

and it is partly because of my personal interest in microscopy that I have traced them back. But, for one thing, structure is just as important in other branches of biology as in those in which my own work has lain and, for another, there are plenty of examples that have nothing to do with microscopy. In connection with muscle, for instance, A. V. Hill¹ mentions the remarkable fact that Heidenhain in 1864 was able to show that the heat liberated in a muscle twitch was increased if the muscle was allowed to shorten and so to do work, and that this was not generally known at the time when it was rediscovered by Fenn in 1923; and Finck (1968) recently drew attention to the description by Halliburton in 1887 of a protein which was lost sight of until rediscovered by Straub in 1943 and given the name 'actin'. In another branch of physiology, König in 1894 discovered that human vision is blue-blind at the very centre of the visual field, and this striking—indeed almost incredible—phenomenon was forgotten until rediscovered by Willmer in 1944.² I believe also that there was not anything exceptional about the climate of opinion in the early part of this century that allowed these discoveries to be forgotten. The 'latency relaxation' was discovered by Rauh in 1922, but was so little known by 1941 that when Sandow observed it in that year he believed it to be a new discovery.³

Many people would no doubt say that there is no danger of present-day knowledge being lost in a similar way a few decades hence, but I am not so confident. It struck me, while I was preparing a lecture for one of the centenaries that I spoke of, that there are some intriguing parallels between the general position of biology at the present day and its position a hundred years ago: if the analogy is a valid one, it may suggest that advance is in some respects a cyclical process and that we are again entering a phase in which biologists are liable to lose sight of any part of the vast mass of current information which does not become satisfactorily integrated into an accepted theoretical framework.

1. A. V. Hill, 1959, p. 9.

2. Willmer's book (1946) contains a colour plate by means of which this defect of colour vision is easily appreciated (Pl. 3, and p. 143).

3. When a skeletal muscle is stimulated, the tension falls slightly from its initial resting value before the main rise of tension begins; this fall, the 'latency relaxation', begins during the action potential and is of the order of a thousandth of the tetanic tension. A personal account of the rediscovery of this phenomenon is given by Sandow (1966).

BIOLOGY IN THE NINETEENTH AND TWENTIETH CENTURIES

Some of these parallels between nineteenth- and twentieth-century biology are set out in Table 1. In each case, a number of key steps were taken in the thirties and led to rapid and extensive development. In the nineteenth century this phase of expansion continued until about the end of the century; in the twentieth it is still going strong. I think it is not too fanciful to see a close analogy, for example, between the development and use of the light microscope in the nineteenth century and of the electron microscope in the twentieth, or between the development of classical physiology, chiefly in Germany and France, in the half-century after the appearance of Johannes Müller's *Handbuch* in 1833–40, and the explosion in biochemistry, chiefly in the United States, since the appearance of ATP, the glycolytic cycle, and so forth in the 1930s. I make no apology for not giving an earlier date for the impact of biochemistry on other branches of biology. Its earlier progress was an internal affair: as an example, the attempt to apply its results to explain a phenomenon that was not of a straight-forwardly chemical kind—the lactic acid theory of muscle contraction—was wide of the mark because of the great gaps that still existed in the subject. In the same way, it was not until several decades after the rediscovery of Mendel's laws that genetics reached the point of contributing to other branches of biology. The emphasis that the early Mendelians placed on the effects of particular mutations in fixing the direction of evolutionary change was excessive, and a synthesis of the Mendelian with the biometric approach, and a full recognition of the power of natural selection, did not come until the work of J. B. S. Haldane, Chetverikov, Sewall Wright, and Fisher, culminating in the latter's *Genetical Basis of Natural Selection* published in 1930. The synthesis of genetics with biochemistry had to wait even longer, until the discovery of the roles of the nucleic acids in the 1940s, and of the mechanism of gene replication in 1953 by Watson and Crick. Genetics has not even now made an appreciable impact on the study of highly organized structures such as muscle, and I suspect that there are additional levels of complexity waiting to be discovered, between the specification of a polypeptide by a nucleotide sequence and the growth of an organism, or even of a subcellular structure, into a particular shape.