DNA
by Dr. Ty C.M. Hoffman

Slide 1
A bacteriophage is a virus hat invades a bacterium. Bacteriophages are made of a combination of protein and DNA, and they were therefore chosen as an ideal subject in an experiment to answer the question of whether the genetic material is DNA or protein.

Slide 2
In the Hershey-Chase experiment, bacteriophages were radiolabeled with either radioactive sulfur (which labeled the protein) or radioactive phosphorus (which labeled the DNA) to determine whether it is the protein or the DNA that a bacteriophage injects into a bacterium. Since the DNA is what is injected by the virus into the cell, this demonstrates that DNA - and not protein - is the genetic material.

Slide 3
A strand of nucleotides linked end-to-end is called a polynucleotide. Any two adjacent nucleotides within a polynucleotide are held together by a covalent phosphodiester bond that links the sugar of one nucleotide to the phosphate of the adjacent nucleotide. The combination of all the phosphodiester bonds in a polynucleotide is therefore called the sugar-phosphate backbone, and it holds the strand together along its length. The nitrogenous bases are not involved in holding the polynucleotide together; they simply extend to the side of the backbone.

Slide 4
Rosalind Franklin was an expert at x-ray crystallography, a technique in which x-rays are directed at a molecule of unknown shape before exposing a photographic film. Based on the pattern made by the x-rays after being diffracted (bent) by DNA, Franklin was able to help Watson and Crick figure out that the shape of a DNA molecule is a double helix.

Side 5
Whereas an RNA molecule occurs as a single strand, a DNA molecule is a double stranded molecule. Two DNA polynucleotides, each with a helical shape, make up one DNA molecule. The two strands have an antiparallel arrangement, with one strand in a 3' to 5' direction, and the other strand in a 5' to 3' direction. The two strands are held together by hydrogen bonds that occur between nitrogenous bases at the same position but on opposite strands. These weak hydrogen bonds allow for easy separation of the two strands for the purposes of replication and transcription.

Slide 6
There are two classes of nitrogenous bases:
- A purines has two rings in its structure. The purines used in DNA are adenine and guanine.
- A pyrimidine has one ring in its structure. The pyrimidines used in DNA are thymine and cytosine.

Chargaff noticed that all organisms have an equal amount of purine and pyrimidine in the DNA. This is because a base pair (which is a nitrogenous base on one strand hydrogen-bonded to a nitrogenous base at the same position on the other strand) must consist of one purine and one pyrimidine. This allows for equal spacing between the two strands at each position.

Slide 7
Though it is true that a normal base pair consists of one purine and one pyrimidine, an even more stringent requirement is met in DNA. In making a base pair, adenine normally binds only with thymine (and vice versa), and cytosine normally binds only with guanine (and vice versa). This is known as complementarity. Therefore one strand within a DNA molecule is complementary to the other strand.

Slide 8
The complementary relationship between the two strands of a DNA molecule allow each of the strands in isolation to serve as a template for building the other. Thus, DNA replication occurs by separating the two strands from each other and "reading" the sequence of nucleotides in each strand to assemble a complementary strand. When this is done for each of the original two strands, the result is two identical copies of the original two-stranded molecule. Each copy will end up in one of two daughter cells created when the cell divides.

Slide 9
DNA replication begins at the origin of replication, where the two strands are separated, thus forming a replication bubble with two replication forks. Each strand is used as a template for replacing the other strand. At completion of replication, two identical copies of the double-stranded DNA molecule replace the original one. A prokaryotic cell has a single circular chromosome, and it replicates by making one replication bubble that grows. A eukaryotic cell has multiple linear chromosomes, each of which replicates by forming multiple replication bubbles, thereby increasing the speed of replication.

Slide 10
The raw material for a new nucleotide to be added to a growing strand starts out as a nucleoside triphosphate, which has two additional phosphates compared to a nucleotide. When the two extra phosphates are removed to produce the nucleotide, the energy released is used for the endergonic reaction required to form a phosphodiester bond between the new nucleotide and the previous nucleotide. The enzyme that catalyzes this reaction is DNA polymerase III. Each new nucleotide must be complementary to the nucleotide at the same position on the template strand. Also, any new nucleotide must be added to he 3' end of the growing strand.

Slides 11 & 12
The enormously long DNA molecule in a chromosome is able to fit into a tiny cell nucleus, because the DNA is spooled around complexes of histone proteins. These complexes are then extensively looped, resulting in the chromatin condensing into a compact chromosome.