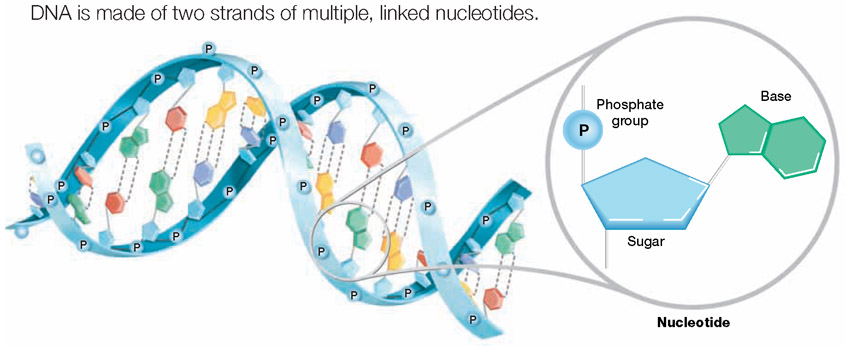
**DNA: The Genetic Material**

*All of this information can be found in the book in chapter 8*

Why Its Important 🡪 Learning about DNA contributes to our knowledge of: genetic disorders, viral diseases, cancer, aging, genetic engineering, criminal investigations

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| --- | --- |
| Objectives | Vocabulary |
| * **Relate** Griffith’s conclusions to the observations he made during the transformation experiments. * **Summarize** the steps involved in Avery’s transformation experiments, and state the results. * **Evaluate** the results of the Hershey and Chase experiment. | * Vaccine * Virulent * Restriction enzyme * Transformation * Bacteriophage |

DNA Review



* + What does DNA stand for?
  + What subunits make up DNA?
  + What three parts do the subunits consist of?

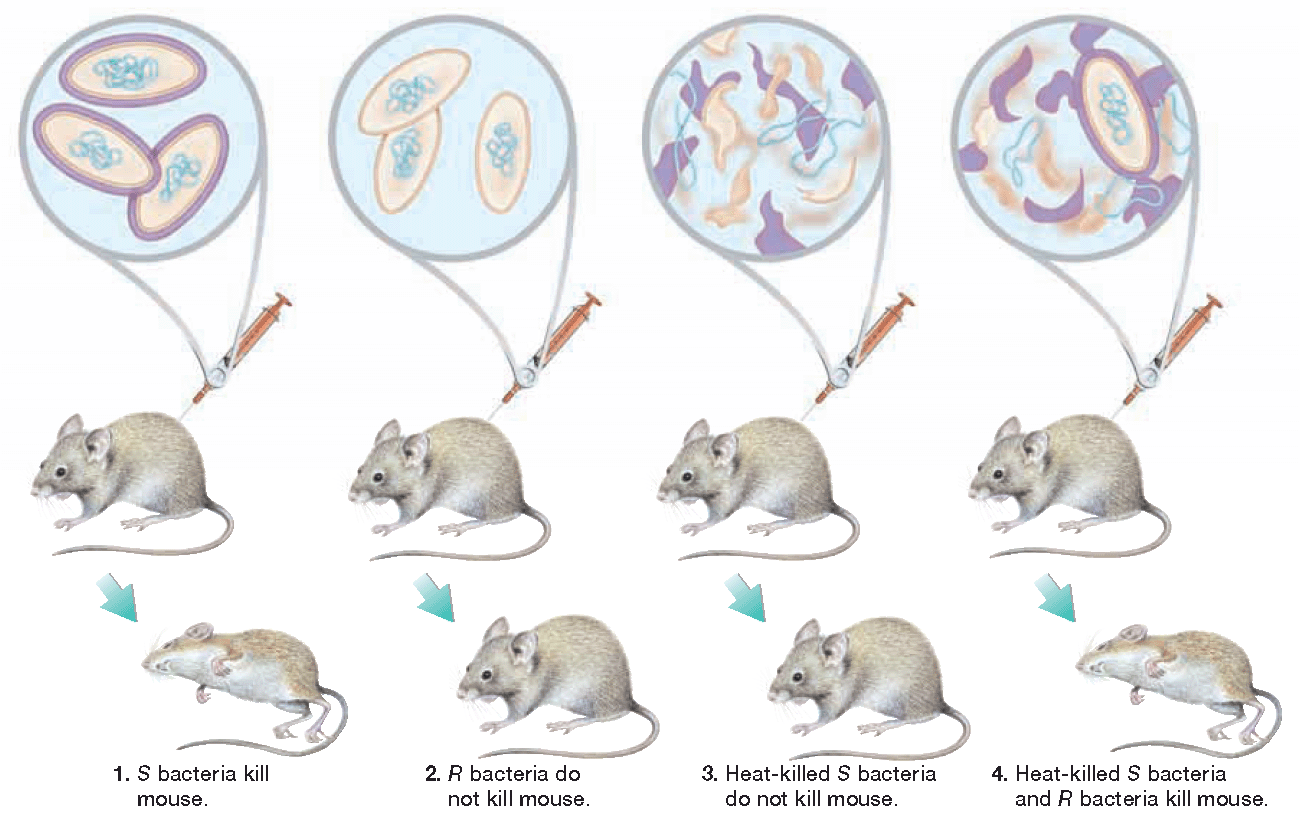
**Transformation 🡪 Griffith’s Experiments**

* In 1928, Frederick \_\_\_\_\_\_\_\_\_\_\_\_\_, a bacteriologist, carried out an experiment that led to an \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ discovery about DNA
* He was actually trying to prepare a vaccine against the bacteria, *Streptococcus pneumoniae*, which causes \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* A **vaccine** is a substance that is prepared from killed or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ disease-causing agents
* When administered, it is easier for your body’s immune system to \_\_\_\_\_\_\_\_\_\_\_ off the disease and prevent \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ infections
* For example…
  + people who get a flu vaccine every year, will easily fight off that \_\_\_\_\_\_\_\_\_\_ of the virus and avoid having any \_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Griffith was working with two strains of S. pneumoniae…
  + One enclosed in a \_\_\_\_\_\_\_\_\_\_\_\_\_ of polysaccharides, that protects the bacterium from the body’s defense system
  + This helps make the bacterium \_\_\_\_\_\_\_\_\_, or able to cause disease
    - Smooth-edged ( )
* The other strain \_\_\_\_\_\_\_\_\_\_\_ the polysaccharide capsule and is unable to cause disease
  + Rough – edged ( )
* In Griffith’s experiment, he injected mice with…
  + S bacteria
  + R bacteria
  + Heat-killed S bacteria
  + Heat-killed S bacteria and normal R bacteria

Note about “heat-killing”…

During Griffith’s time, it was ***not*** understood that DNA can tolerate temperatures around 90°C without being altered, but \_\_\_\_\_\_\_\_\_\_\_ are altered at around 60°C

So “heat-killing” damages a cells proteins and \_\_\_\_\_\_\_\_\_\_\_, but leaves DNA \_\_\_\_\_\_\_\_\_



* Somehow, the harmless R bacteria had changed and become \_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Griffith had discovered what is now called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Occurs when a cell picks up new DNA from it’s \_\_\_\_\_\_\_\_\_\_\_\_\_, changing its combination of genes, called a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Then restriction enzymes \_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_ the two pieces of DNA together
* But during Griffith’s time, scientists really didn’t understand transformation
* During the 1940s and 1950s, scientists were still debating over what cell part contained genetic information
* Many scientists actually thought that \_\_\_\_\_\_\_\_\_\_\_ contained our genetic information, and not DNA.

**Oswald Avery**

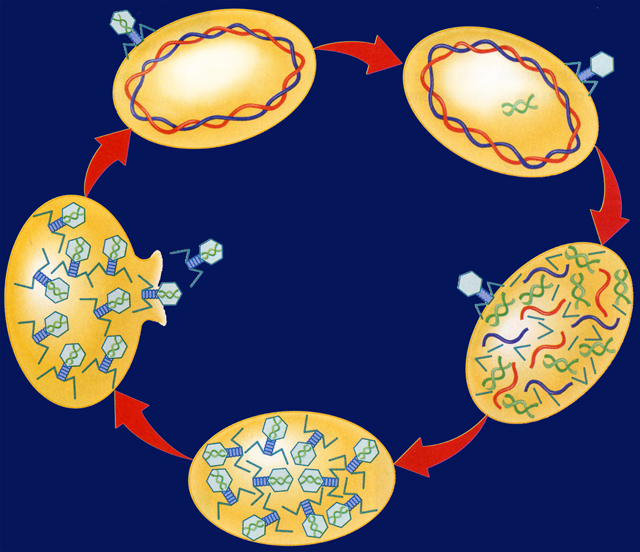
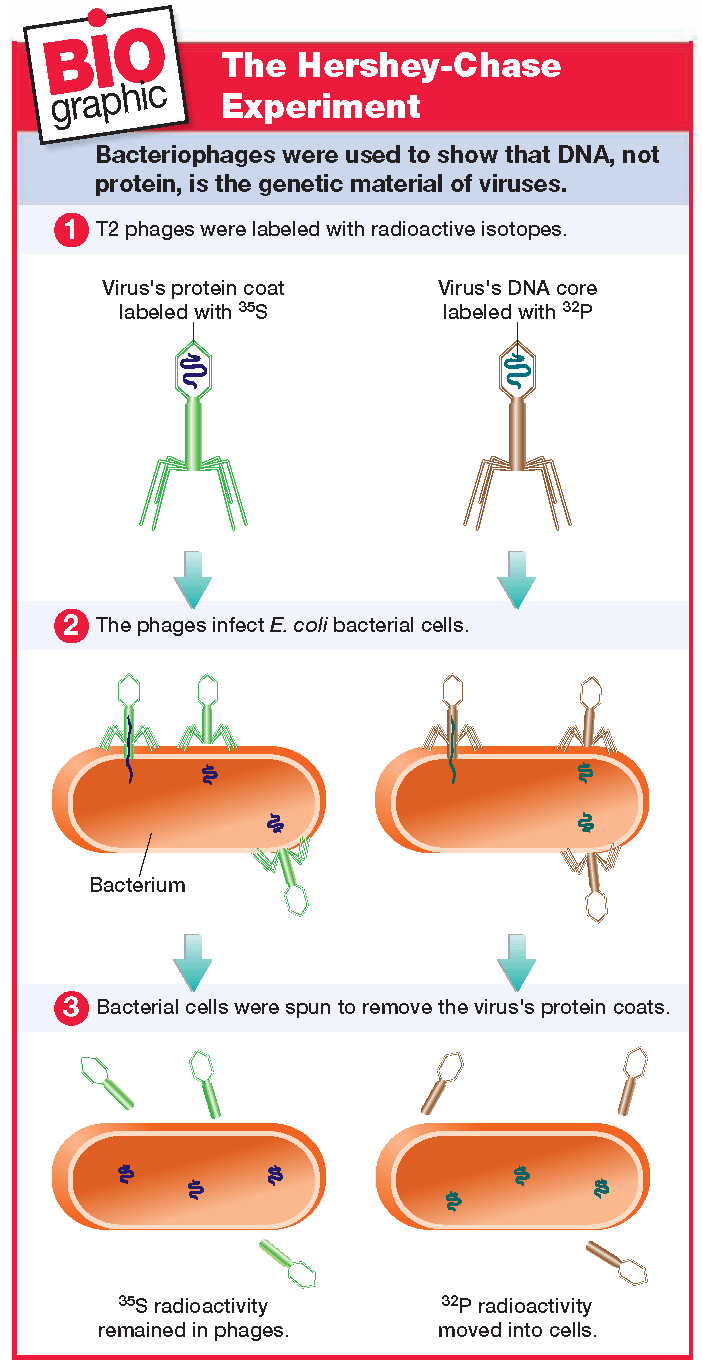
* In 1944, a scientist named Oswald \_\_\_\_\_\_\_\_\_\_ conducted a transformation experiment under two different conditions…
  + Condition 1: Added an enzyme that destroyed \_\_\_\_\_\_\_\_\_\_\_\_
  + Condition 2: Added an enzyme that destroyed \_\_\_\_\_\_\_\_\_\_\_\_
* Result?
  + Transformation was only stopped by the enzymes that destroyed \_\_\_\_\_\_\_\_\_...so it must contain the genetic material!
* Despite Avery’s results, scientists remained \_\_\_\_\_\_\_\_\_\_\_\_\_
* Since proteins are so important to many cell \_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, most scientists still thought that proteins contained the genetic material

**Hershey & Chase**

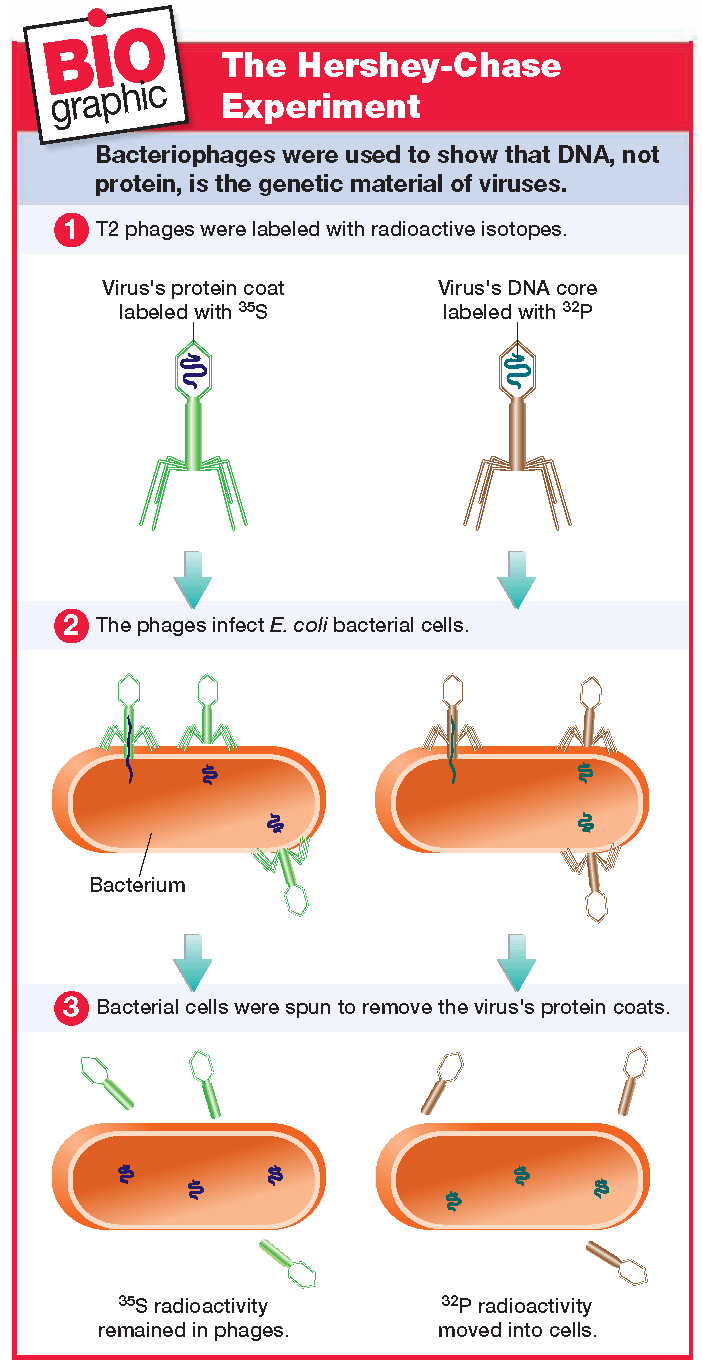
* In 1952, Alfred \_\_\_\_\_\_\_\_\_\_\_ and Martha \_\_\_\_\_\_\_\_\_\_\_\_\_ set out to settle the controversy.



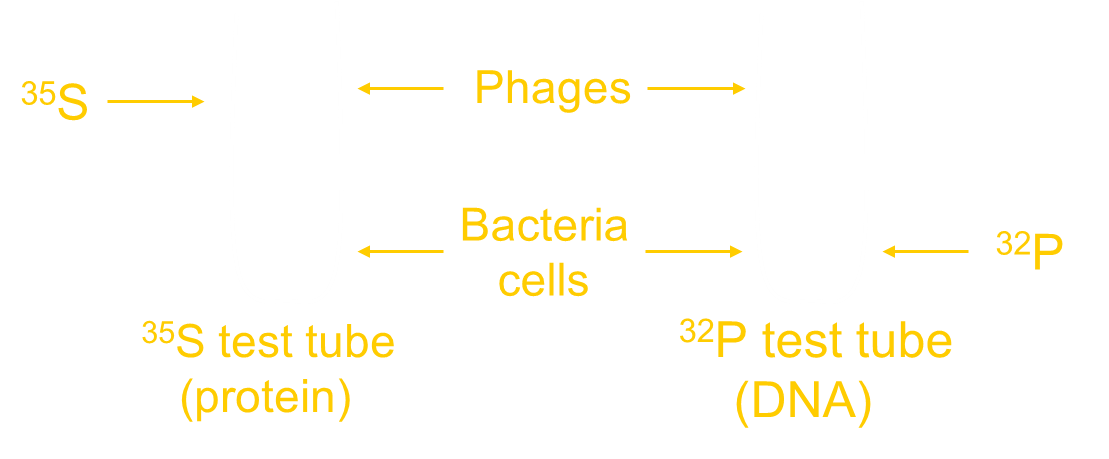
* Their experiments made use of a substance called a \_\_\_\_\_\_\_\_\_\_\_, which attacks and infects cells
  + A virus is much \_\_\_\_\_\_\_\_\_\_\_\_\_ than a cell and consists of \_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_ surrounded by a protective protein coat called a \_\_\_\_\_\_\_\_\_\_\_\_
* When a virus infect a cell, it causes the cell to produce more \_\_\_\_\_\_\_\_\_\_ instead of carrying out its normal cell activities
* Eventually the cell \_\_\_\_\_\_\_\_\_\_\_ open during a process called \_\_\_\_\_\_\_\_\_\_\_\_, and the released viruses seek out another cell to infect

* A special type of virus that infects \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cells is called a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or a \_\_\_\_\_\_\_\_\_ for short
* The viral DNA is contained in the \_\_\_\_\_\_\_\_ and the tail \_\_\_\_\_\_\_\_\_\_ attach to the bacteria cell
* After attachment, the DNA is injected into cell, almost like a \_\_\_\_\_\_\_\_\_
* The bacteriophage made the perfect test subject, because it was a simple substance that contained both \_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_
  + Scientists knew that DNA contained a \_\_\_\_\_\_\_\_\_\_\_\_ group
  + They also knew that So Hershey and Chase labeled the phages with one of the following radioactive isotopes…



* + \_\_\_\_\_\_, which would be found in DNA
  + \_\_\_\_\_\_, which would be found in the protein coat
  + proteins often contain the element \_\_\_\_\_\_\_\_\_\_
* These radioactive isotopes will \_\_\_\_\_\_\_\_\_\_ or break down into stable particles that can be \_\_\_\_\_\_\_\_\_\_\_\_ with machines
* Next the labeled phages were allowed to \_\_\_\_\_\_\_\_\_\_\_ the bacteria cells
* Hershey and Chase then checked to see which \_\_\_\_\_\_\_\_\_\_\_\_\_\_ entered the bacteria cells
* First the phages that were still attached to the bacteria cells were removed with a\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Then the bacteria cells and the phages were placed in test tubes and \_\_\_\_\_\_\_\_\_\_\_ in a machine called a centrifuge
* As the centrifuge spins, the different substances settle out by \_\_\_\_\_\_\_\_\_
* The heavier bacteria cells settled at the \_\_\_\_\_\_\_\_\_\_ of the test tubes while the lighter phages settled at the \_\_\_\_\_\_
* Only the \_\_\_\_\_\_ isotope was found inside of the bacteria cells

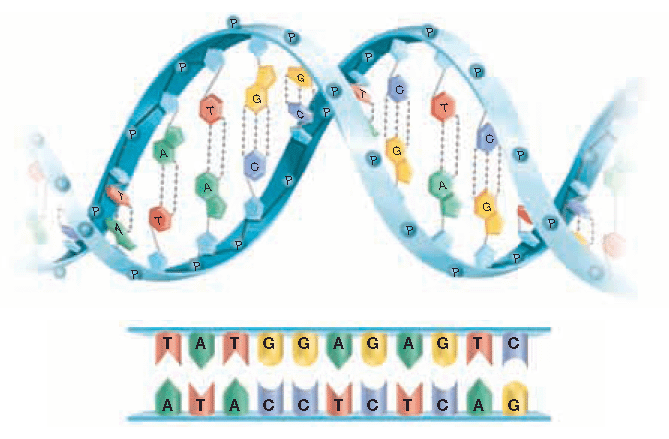


So based on these results… which substance, proteins or DNA, would you conclude is responsible for transformation?

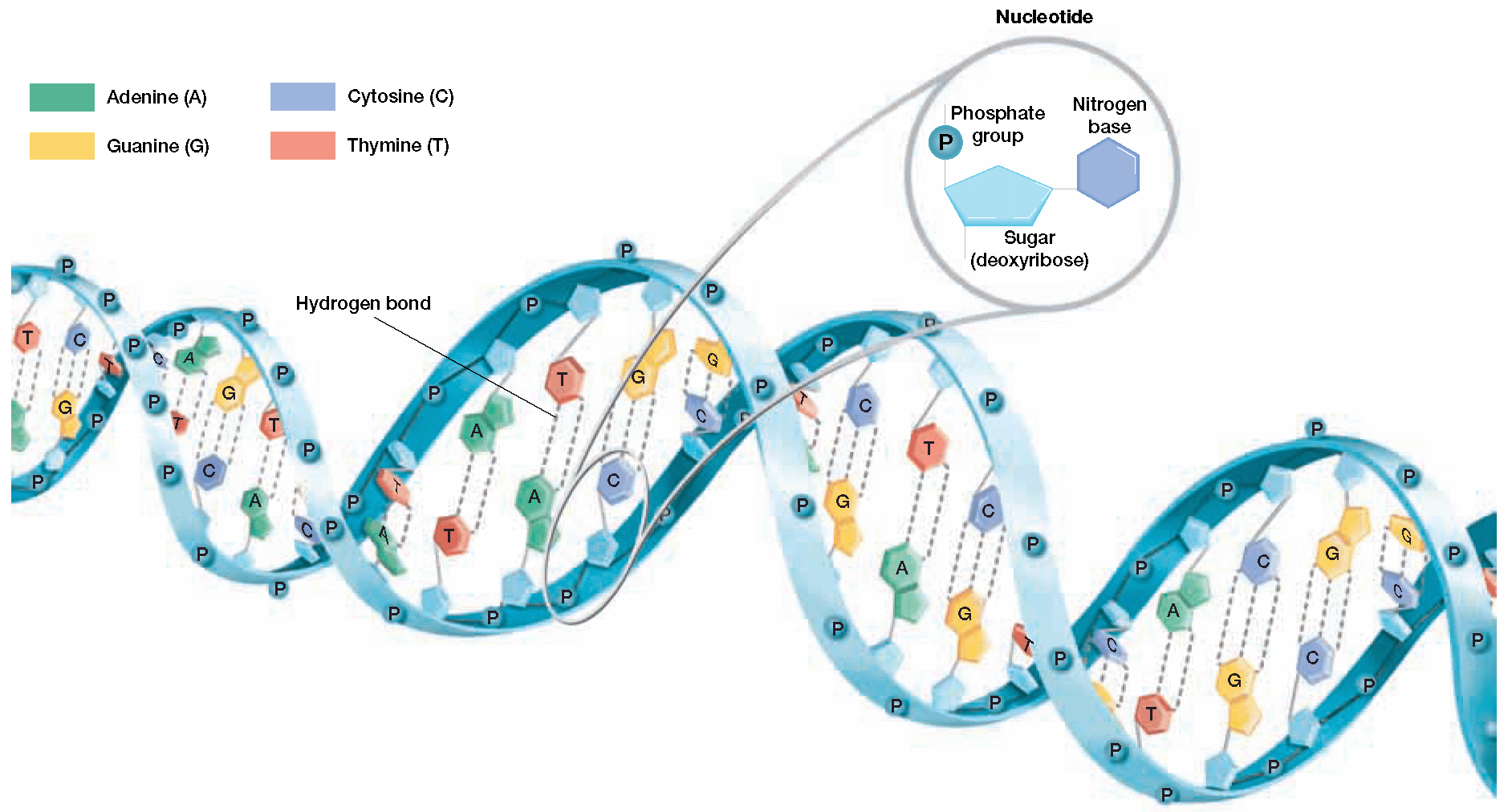
1. Relate Griffith’s conclusions to the observations he made during the transformation experiments.
2. Summarize the steps involved in Avery’s transformation experiments, and state the results.
3. Evaluate the results of the Hershey and Chase experiment.

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| --- | --- |
| Objectives | Vocabulary |
| * **Describe** the three components of a nucleotide. * **Develop** a model of the structure of a DNA molecule. * **Evaluate** the contributions of Chargaff, Franklin, and Wilkins in helping Watson and Crick determine the double-helical structure of DNA. * **Relate** the role of the base-pairing rules to the structure of DNA. * **Summarize** the process of DNA replication. * **Describe** how errors are corrected during DNA replication * **Compare** the number of of replication forks in prokaryotic and eukaryotic DNA. | Double helix  Nucleotide  Deoxyribose  Base-pairing rules  Complementary base pair  DNA replication  DNA helicase  Replication fork  DNA polymerase |

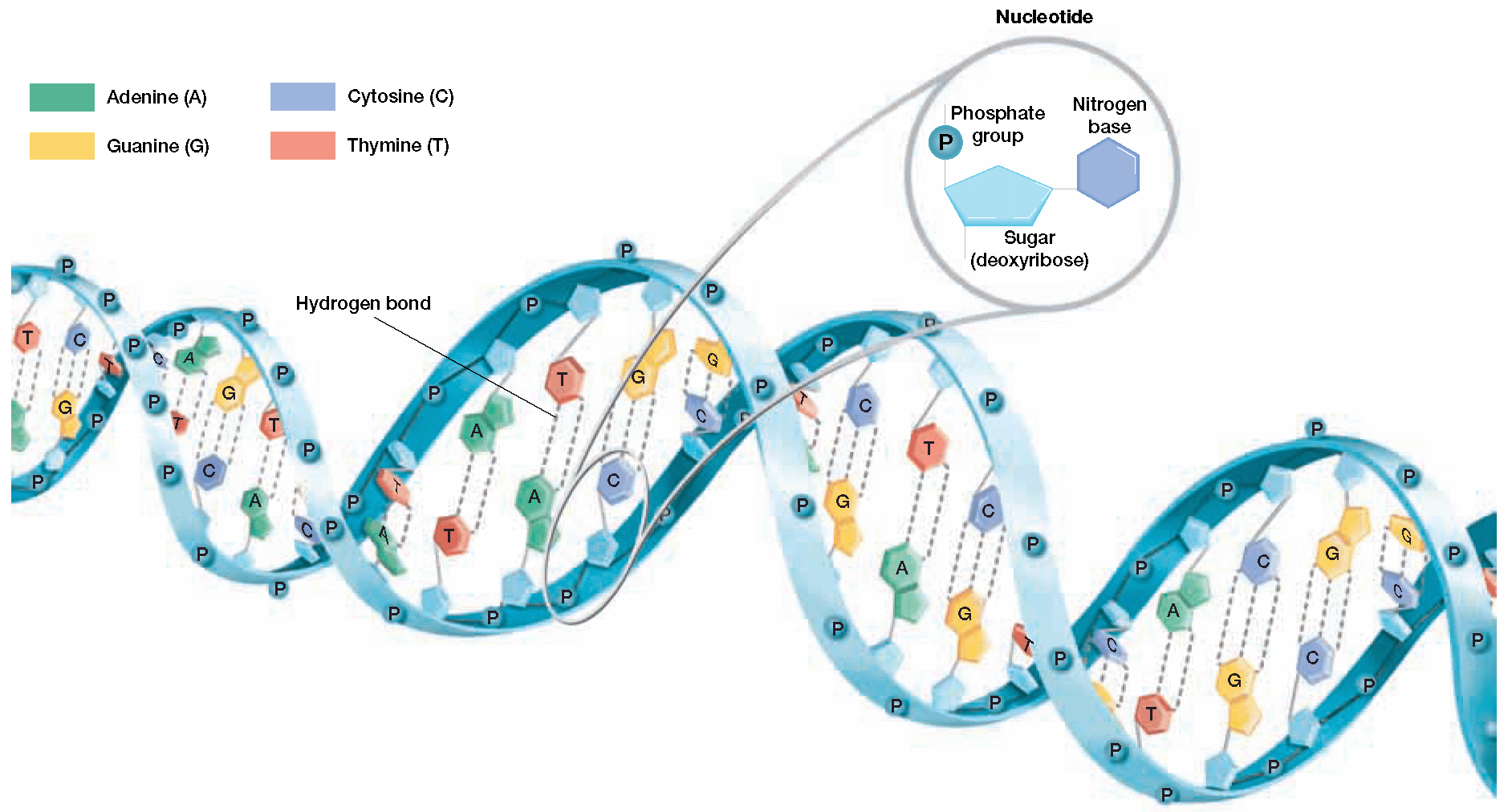
* After the Hershey and Chase experiment, scientists were convinced that DNA contained the genetic material…
  + But how is this information \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_?
  + And how is it \_\_\_\_\_\_\_\_\_\_\_\_\_ on?
  + To answer these questions, scientists began studying the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of DNA
* In 1953, James \_\_\_\_\_\_\_\_\_\_ and Francis \_\_\_\_\_\_\_\_\_ determined that a DNA molecule is a \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_
  + Meaning that it consists of \_\_\_\_\_\_ strands \_\_\_\_\_\_\_\_\_\_ around each other like a winding staircase



**Each strand is made of \_\_\_\_\_\_\_\_\_\_\_ nucleotides, which consist of three parts…**



* + **A phosphate group**
  + **A 5 carbon sugar called \_\_\_\_\_\_\_\_\_\_\_\_\_**
  + **A \_\_\_\_\_\_\_\_\_\_\_\_ base**
* One nucleotide is circled for you…
* Circle several more nucleotides
* Label a the 5 carbon sugar deoxyribose



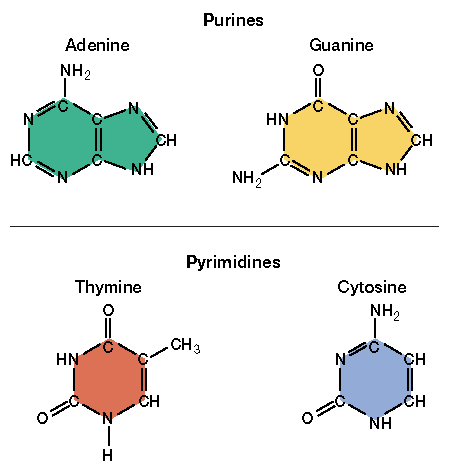
Note how DNA resembles a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The side rails or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of each strand consist of the…

* + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The phosphate and the sugar are held together by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ bonds

* The rungs of the ladder are made of the nitrogenous \_\_\_\_\_\_\_\_\_\_
  + They are held together by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ bonds
* While each DNA nucleotide contains the \_\_\_\_\_\_\_ sugar and phosphate group, the nitrogenous \_\_\_\_\_\_\_\_\_\_\_\_ may be any one of the four different kinds…



* + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Adenine and guanine contain \_\_\_\_\_\_\_\_\_\_\_\_ rings,

which are classified as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* Thymine and cytosine consist of \_\_\_\_\_\_\_\_\_\_\_ rings,

which are classified as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* Which bases look larger…
  + Purines or pyrimidines?
* How were Watson and Crick able to determine the double helical structure of DNA?
  + They based their structure on \_\_\_\_\_\_\_\_\_\_ acquired from \_\_\_\_\_\_\_\_\_\_\_ scientists

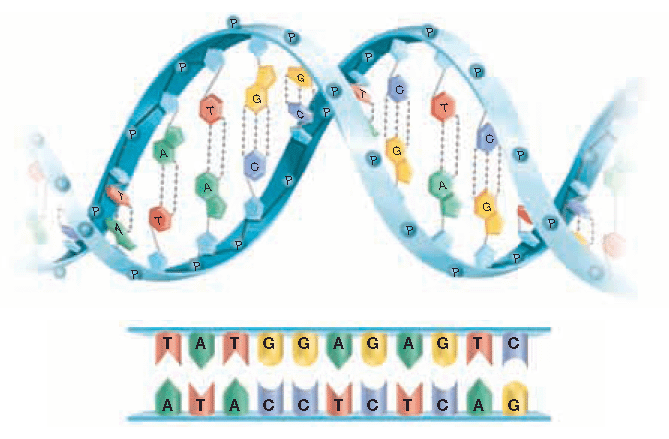
**Erwin Chargaff**

* In 1949, Erwin Chargaff observed that for each organism he studied, the amount of adenine always equaled the amount of thymine… \_\_\_\_\_\_\_ = \_\_\_\_\_\_
* Likewise, the amount of guanine always equaled the amount of cytosine… \_\_\_\_\_ = \_\_\_\_\_
* However, the amount of each equal pair \_\_\_\_\_\_\_\_\_ between different organisms.

**Maurice \_\_\_\_\_\_\_\_\_\_ and Rosalind \_\_\_\_\_\_\_\_\_\_\_\_\_\_**

|  |  |
| --- | --- |
| * In 1952, they took many photographs of sections of DNA using a method called \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_   + In the process, X-ray beams were bounced off of DNA and the rays were diffracted or \_\_\_\_\_\_\_\_\_\_\_\_\_\_ onto a piece of film   + This method is similar to shining a light on an object and analyzing its \_\_\_\_\_\_\_\_\_\_\_\_ * The X-ray photos clearly showed that DNA is composed of \_\_\_\_\_ strands that are \_\_\_\_\_\_\_\_\_ * In 1962 Watson, Crick, and Wilkins were awarded a \_\_\_\_\_\_\_\_\_\_\_\_ prize for their work * Rosalind Franklin was not recognized as a reward recipient because she had already died of cancer likely caused by too much X-ray \_\_\_\_\_\_\_\_\_\_\_\_\_\_ | hx6ne0196 |

* Based on all of the compiled data, Watson and Crick determined that a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ on one strand of the DNA is always paired with a \_\_\_\_\_\_\_\_\_\_\_\_\_\_ on the opposite strand
* Since adenine and thymine are always found in equal amounts…\_\_\_ pairs with \_\_\_\_
* Likewise, guanine and cytosine are found in equal amounts, so \_\_\_\_ pairs with \_\_\_\_



* A and T form \_\_\_\_ hydrogen bonds
* G and C form \_\_\_\_ hydrogen bonds
* The strictness of the base-pairing rules results in two strands that contain \_\_\_\_\_\_\_\_\_\_\_\_\_\_ base pairs…
* Meaning that the order of bases on one side \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the order of bases on the other side
* Determine the complementary base pairs for the DNA strand below…

A T A C G T

Roles of Enzymes in DNA Replication

* The complementary structure of DNA is also used as a basis to make \_\_\_\_\_\_\_\_\_\_\_ copies of the DNA each time a cell \_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Cell division allows an organism to \_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_, and to \_\_\_\_\_\_\_\_\_\_\_\_\_ old cells
* As we learned last semester, why can’t a cell simply just grow larger instead of dividing?
* The actual process of cell division is called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Why might it be a good idea for one of your body cells, like a skin cell, to make an exact copy of its DNA before it divides?
* The process of making a copy of DNA is called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* DNA replication occurs in three steps:
  + Step 1
    - Enzymes called **DNA \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**  open the double helix by breaking the \_\_\_\_\_\_\_\_\_\_\_\_\_\_ bonds that link the bases together
    - The areas where the double helix separates are called **replication \_\_\_\_\_\_\_\_\_\_.**
  + Step 2
    - At the replication fork, enzymes known as **DNA \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** move along each of the DNA strands and add \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to the exposed nitrogen base, according to the base-pairing rules.
    - Notice that the strands of DNA are copied in \_\_\_\_\_\_\_\_\_\_\_\_\_\_ directions …
      * This phenomenon is known as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
      * The direction is controlled by the location of \_\_\_\_\_\_\_\_\_\_ atoms in deoxyribose…
      * 5th Carbon to 3rd Carbon
  + Step 3
    - DNA polymerases \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ after two \_\_\_\_\_\_\_\_\_\_\_\_\_\_ molecules are formed
    - Each new molecule consists of one \_\_\_\_\_ strand and one \_\_\_\_\_\_ strand

**Checking for Errors**

* In the course of DNA replication, errors sometimes occur and the \_\_\_\_\_\_\_\_\_\_\_ nucleotide is added to the new strand.
* An important feature of DNA replication is that DNA polymerases have a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ role.
* In the event of an error, the polymerases can \_\_\_\_\_\_\_\_\_\_\_\_\_
* Under normal circumstances, this proofreading reduces errors in DNA replication to about \_\_\_\_\_\_\_\_ error per 1 \_\_\_\_\_\_\_\_\_\_\_\_\_ nucleotides.

**The Rate of Replication**

* Replication does not begin at one end of the DNA molecule and end at the other because that would take too \_\_\_\_\_\_\_\_\_.
* Recall that DNA in prokaryotes is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
* They usually have \_\_\_\_\_\_ replication forks that begin at a single point meet on the \_\_\_\_\_\_\_\_\_\_\_\_\_ side of the DNA circle
* In eukaryotic cells, each chromosome contains a single, \_\_\_\_\_\_\_\_\_\_\_\_ strand of DNA.
* Each human chromosome is replicated in about \_\_\_\_\_\_ sections that are 100,000 nucleotides long, each section with its own starting point.
* An entire human chromosome can be replicated in about \_\_\_ hours.

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