

ity that the minute quantities of protein that probably remain attached to DNA, though undetectable by the tests applied, are necessary for activity—itsself an exceedingly sensitive test. Transformation of pneumococci is a self-duplication phenomenon, for the effect finally observed is not due immediately to the active principle added, but to the enormously greater quantity of active principle generated in the course of the experiment. It is, therefore, possible that no more than a few particles of active principle are required; and if no more than a few particles of DNA were effective, there would be no doubt that the active principle consisted of nothing but DNA. In his work on preparation of the bacteriophage Northrop (1937) recognized that he was dealing with a self-duplication phenomenon and was able to demonstrate that the material which he isolated was actually the bacteriophage because only a few particles were required for activity. Actually a very large number of DNA particles (more than 10^8 , if a molecular weight of a million is assumed for DNA) are required for pneumococcus transformation, and the minimal mass of material is about 2,000,000 times that of the minimal mass of nucleoprotein required for phage activity. There is, accordingly, some doubt whether DNA is itself the transforming agent, although it can be regarded as established that DNA is at least part of the active principle. It should be mentioned that even if DNA itself is the active principle, much more than several particles may be needed.

Since it is now known that the material derived from the heat-killed cells that is effective in pneumococcus transformation contains DNA, this is in itself evidence for considering the process to be essentially a hybridization. In those cells which can be studied cytologically, all the DNA is localized in chromosomes and the essential role of chromosomal material in hybridization is well-known. It is remarkable in the pneumococcus transformation that part of the DNA-containing material is derived from heat-killed cells, and that before being used for "hybridization" it can be examined chemically.