis) bore marked similarities to the theory offered by Maupertuis more than 120 years before (*Epigenesis and the Emergence of Cell Theory*), but one key new element was the premise that the hereditary 'germs' or 'gemmules' compete with each other in the process of determining which traits will be propagated in the offspring. By this device, 'survival of the fittest' natural selection would become determinative in every step of the life process including the initial genetic inheritance and development of the fetus. While Darwin seemed to have lost interest in the bulk of his text by the time *Variation* was published, he doted on his theory of pangenesis as a 'beloved child'. As such, Darwin was severely disappointed when both Joseph Hooker's and T. H. Huxley's reaction to that theory made him initially fear that he would have to give up "the great god Pan [i.e., his pangenesis theory] as a still-born deity" (Darwin, 1868, pp. 550-551).

While Maupertuis had proposed that his undetectable gemmules function as templates for directing the process of organ formation in the developing embryo, Darwin invoked the recently introduced cell theory to propose that his gemmules operate at the level of cell division:

“It is almost universally admitted that cells, or the units of the body, propagate themselves by self-division or proliferation, retaining the same nature, and ultimately becoming converted into the various tissues and substances of the body. But besides this means of increase I assume that cells, before their conversion into completely passive or “formed material,” throw off minute granules or atoms, which circulate freely throughout the system, and when supplied with proper nutriment multiply by self-division, subsequently becoming developed into cells like those from which they were derived. These granules for the sake of distinctness may be called cell-gemmules, or, as the cellular theory is not fully established, simply gemmules. They are supposed to be transmitted from the parents to the offspring, and are generally developed in the generation which immediately follows, but are often transmitted in a dormant state during many generations and are then developed” (Darwin, 1868, p. 374).

“in the cases in which the organization has been modified by changed conditions, the increased use or disuse of parts, or any other cause, the gemmules cast off from the modified units of the body will be themselves modified, and, when sufficiently multiplied, will be developed into new and changed structures.” (Darwin, 1868, p. 397)

The experimentally observable cells were to be regarded as simply passive elements in the process of embryonic development as well as in the process of inheritance. In contrast, it is Darwin’s proposed minute granules or atoms (gemmules) which possess the crucial characteristics of accumulating nutrition, self-division, and development. It is these gemmules which purportedly direct the path of tissue development and differentiation (Darwin, 1868, p. 381).

“In the offspring, as soon as any particular cell or unit in the proper order of development becomes partially developed, it unites with (or to speak metaphorically is fertilised by) the gemmule of the next succeeding cell” (Darwin, 1868, p. 389)

Having set the stage, Darwin was then positioned to propose how ‘survival of the fittest’ directly determines both physiology and inheritance.

“It is generally, perhaps always, necessary that an organism should be exposed during several generations to changed conditions or habits, in order that any modification in the structure of the offspring should ensue … gemmules derived from each cell before it had undergone the least modification are transmitted in large numbers to successive generations, but that the gemmules derived from the same cells after modification, naturally go on increasing under the same favouring conditions, until at last they become sufficiently numerous to overpower and supplant the old gemmules.” (Darwin, 1868, p. 395)

“When two forms are crossed, one is not rarely found to be prepotent in the transmission of character over the other; and this we can explain only by again assuming that the one form has some advantage in the number, vigour, or affinity of its gemmules” (Darwin, 1868, p. 386)

“it might well happen that a sufficiency of gemmules in the male alone for the reproduction of his peculiar characters, and in the female alone for the reproduction of her peculiar characters, would not be present; and in this case dormant gemmules derived from some remote progenitor might easily gain ascendency, and cause the reappearance of long-lost characters.” (Darwin, 1868, p. 401)

Through his “great god Pan”, Darwin had closed the loop on applying natural selection to explain biological evolution. Now every stage of life could be understood as an act of aggressive conquest by the superior form. In particular, the challenge posed by Fleeming Jenkin could now be met. At least in principle, the plight of the lonely white seaman could be overcome if the vigor of his gemmules were sufficient to out-compete those of the native tribal women. Indeed, Darwin offered the seaman an extra boost in his effort to thoroughly dominate his future progeny by taking advantage of the then still unresolved question of whether a single small sperm cell is sufficient to impregnate the much larger egg cell. On the presumption that impregnation requires the penetration of the egg cell by multiple sperm cells and thus a proportionally greater hereditary contribution from the male, Darwin argued that (Darwin, 1868, p. 385):

“We may conclude from the fact of a single spermatozoon or pollen-grain being insufficient for impregnation, that a certain number of gemmules derived from each cell or unit are required for the development of each part.”

As odd as Darwin's claim might seem in hindsight, it should be recognized that during the eighteenth century when the ovists had defeated the spermists in the debate over which sex carries the miniature homunculus that grows into their progeny, the sperm was demoted to the role of merely stimulating the development of the homunculus within the egg. Under such circumstances the involvement of multiple sperm cells seemed plausible. While that paradigm had been abandoned by the time of Darwin's writings, the seemingly superfluous overabundance of sperm within the semen still remained an unsettling observation. It was not until 1876 that Oskar Hertwig would first clearly demonstrate that a single sperm cell is sufficient for impregnation.

Darwin had opened the door of racial science for the application of 'positive' eugenics by allegedly demonstrating how not only Jenkin's seaman but the *Best* as a whole could preserve the quality of their hereditary superiority despite occasional mixing with the *Cattle*. Politically far more consequential, Darwin's analysis had also opened the door for 'negative' eugenics. In the political context of the ongoing tremendous public excitement over Pasteur's new germ theory of communicable diseases, the longstanding fear that the 'bad seed' of a lower race could invade the future progeny of the superior race now had a scientifically respectable mechanistic justification. Darwin directly fed into that racial fear by invoking the traditional canard that any woman who allowed herself to be 'polluted' by a male of lower racial standing would be forever condemned by the threat of producing similarly inferior offspring resulting from that earlier sexual intercourse. Taking advantage of the idea that an egg cell might require combination with multiple sperm cells before entering into development, Darwin envisioned a process in which the sperm cell from one male could be stored within the egg cell in wait for a future enabling impregnation. By this means, blended inherited traits may arise "occasionally from the effects of a previous fertilisation on the mother" (Darwin, 1868, p. 71).

"it is certain that her ovaria are sometimes affected by a previous impregnation, so that the ovules subsequently fertilised by a distinct male are plainly influenced in character; and this, as in the case of foreign pollen, is intelligible through the diffusion, retention, and action of the gemmules included within the spermatozoa of the previous male" (Darwin, 1868, p. 388).

Henceforth, the doctrine of 'one drop of n----r blood' would bear the Darwinian stamp of approval.

Darwin's theory of 'survival of the fittest' gemmules suffered the obvious weakness that no one had ever reported any experimental evidence in support of their physical existence. Present day biology texts may describe the various experimental efforts that were made to obtain empirical evidence supporting Darwin's theory of pangenesis. The complete failure of those attempts has been trivialized by his disciples as having simply served to take the wind out of Darwin's brief flight of fantasy. In this argument a blind eye is turned to the fact that, by the time these empirical disproofs were reported, Darwin's germ theory of heredity had long since jumped out of the box and was well on its way to putting the 'science' into racial science.

The political timing of Darwin's writings was exquisite. On an operational level, Gobineau's infamous *An Essay on the Inequality of the Human Races* (1853) marked the transition from the earlier efforts to accumulate evidence on the ancient Aryan conquests to the later more focused efforts on explaining the 'inherent' superiority of the Aryan race. Through his writings and the resulting emergence of the Gobinism movement, Gobineau played a central role in insuring that the 'survival of the fittest' struggle between racial nations had already come into widespread discussion within the European intellectual class well before Charles Darwin 'proved' that it was a fundamental fact of nature. By that time, the language of European politics had become increasingly dominated by militant nationalism, a process that became particularly virulent in Central and Eastern Europe. Although useful during the initial rallying of the troops, the 'survival of the fittest' doctrine of *Origin of Species* did not necessarily create an imperative to actively hasten the complete extermination of those lesser races. It was here that Darwin's germ theory of heredity came into play. By Darwin's analysis, the continued existence of the inferior races serve as reservoirs of 'infectious' degenerative gemmules that pose an ongoing imminent threat to the superior race.

Bibliography

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