Molecular biology and bacterial genetics

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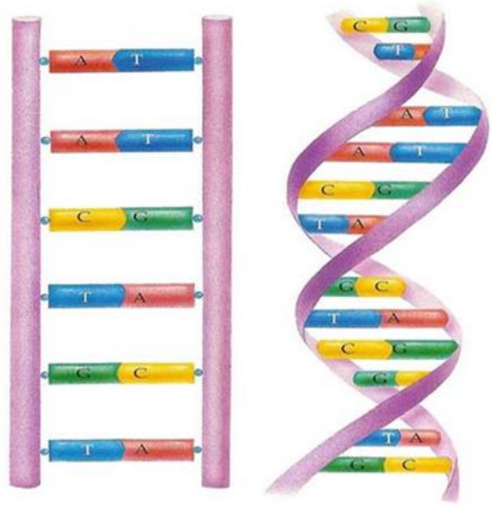


2020-2019 **د.مروة عباس كبة**

Molecular biology

Each species of living organism has a unique set of inherited characteristics that makes if different from other species. Each species has its own developmental plan-often described as a sort of ‘ blueprint’ for building the organism which is encoded in the DNA molecules present in its cells.

The developmental plan determines the characteristics that are inherited. Because organisms in the same species share the same developmental plane, organisms that are members of the same species usually resemble one another, although some notable exceptions usually are differences between males and females. For example, it is easy to distinguish a human being from a chimpanzee or gorilla.

Genetics:

Is the study of biologically inherited traits, including traits that are influenced in part by the environment.

The fundamental concept of genetics is that(<u>inherited traits are determined by the elements of heredity that are transmitted from parents to offspring in reproduction: these elements of heredity are called genes.</u>

DNA : The Genetic Material

Experimental proof of the genetic function of DNA

An important first step was taken by Frederick Griffith in 1928 when he demonstrated that a physical trait can be passed from one cell to another. He was working with two strains of the Bacterium *Streptococcus pneumoniae* identified as S and R. when a bacterial cell is grown on solid medium , it undergoes repeated cell divisions to form a visible clump of cells called a colony. The S type of *S. pneumonia* synthesizes a gelatinous capsule composed of complex carbohydrate (polysaccharide). The enveloping capsule makes each colony large and gives it a glistening or smooth (S) appearance, this capsule also enables the bacterium to cause pneumonia by protecting it from the defence mechanism of an infected animal.

The R strains of *S. pneumonia* are unable to synthesize the capsular polysaccharide, they form small colonies that have a rough (R), surface, this strain of the bacterium does not cause pneumonia because without the capsule the bacteria are inactivated by the immune system of the host. Both types of bacteria ‘ breed true’ in the sense that the progeny formed by cell division have the capsular type of the parent, either S or R. (figure 1-1).

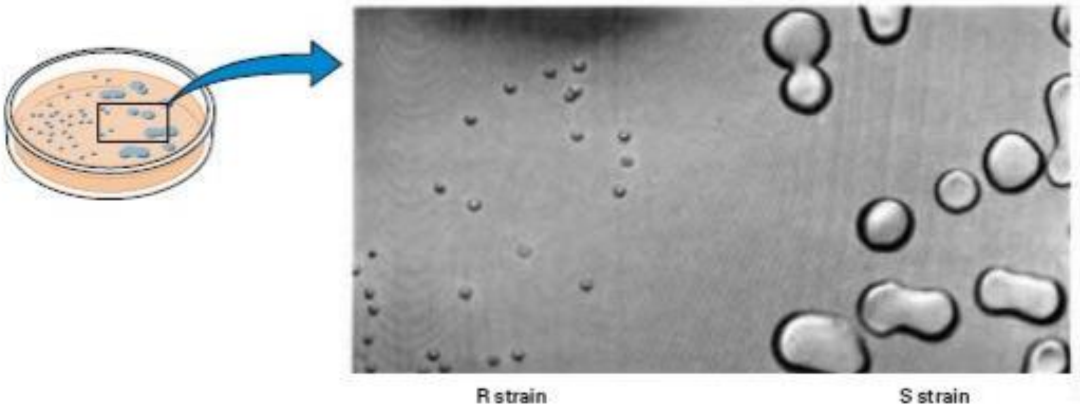


Figure 1-1:Colonies of rough (R, the small colonies) and smooth (S, the large colonies) strains of streptococcus pneumoniae. The S colonies are larger because of the gelatinous capsule on the S cells. Photograph from O. T. Avery, C. M. MacLeod, and M. McCarty.

Mice injected with living S cells get pneumonia. Mice injected either with living R cells or with heat-killed S cells remain healthy. Here is Griffith’s critical finding : mice injected with mixture of living R cells and heat killed S cells contract the disease they often die of pneumonia

Bacteria isolated from blood samples of these dead mice produce S cultures with a capsule typical of the injected S cells, even though the injected S cells had been killed by heat.

Evidently, the injected materials from the dead S cells includes a substance that can be transferred to living R cells and confer the ability to resist the immunological system of the mouse and cause pneumonia. figure (1-2).

In other words, the R bacteria can be changed or undergo **transformation** into S bacteria. Furthermore , the new characteristics are inherited by descendants of the transformed bacteria.

In the milestone experiment, Oswald Avery, Colin MacLeod, and Maclyn McCarty showed that the substance causing the transformation of R cells into S cells was DNA.

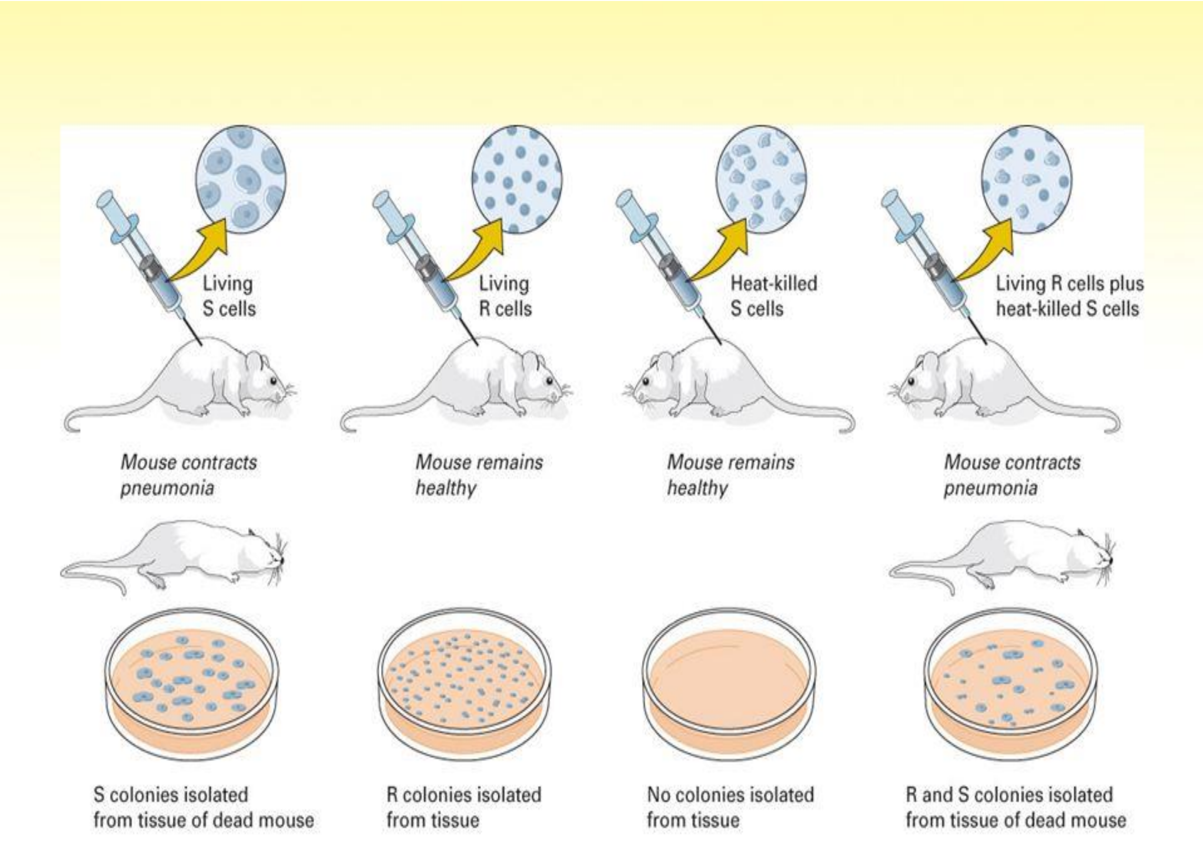


Figure 1.2: Griffith's experiment demonstrating bacterial transformation

the Griffith's experiment demonstrating bacterial transformation. A mouse remains healthy if injected with either the non-virulent R strain of S. pneumonia or heat-killed cell fragments of the usually virulent S strain. R cells in the presence of heat-killed S cells are transformed into the virulent S strain , causing pneumonia in the mouse.

In doing these experiments:

1- Isolating almost pure DNA from S cells, which had never been done before.
2- Added DNA isolated from S cells to growing cultures of R cells.
3- They observed transformation: A few cells of type S cells were produced.

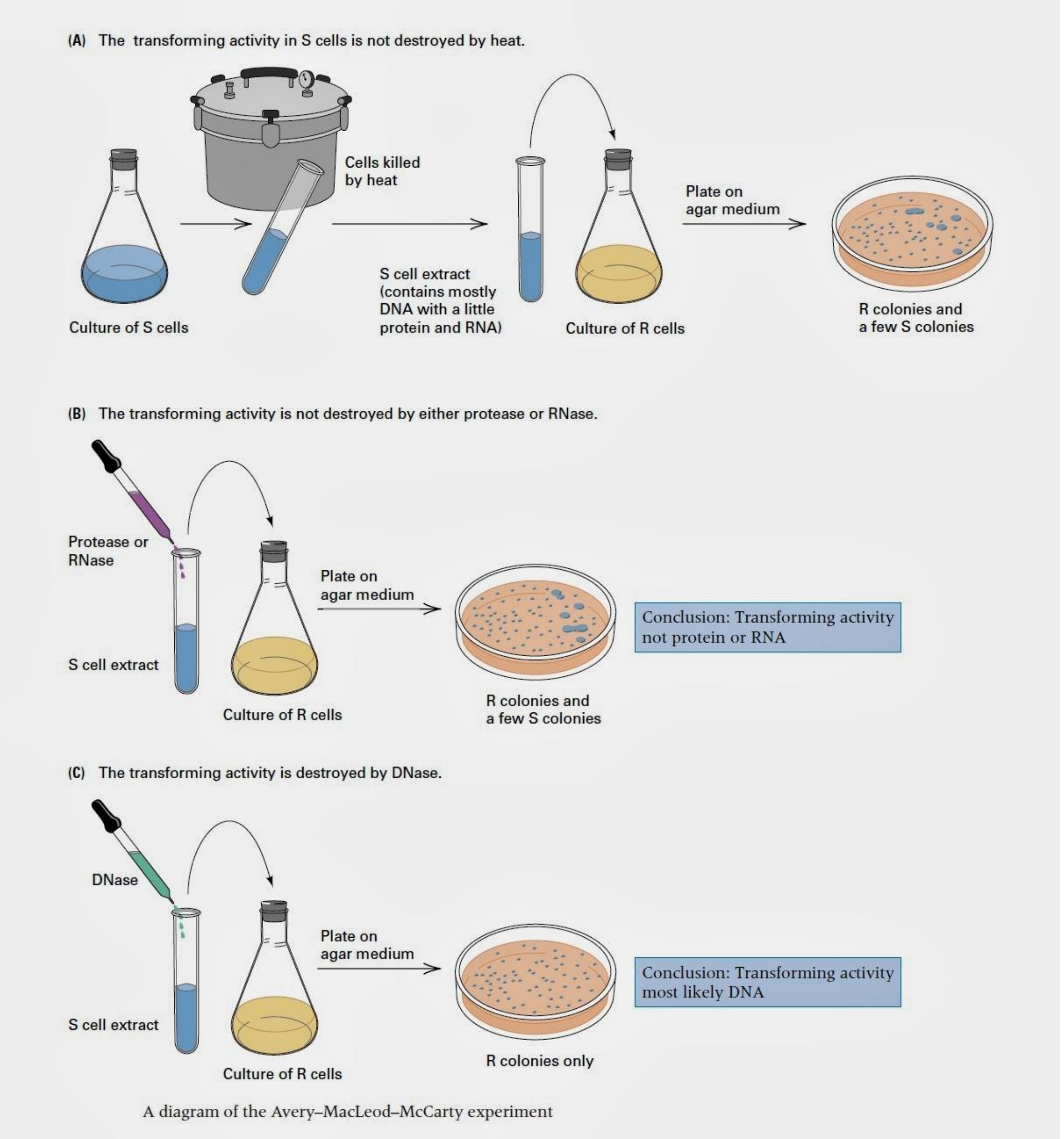


Figure1-3: A diagram of the Avery-MacLeod-McCarty experiment that demonstrated that DNA is the active material in bacterial transformation. (A) purified DNA extracted from heat-killed S cells can convert some living R cells into S cells, but the material may still contain undetectable traces of protein and/or RNA.(B) the transforming activity is not destroyed by either protease or RNase. (C) The transforming activity is destroyed by DNase and so probably consist of DNA.

Note:

Although the DNA preparations contained traces of protein and RNA (ribonucleic acid, an abundant cellular macromolecule chemically related to DNA), the transforming activity was not altered by treatments that destroyed either protein or RNA. However, treatments that destroyed DNA eliminated the transforming activity.

Genetic role of DNA in Bacteriophage

A second pivotal finding was reported by Alfred Hershey and Martha Chase in 1952. They studied cells of the intestinal bacterium *Escherichia coli* after infection by the virus T2 .

A virus that attacks bacterial cells is called **a bacteriophage**, a term often shortened to **phage**. Bacteriophage means bacteria-eater.

Hershey and Chase designed a series of experiments to determine whether the phage protein or the phage DNA was transmitted in phage reproduction.

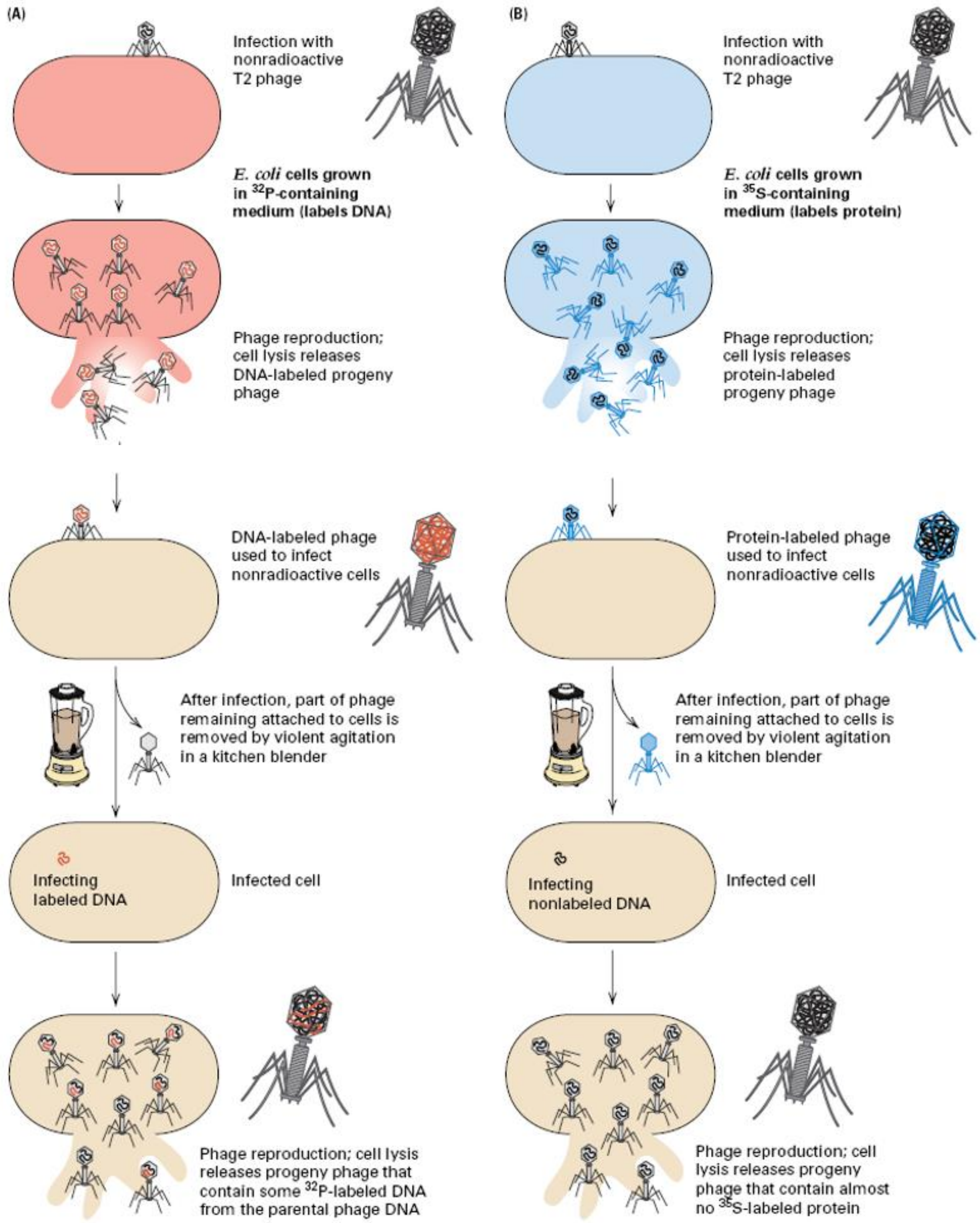
To follow the fate of protein and DNA, they used radioactive forms (isotopes) of phosphorus and sulfur. A radioactive isotope can be used as a tracer to identify the location of a specific molecule, because any molecule containing the isotope will be radioactive and therefore easily detected.

Because DNA contains phosphorus but no sulphur, whereas most proteins contain sulphur but no phosphorus, it is possible to label DNA and proteins differentially by using radioactive isotopes of the two elements. Hershey and Chase produced particles containing radioactive DNA by infecting E. coli cells that had been grown for several generations in a medium that included 32p (a radioactive isotope of phosphorus) and then collecting the phage progeny.

Other particles containing labelled proteins were obtained in the same way, by using medium that included 35S (a radioactive isotope of sulphur). Figure (1-4).

Conclusion

DNA from an infected parental phage is inherited in the progeny phage.



Figure(1-4): The Hershey-Chase (blender) experiment demonstrating that DNA, not protein is responsible for directing the reproduction of phage T2 in infected *E. coli* cells. (A) Radioactive DNA is transmitted to progeny phage in substantial amounts. (B) Radioactive protein is transmitted to progeny phage in negligible amounts.