80
DNA IN BACTERIOPHAGE

The next major milestone in the search for the molecular nature of the gene came in 1952, when Alfred Hershey and Margaret Chase published the results of their experiments with bacteriophage, a type of virus that parasitizes bacteria (Greek: *phagein,* "to eat").

Viruses are incredibly tiny particles, so small that they can't be seen in a light microscope. They live as "obligate intracellular parasites," which means that they are unable to live independently but must enter a living cell and parasitize it from the inside. Viruses themselves have no cells, are unable to reproduce or carry out any sort of metabolism outside a host cell, and are generally regarded as not really being "alive."

Color the heading Bacteriophage, titles A through D, and the associated illustrations.

The virus known as bacteriophage (phage, for short) has a peculiar shape, consisting of a head, stalk, and arms. The arms appear to be used in attaching the phage to the bacterial cell *(bacterium)* to be infected. When Hershey and Chase began their experiment, little was known about the structure and composition of bacteriophages except that they consisted of protein and DNA. Nothing was known about which part was protein and which was DNA. It was known that a bacteriophage would attach to a bacterial cell, inject its *core* into the cell, leaving its outer *coat* as a "ghost" attached to the outside of the cell, and in less than an hour, 100 or more *new bacteriophage* particles would be formed inside the cell and the bacterium would disintegrate, releasing the phages to infect new cells. Whatever the phages were injecting, it was clearly acting like a gene, carrying all the information necessary for making new phage. The question was, Was it DNA or protein?

Color the heading Preparation of "Hot" Bacteria, titles E through H, and the associated portion of the illustration. Use a light color for F.

Hershey and Chase began their experiment by growing some *bacteria* of the species *Escherichia coli* (a harmless resident of almost everyone's large intestine) on *nutrients* containing *radioactive phosphorus (^{32}P),* which the bacteria took up and incorporated into their own molecules just as they would nonradioactive atoms. They also grew some other bacteria of the same species on nutrients containing *radioactive sulfur (^{35}S),* which the bacteria also took up and incorporated into their own molecules. Thus the bacteria became "hot" in the radioactive sense.

Color the heading Preparation of "Hot" Phage, titles I through H^2, and the associated portion of the illustration.

Next bacteriophages *(phage culture)* were inoculated into each of the bacterial cultures, where they invaded the bacterial cells and consumed them in the production of more phages. The *radioactive atoms of the bacteria* thus became incorporated into the newly formed phages, so that two different strains of *"hot" phages* were prepared: one in which many of the *sulfur atoms* were *radioactive* and the other in which many of the *phosphorus atoms* were *radioactive.* Hershey and Chase knew that protein contained sulfur but no phosphorus, while DNA contained phosphorus but no sulfur, so they could follow the radioactivity and tell whether the protein, the DNA, or both were injected into the bacterial cell.

Color the heading "Hot" Phage Plus "Cold" Bacteria, titles J through M, and the associated portion of the illustration.

Finally, some bacterial cultures were infected with phage containing radioactive sulfur and some others were infected with phage containing radioactive phosphorus. Enough time was allowed for the bacteriophages to inject their cores into the cells, but not enough for more phages to be produced. Next the cultures were run in a *blender* just long enough to knock the empty phage coats off the bacterial cells but not long enough to disrupt the cells. Then the cultures were spun in a *centrifuge,* where the bacterial cells with the *phage cores* settled to the bottom while the outer *coats of the bacteriophages* remained suspended.

Color the heading Results, titles G^3 and H^3, and the magnifications.

In the culture infected with phage having *radioactive sulfur (in protein),* virtually all of the radioactivity was found in the liquid portion containing the *phage coats.* That meant that nearly all of the phage protein remained outside the bacterial cell. In the culture infected with phage having *radioactive phosphorus (in DNA),* virtually all of the radioactivity was found in the sediment containing the bacterial cells, showing that DNA was injected *(phage core)* and protein was not injected. This strongly supported the idea that, in bacteriophage at least, DNA could function as a gene.

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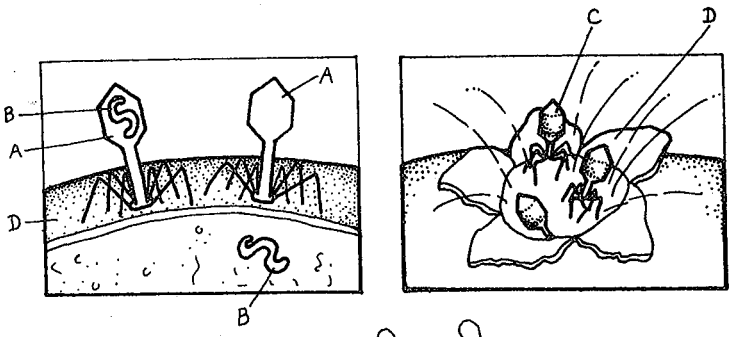
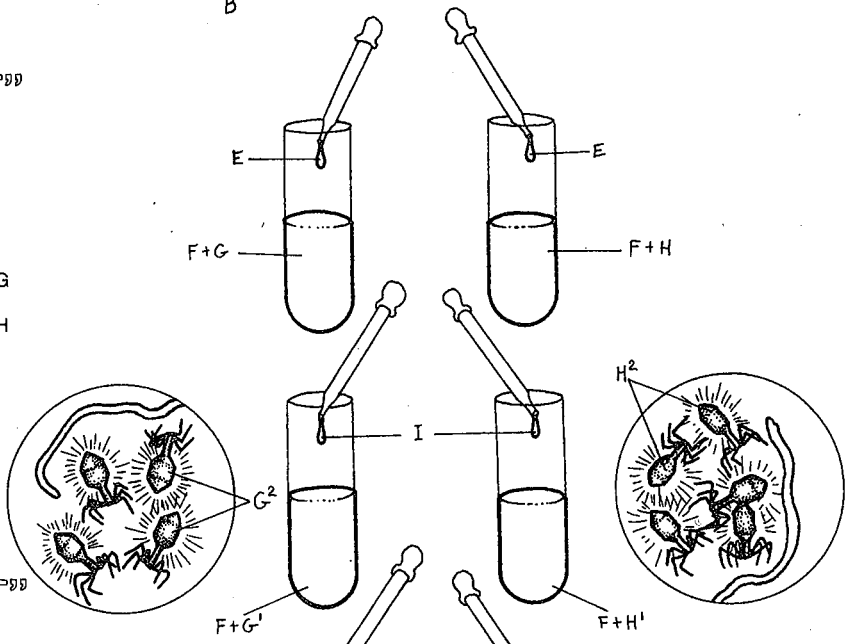
DNA IN BACTERIOPHAGE.

BACTERIOPHAGE★
COAT$_A$
CORE$_B$
NEW PHAGE$_C$
BACTERIUM$_D$

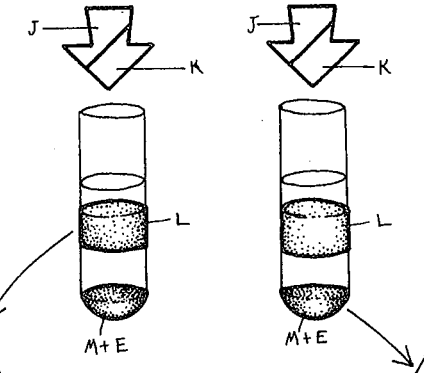


PREPARATION OF "HOT" BACTERIA★
BACTERIA CULTURE$_E$
NUTRIENT MEDIUM$_F$
MOLECULES WITH $^{35}S_G$
MOLECULES WITH $^{32}P_H$



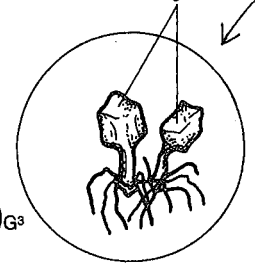
PREPARATION OF "HOT" PHAGE★
PHAGE CULTURE$_I$
BACTERIA WITH $^{35}S_{G'}$
BACTERIA WITH $^{32}P_{H'}$
PHAGE WITH $^{35}S_{G^2}$
PHAGE WITH $^{32}P_{H^2}$

"HOT" PHAGE PLUS "COLD" BACTERIA★
BLENDED$_J$
CENTRIFUGED$_K$
PHAGE COATS$_L$
PHAGE CORES$_M$



RESULTS★

COATS/PROTEIN (CONTAINING $^{35}S)_{G^3}$



CORES/DNA (CONTAINING $^{32}P)_{H^3}$