



In 1920s, Frederick Griffith experimented with smooth and rough *Streptococcus pneumoniae* bacteria. Griffith found that contrary to expectations, infecting a mouse with a mixture of live rough bacteria of type II (R<sub>II</sub>) and heat-killed smooth bacteria of type III (S<sub>III</sub>), killed the mouse. Griffith concluded that something was transferred in the course of the experiment from one type of bacteria to another, and as a result transformed the recipient bacteria. He named that substance “transforming principle.” In fact, Griffith was able to isolate virulent bacteria from the dead mouse.

4. What was transferred in the experiment?
  
5. What type of bacteria was the recipient of the transforming principle, and what type was the “sender?”
  
6. How did the transfer enable the appearance of virulent bacteria?
  
7. Were all the bacteria of the recipient type transformed? Describe the probable process from co-infection to the death of the mouse.

## **~~B. DNA Replication~~**

- ~~1. DNA replication is remarkably accurate. Do you think it would have been possible to evolve a more accurate polymerase? If so, would it have been evolutionarily advantageous? Why or why not?~~

## Molecular Biology—DNA as Genetic Material and DNA Replication

### A. DNA as Genetic Material

Before people used words such as “genetic material,” the concept behind this term was well established. In fact, an entire industry based in large part on this concept played an enormous role in the development of our civilization.

1. What is this industry? How was the concept of “genetic material” central, if not articulated, part of this industry?

*Agricultural breeding programs have been in existence for millennia and have allowed our civilization to expand as people’s capacity to produce enough food to feed the expanding population also grew. At the heart of these programs is the understanding that all living things possess heritable traits that are passed down from generation to generation. Breeding programs rely on controlled crosses and artificial selection to isolate and propagate species with particular desirable heritable traits.*

After the work of Mendel was re-discovered, trying to understand what that “genetic material” was became a key part of scientific endeavor. While scientists did not discover what that substance was for some time, they fairly quickly formulated the three requirements that genetic material must satisfy.

2. What are those requirements? Why do they make sense?

*Genetic material must*

*Encode genetic information*

*Pass that information on to offspring (replicate)*

*Change that information (mutate)*

*Observations of heritable traits indicate that genetic information must be recorded somehow and also must be passed on to offspring. In addition, change over time indicates that there must also be a mechanism that allows the information to be changed.*

3. Given what you now know about DNA structure, how does DNA satisfy these requirements?

*Information is encoded in the sequence of DNA bases.*

*Because DNA is complementary and paired, one strand of DNA gives rise to two identical strands in DNA replication. That allows for production of two cells carrying identical copies of genetic material.*

*If, as a result of environmental factors, or as a result of normal processes during replication, DNA sequence in a germ cell is changed, this mutated information is going to be passed on to the offspring, and may result in a new or changed trait.*

In 1920s, Frederick Griffith experimented with smooth and rough *Streptococcus pneumoniae* bacteria. Griffith found that contrary to expectations, infecting a mouse with a mixture of live rough bacteria of type II ( $R_{II}$ ) and heat-killed smooth bacteria of type III ( $S_{III}$ ), killed the mouse. Griffith concluded that something was transferred in the course of the experiment from one type of bacteria to another, and as a result transformed the recipient bacteria. He named that substance “transforming principle.” In fact, Griffith was able to isolate virulent bacteria from the dead mouse.

4. What was transferred in the experiment?

*DNA was transferred from one type of bacteria to another.*

5. What type of bacteria was the recipient of the transforming principle, and what type was the “sender?”

*Heat-killed  $S_{III}$  was the sender of genetic information and live  $R_{II}$  was the receiver.*

*Only a live cell can change and acquire new characteristics, so the recipient had to be  $R_{II}$ .*

6. How did the transfer enable the appearance of virulent bacteria?

*After the transfer,  $R_{II}$  acquired characteristics of the virulent  $S_{III}$  strain. In fact, Griffith isolated live  $S_{III}$  from the dead mouse. We now understand it to be because some genes (segments of DNA) that encode for formation of polysaccharide coat were transferred in the experiment.*

7. Were all the bacteria of the recipient type transformed? Describe the probable process from co-infection to the death of the mouse.

*It is unlikely that a significant number of  $R_{II}$  bacteria were actually transformed, or that all those transformed were transformed with the same section of DNA. It is much more likely that a single  $R_{II}$  bacterium ( $T$ ) got transformed with a section of  $S_{III}$ 's genome that encodes for the polysaccharide coat.  $T$  integrated those portions into its own genome, and began producing the coat. This coat provided  $T$  with selective advantage because the immune system cells could not destroy  $T$ . Some other bacteria around  $T$  likely acquired certain other portions of the genome. However, mouse immune system acted as selection that favored  $T$  and disfavored all other variations. This is because the immune system could destroy all bacteria that did not exhibit polysaccharide coating. Thus, in effect, the immune system was clearing space for  $T$  and its descendants. Not having to compete for resources with many other bacteria,  $T$ 's descendants were able to grow and divide until there were so many of them that they caused the death of the mouse.*

## **~~B. DNA Replication~~**

~~1. DNA replication is remarkably accurate. Do you think it would have been possible to evolve a more accurate polymerase? If so, would it have been evolutionarily advantageous? Why or why not?~~

~~*It would probably be possible to evolve a more accurate polymerase. But the cost would be slower or nonexistent rate of mutation. That would leave an organism with such a polymerase at a selective disadvantage, since the organism would lack the ability to acquire favorable mutations that would otherwise give it and its descendants a selective advantage.*~~