DNA as genetic material

DNA is the fundamental component of our being. The human body is merely the carrier for this genetic material, passing it down from generation to generation. Our purpose is to ensure the survival of the species. Humans are to DNA like a fruit is to a seed. We are just an outer covering to ensure the safe passage and protection of the source code of our existence through time.

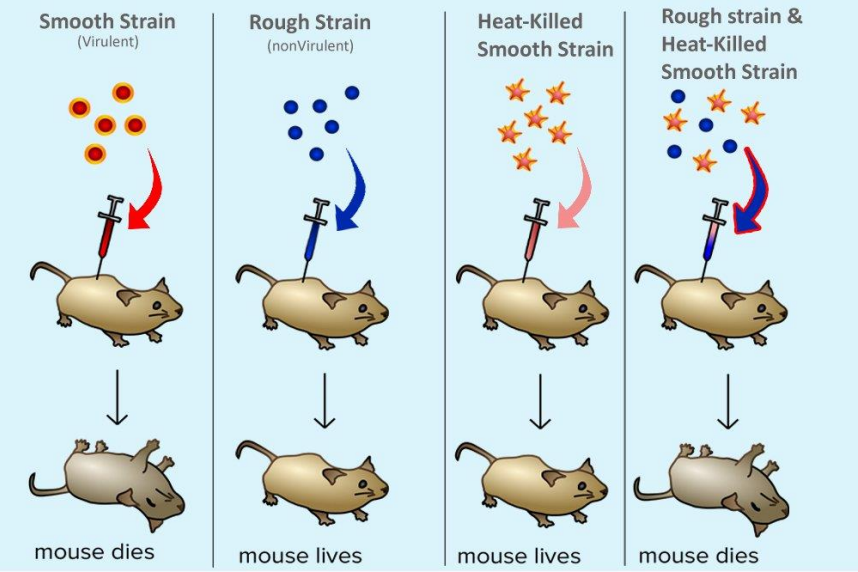
The History of DNA

Modern understandings of DNA have evolved from the discovery of nucleic acid to the development of the double-helix model. In the 1860, Friedrich Miescher was the first person to isolate phosphate-rich chemicals from white blood cells or leukocytes. He named these chemicals (which would eventually be known as RNA and DNA) nuclein because they were isolated from the nuclei of the cells.

Griffith's transformation experiments

A half century later, British bacteriologist Frederick Griffith was perhaps the first person to show that hereditary information could be transferred from one cell to another "horizontally," rather than by descent. In 1928, he reported the first demonstration of bacterial **transformation**, a process in which external DNA is taken up by a cell, thereby changing morphology and physiology. He was working with *Streptococcus pneumoniae,* the bacterium that causes pneumonia. Griffith worked with two strains, rough (R) and smooth (S). The R strain is non-pathogenic (does not cause disease) and is called rough because its outer surface is a cell wall and lacks a capsule; as a result, the cell surface appears uneven under the microscope. The S strain is pathogenic (disease-causing) and has a capsule outside its cell wall. As a result, it has a smooth appearance under the microscope. Griffith injected the live R strain into mice and they survived. In another experiment, when he injected mice with the heat-killed S strain, they also survived. In a third set of experiments, a mixture of live R strain and heat-killed S strain were injected into mice, and—to his surprise—the mice died. Upon isolating the live bacteria from the dead mouse, only the S strain of bacteria was recovered. When this isolated S

strain was injected into fresh mice, the mice died. Griffith concluded that something had passed from the heat-killed S strain into the live R strain and transformed it into the pathogenic S strain, and he called this the transforming principle



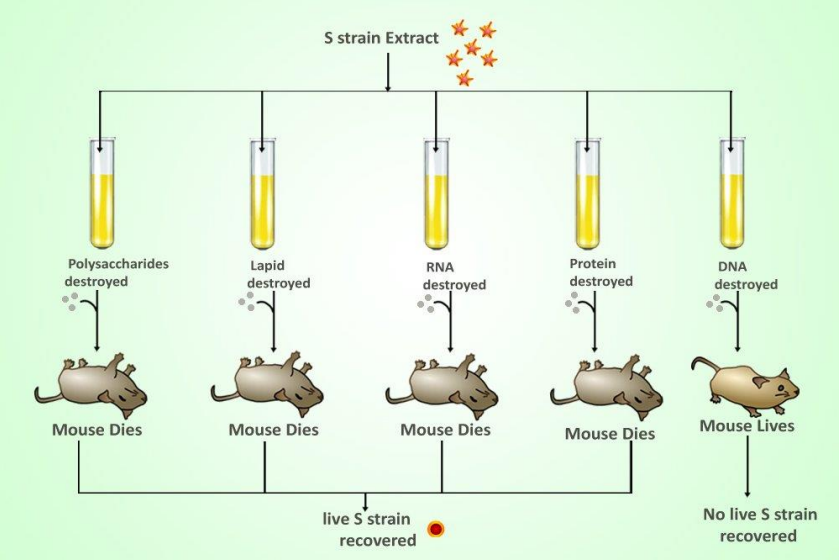
Avery, MacLeod, and McCarty experiment

While Griffith's experiment had provided a surprising result, it wasn't clear as to what component of the dead S strain bacteria were responsible for the transformation. 16 years later, in 1944, Oswald Avery, Colin Macleod and MacLynn McCarty solved this puzzle.

They worked with a batch of heat-killed S strain bacteria. They divided it into 5 batches. In the first batch, they destroyed the polysaccharide coat of the bacteria; in the second batch they destroyed its lipid content; they destroyed the RNA of the bacteria in the third batch; with the fourth batch, they destroyed the proteins; and in the last batch, they destroyed the DNA. Each of these batches was individually mixed with live R strain bacteria and injected into individual mice.

From all 5 mice, all of them died except the last mouse. From all the dead mice, live S strain bacteria was retrieved. This experiment clearly proved that when the DNA of the S strain bacteria were destroyed, they lost the ability to transform the R strain bacteria into live S strain ones. When other components, such as the polysaccharide coat, lipid, RNA or protein were destroyed, transformation still took place. Although the

polysaccharide coat was a virulent factor, it wasn't responsible for the transfer of the genetic matter.



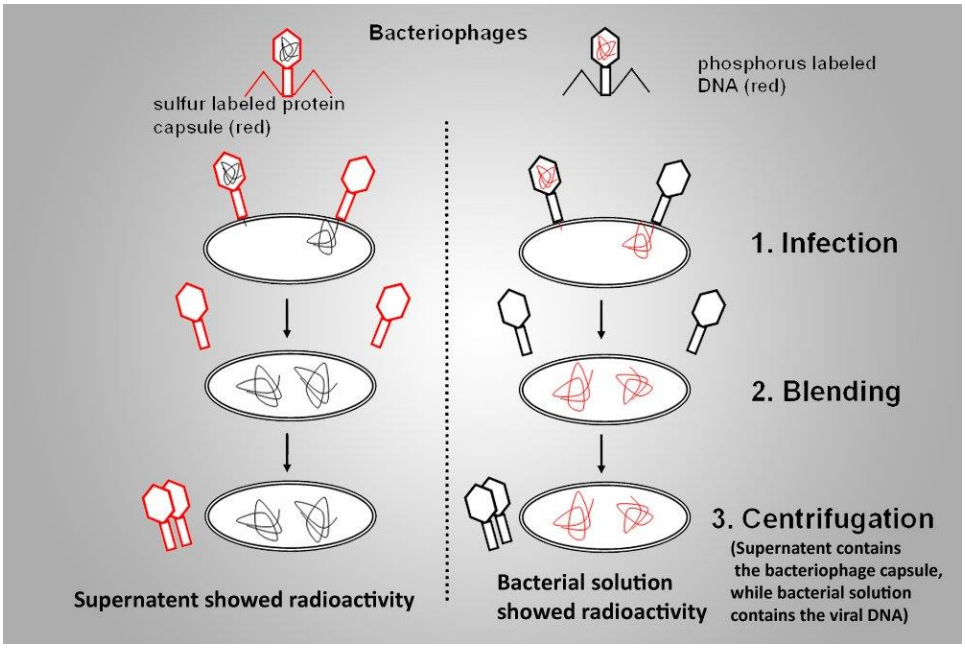
Hershey and Chase Experiment

Even after the compelling evidence provided by the Avery, Macleod and McCarty experiment, there were still a few skeptics out there who weren't convinced. The debate still raged between proteins and DNA. However, the Hershey – Chase experiment permanently put an end to this long-standing debate.

Alfred Hershey and Martha Chase in 1952, performed an experiment that proved, without a doubt, that DNA was the carrier of information. For their experiment, they employed the use of the bacteriophage T2. A bacteriophage is a virus that only infects bacteria. This particular virus infects *Escherichia coli*. T2 had a simple structure that consisted of just 2 components – an outer protein casing and the inner DNA. Hershey and Chase took 2 different samples of T2. They grew one sample with ^{32}P, which is the radioactive isotope of phosphorus, and the other sample was grown with ^{35}S, the radioactive isotope of sulphur!

The protein coat has sulphur and no phosphorus, while the DNA material has phosphorus but no sulphur. Thus, the 2 samples were labelled with 2 different radioactive isotopes.

The viruses were then allowed to infect the *E. coli*. Once the infection was done, the experimental solution was subjected to blending and centrifugation. The former removed the ghost shells, or empty shells of the virus from the body of the bacteria. The latter separated the bacteria from everything else. The bacterial solution and the supernatant were then checked for their radioactivity.



In the first sample, where ^{32}P was used, the bacterial solution showed radioactivity, whereas the supernatant barely had any radioactivity. In the sample where ^{35}S was used, the bacterial solution didn't show any radioactivity, but the supernatant did.
This experiment clearly showed that DNA was transferred from the phage to the bacteria, thus establishing its place as the fundamental carrier of genetic information.

Erwin Chargaff Experiment

Around this same time, Austrian biochemist Erwin Chargaff examined the content of DNA in different species and found that the amounts of adenine, thymine, guanine, and cytosine were not found in equal quantities, and that it varied from species to species, but not between individuals of the same species. He found that the amount of adenine equals the amount of thymine, and the amount of cytosine equals the amount of guanine, or A = T and G = C. This is also known as Chargaff's rules. This finding proved immensely useful when Watson and Crick were getting ready to propose their DNA double helix model.

RNA as Genetic Material

The genome of viruses may be DNA or RNA. Most of the plant viruses have RNA as their hereditary material. Fraenkel-Conrat (1957) conducted experiments on tobacco mosaic virus (TMV) to demonstrate that in some viruses RNA acts as genetic material.

TMV is a small virus composed of a single molecule of spring-like RNA encapsulated in a cylindrical protein coat. Different strains of TMV can be identified on the basis of differences in the chemical composition of their protein coats. By using the appropriate chemical treatments, proteins and RNA of RNV can be separated.

Moreover, these processes are reversible by missing the protein and RNA under appropriate conditions—reconstitution will occur yielding complete infective TMV particles. Fraenkel-Conrat and Singer took two different strains of TMV and separated the RNAs from protein coats, reconstituted hybrid viruses by mixing the proteins of one strain with the RNA of the second strain, and vice versa.

When the hybrid or reconstituted viruses were rubbed into live tobacco leaves, the progeny viruses produced were always found to be phenotypically and genotypically identical to the parental type from where the RNA had been isolated , Thus the genetic information of TMV is stored in the RNA and not in the protein.