Name: _____ Hour: _____Due Date: _____

Discovering DNA

Introduction. How is genetic information stored in chromosomes? And by what code—or language—does the cell interpret this information? To answer these questions, biologists first had to learn which molecule inside chromosomes contains genes—proteins, DNA or carbohydrates. In other words, they had to find the molecule or molecules of heredity. In this investigation you will retrace the work of other scientists that proved DNA is the genetic material of life and then you will duplicate the work of Watson and Crick in order to create a model of DNA from some basic evidence.

Task #1: What molecule found within cells is the genetic material that determines traits? The answer to this question was not an easy one to answer. A scientist named T.H. Morgan showed that genes are found on chromosomes, so scientist suspected that DNA, carbohydrates or a protein determines the traits of an organism because those molecules can be found within chromosomes. But is it DNA, protein, a carbohydrate or a combination of these? Your task is to use the results of the following experiments to prove which molecule determines traits.

Griffith and his work with Pneumonia

In 1928, a British doctor named Frederick Griffith was investigating the way in which a certain type of bacteria, *Diplococcus pneumoniae*, caused pneumonia, a serious and often-fatal lung disease. Scientists already knew which type of bacteria caused the disease, but they were trying to learn how bacteria caused the disease.

Griffith studied two strains of *D. pneumoniae.* Both grew very well in his laboratory, but only one actually caused pneumonia when injected into mice. Griffith was able to distinguish between these two strains based on how they grew on agar plate.

Bacteria grow in colonies (a mass of cells) in petri dishes, and colonies that appeared smooth caused disease, while colonies that appeared rough did not. The reason the two strains look different is because the strain that appears smooth produces a capsule (which is made up of a carbohydrate) that protects the bacterium from the host's immune system while the one that appears rough cannot produce a protective capsule.

Griffith hypothesized that the carbohydrate capsule that surrounds the smooth bacteria was responsible for the disease. He has two important pieces of information before he started his experiment: the bacteria with carbohydrate capsules could kill mice, while the non-capsule forming bacteria could not. *(See diagram at right)*

disease causing ability	appearance of agar plate	diagram of colony appearance on agar plate
nonencapsulated bacteria (does not cause disease)	rough edged colonies	
encapsulated bacteria (causes disease)	smooth colonies	

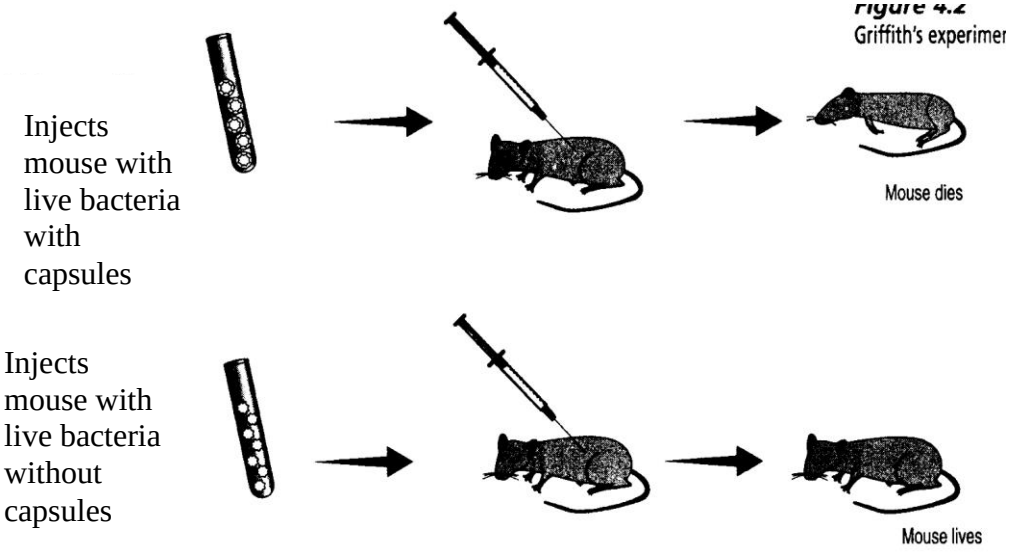
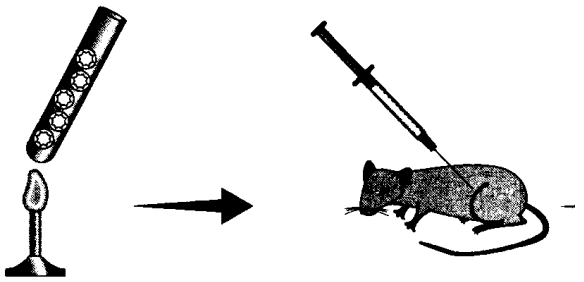


Figure 4.2
Griffith's experimer

With this information he conducted the experiment at right. He heated the bacteria to kill them leaving only the capsule.

Use this information to fill in the flow chart based on this experiment

Injects mice with bacteria with capsules that have been killed with heat



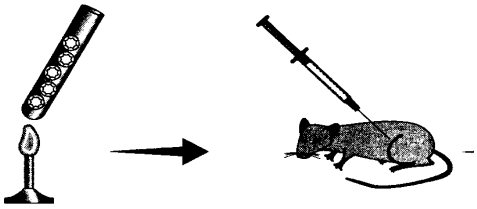
Griffith's First Experimental Question (1 point)

Hypothesis 1 (1 point)

If…

Experiment

Injects mice with bacteria with capsules that have been killed with heat



Things he would have needed to controlled (at least two) (1 point)

And…

Predicted Result if Hypothesis 1 is valid (1 point)

Actual Result

Then…

Mouse lives

No bacteria in mouse's blood

Therefore…

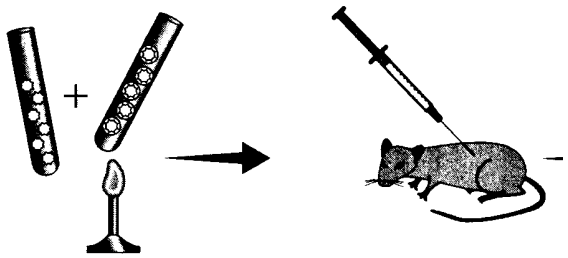
Conclusion (1 point)

_____/ 7 points

Griffith then conducted a second experiment, illustrated at right:

Use this information and the description of the experiment to fill in the flow chart based on this experiment.

Injects mouse with bacteria with capsules that have been killed with heat and live bacteria without

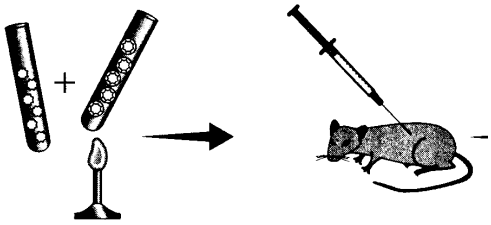


Griffith's Second Experimental Question (1 point)

Hypothesis 1 (1 point)

If…

Injects mouse with bacteria with capsules that have been killed with heat and live bacteria without capsules



Experiment

And…

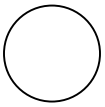
Things he would have needed to control (at least two) (1 point)

Predicted Result if Explanation 1 is True (1 point)

Actual Result

Then…

Mouse dies



Smooth Bacteria found
In mouse's blood

Therefore…

What do you think happened? (1 point)

_____ / 7 points

When Griffith, removed the bacteria from dead mice in his experiment, and grew them on agar plates, he found only colonies of smooth bacteria. Somehow the harmless, non-capsule forming bacteria had changed into the disease causing strain. Something had been transferred from the bacteria killed by heat, disease causing strain, to the living, non-disease causing stain giving it the ability to make the carbohydrate capsule and cause disease. But what was it, DNA or Protein?

Using the information above explain what happened between the bacteria with the capsule that was killed with heat and the bacteria without the capsule that was live. You need to also answer the question is carbohydrates the hereditary material.
-

_____

_____

_____

Hershey and Chase and their work with Viruses

In 1952, two American scientists, Alfred Hershey and Martha Chase carried out an experiment that answered this question once and for all. Hershey and Chase worked with viruses, tiny particles that are made up of only DNA and Protein (similar to a pill with a powder on the inside of it). Hershey and Chase knew that viruses injected their genes into a host cell, where the genes took over the host cell and forced that cell to make 1000's of new viruses. If they could determine which of these two molecules, DNA or Protein, entered a host cell when a virus infects it they could determine what genes are made of, DNA or Protein.

To accomplish this task, they used radioactive particles to mark the DNA and the Protein within viruses. The radioactive marks will enable Hershey and Chase to track the location of DNA and Protein in the sample. Hershey and Chase prepared two samples of viruses, one sample with a radioactive marker called phosphorus-32 that marks DNA, and the other sample with sulfer-35, which marks protein. *See below*.

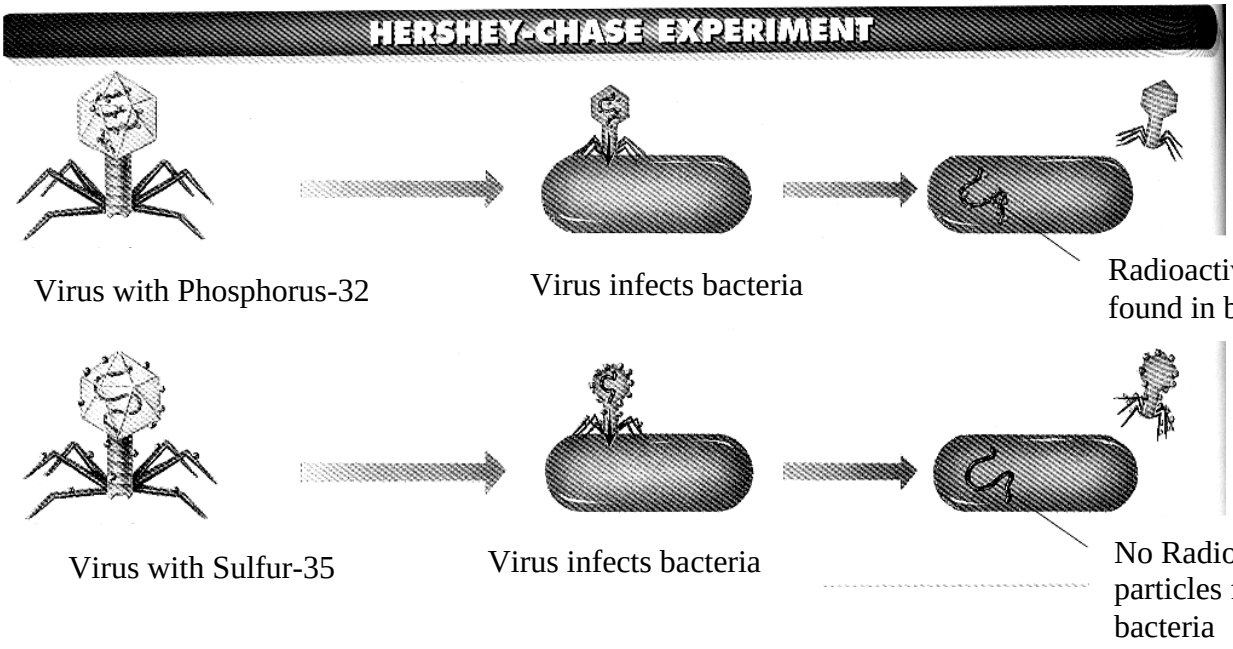
Virus with Phosphorus-32

Virus with Sulfur-35

Phosphorus-32 only marks the DNA of a virus like the pictured above.

Sulfur-35 only marks the Protein that makes up a virus like the pictured above.

Hershey and Chase then allowed both samples of viruses (also known as Bacteriophage) to infect different samples of bacteria and then tested those samples of bacteria to see if they contained any radioactive material from the viruses. Only one of the samples had bacteria that were radioactive. *See the diagram below*.


HERSHEY-CHASE EXPERIMENT
Virus with Phosphorus-32
Virus infects bacteria
Radioactive particles found in bacteria
Virus with Sulfur-35
Virus infects bacteria
No Radioactive particles found in bacteria

Write Hershey and Chase's Experimental Question from the information above (1 point)

Hypothesis 1 DNA (1 point)

If…

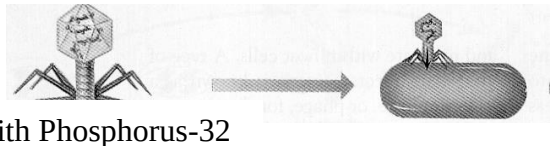
Hypothesis 2 Protein (1 point)

If…

Experiment

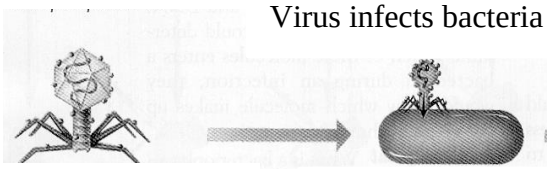
Things they would have needed to Control (at least two) (1 point)

And…



Virus with Phosphorus-32

Virus infects bacteria



Virus with Sulfur-35

Virus infects bacteria

Predicted Result if Hypothesis 1 DNA was valid (1 point)

Predicted Result if Hypothesis 2 Protein was valid (1 point)

Actual Result

Conclusion (1 point)

Then…

Phosphorus-32 found within bacteria

Therefore…

Recap of the experiments

1. In Griffith experiment's he worked with bacteria that caused _____found that something was _____ from one bacteria to the other.
2. Hershey and Chase worked with _____. They found that because _____ was found inside the bacteria then _____ is the genetic material of a _____.

If you had difficulty with the above please go to this website.

http://www.dnai.org/timeline/index.html

Task #2: The American biochemist Erwin Chargaff was testing samples of DNA and made an important discovery in 1950. He figured out which base bonded to which base on strand of DNA. Your task is to reproduce the investigation of Chargaff.

You will reproduce Chargaff's investigation by using a paper bag as your beaker and colored shapes as the bases of DNA. Take the shapes out one by one and record the number of each base you find in the chart below.

Amount of Adenine	Amount of Cytosine	Amount of Thymine	Amount of Guanine

Using the above information make a conclusion about which bases are bonded together.

_____

_____

Task #3: Imagine that you are on a team of research scientists involved in an effort to describe the structure of the DNA molecule. You have decided to tackle this task by modeling, that is, by building a physical representation of a possible structure for DNA. You will then be able to change this model to reflect new information as it becomes available.

The DNA Molecule—Examine the information about DNA available to you listed in the box below. Use this information to build a model of what you think a DNA molecule looks like. Once you have built your model, draw a **color-coded** picture in the box on the next page and **include a key.** On the diagram of your DNA model, show how you model takes all these properties into account by labeling these properties on your model.

Properties of DNA

- DNA is a very long, chain-like molecule composed of smaller (subunit) molecules. Subunit molecules are like the links of a chain.
- DNA is composed of 6 different subunit molecules:
  Guanine (a base) Thymine (a base) Deoxyribose (a sugar) Adenine (a base)
  Phosphate Cytosine (a base)
- DNA consists of two long chains of subunits twisted around each other to form a "double" helix (a helix is the shape a pipe cleaner takes when you wrap it around a pencil)
- The two chains are bonded together. A subunit from one strand bonds to a subunit on the other.
- The diameter of DNA is the same along its entire length (exactly 4 molecules or subunits wide)—*which was discovered by Rosalind Franklin in 1951.*
- In a molecule of DNA, the # of guanine molecules = the # of cytosine molecules and the # of adenine molecules = the # of thymine molecules. *This fact is known as Chargaff's Rule because of the American biochemist Erwin Chargaff who made this important discovery on 1950.*
- In a molecule of DNA, a sugar can only bind with a base and a phosphate
- In a molecule of DNA, a base can only bind with a sugar and another base
- In a molecule of DNA, a phosphate can only bind with a sugar

You will use K'NEX pieces to build your model
Yellow pieces represent sugar
White pieces represent phosphate
Blue pieces represent the bases (each one will have a different color tape attached)
Thymine (yellow tape) Cytosine (orange tape) Guanine (green tape) Adenine (red tape)

Your Model

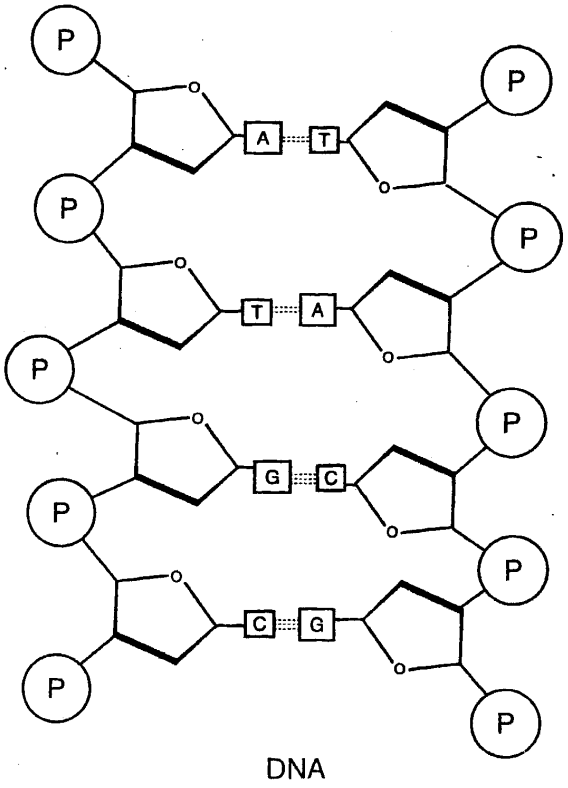
Key

- ❑ Phosphate
- ❑ Deoxyribose (sugar)
- ❑ Adenine (base)
- ❑ Cytocine (base)
- ❑ Thymine (base)

4 3 2 1

<u>The Actual Structure of DNA</u>—Examine the video model of DNA and read DNA "Structure and Replication" (page 175-180 in Biology: The Living Science) and then answer the following questions.

Label each part of the DNA molecule in the diagram below.



DNA

Explain how DNA is able to store genetic information. *Include a diagram if needed.*

Explain how DNA is copied (replicated) so it can be passed on to the four cells formed through meiosis. *Include diagrams as needed.*

4 3 2 1