Explore Student Guide

Name: _____ Date: _____

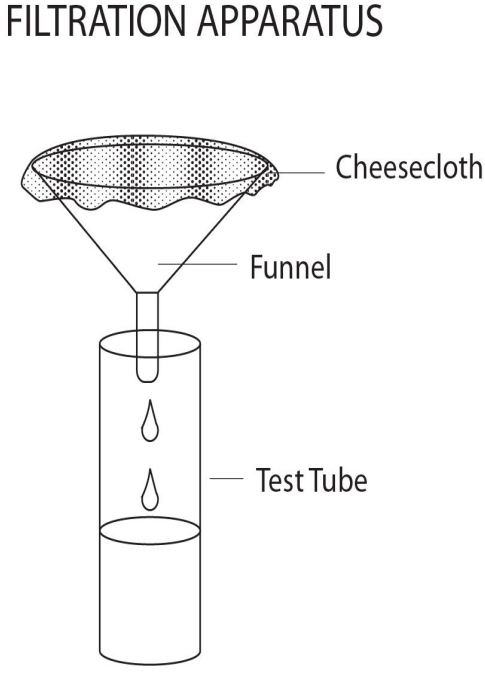
Part I: Extract DNA

Deoxyribose nucleic acid (DNA) is found in all organisms. Strawberries are an excellent source for extracting DNA. They are soft and can be pulverized easily. In addition, strawberries have very large genomes. They have eight copies of each chromosome, in other words, which makes them octoploid. For comparison, humans are diploid, having only two copies of each chromosome.

In this lab, you need to extract DNA from the cell of an organism. An extraction buffer containing salt and dish soap will be used to extract the DNA from the cells. The salt breaks up protein chains that hold the nucleic acids together, while the dish soap helps to dissolve the lipid layer of the cell membranes. In Part II, you will discover that even though the size and location of the DNA may vary among species, the components of DNA are the same.

Procedure:

1. Place one strawberry in a plastic baggie.
2. Smash the strawberry with your fingers for 2-3 minutes. Make sure that you do not break the bag!
3. Add 10 mL of extraction buffer to the bag.
4. Mix the extraction buffer and strawberry together using your fingers. Knead the mixture for one minute.
5. Make the filtration apparatus as shown in the diagram.
6. Pour the strawberry solution into the filtration apparatus. The solution will take a while to drip and filter out the liquid from the solid pieces.
7. Remove the filtration apparatus from the test tube.
8. Slowly drizzle the alcohol into the test tube. Tilt the test tube so that the alcohol runs down the side of the glass.
9. Hold the test tube at eye level. Can you see a white cloudy mixture where the alcohol and strawberry solution meet?
10. Dip the popsicle stick into the test tube where the two liquids meet.
11. Gently swirl the popsicle stick to gather the DNA.



Complete Part I in your Student Journal.

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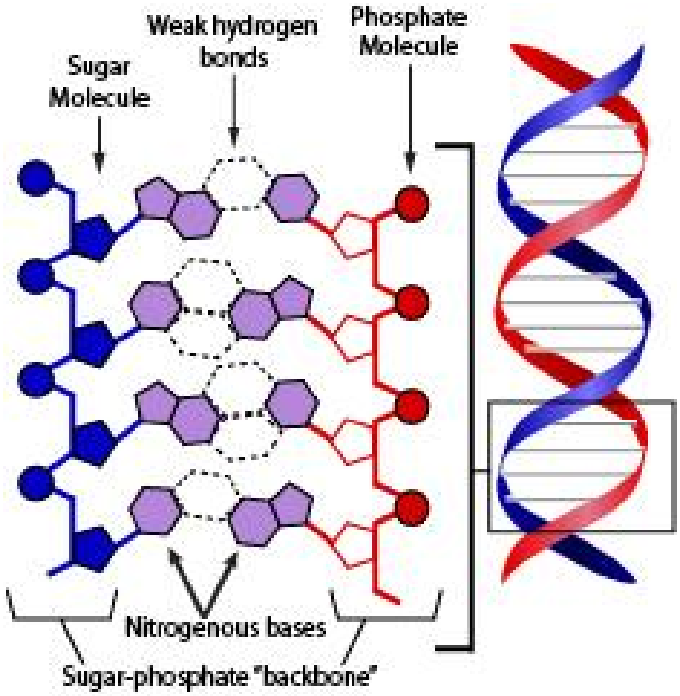
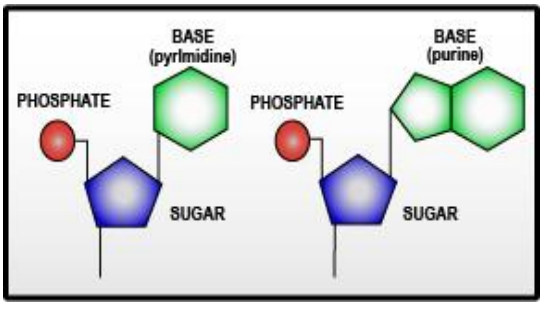
Part II: Components of DNA

All known forms of life contain nucleic acids DNA and RNA. DNA needs to be coded, transmitted, and expressed. Ribonucleic acid (RNA) and deoxyribonucleic acid (DNA) are found in abundance in all living cells, from single celled prokaryotes to complex eukaryotes such as human beings. To understand how DNA carries information about the physical traits of an organism, it is necessary to first understand the structure of the DNA molecule.



DNA consists of repeating monomers called nucleotides. Each nucleotide consists of three parts as illustrated on the right:

- A phosphate group
- A five-carbon (pentose) sugar
- A nitrogenous base



The phosphate group is attached to one end of the five-carbon sugar. The phosphate of one nucleotide binds to the sugar of the next to form what is called the sugar-phosphate-backbone. It is the sugar, deoxyribose, which gives DNA part of its name.

There are four nitrogenous bases within DNA: adenine (A), thymine (T), cytosine (C), and guanine (G). These four bases can further be divided into two groups based on their atomic structure: (A) and (G) are called purines, while T and C are called pyrimidines. Each of the nitrogenous bases has specific partner that it shares a hydrogen bond with. Adenine always binds to thymine, and cytosine always binds only to guanine. The entire structure of DNA looks like a ladder twisted into a spiral. This shape is known as a double helix.

Please continue to the next page.

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Part II: Components of DNA, continued

Procedure for building a model of DNA:

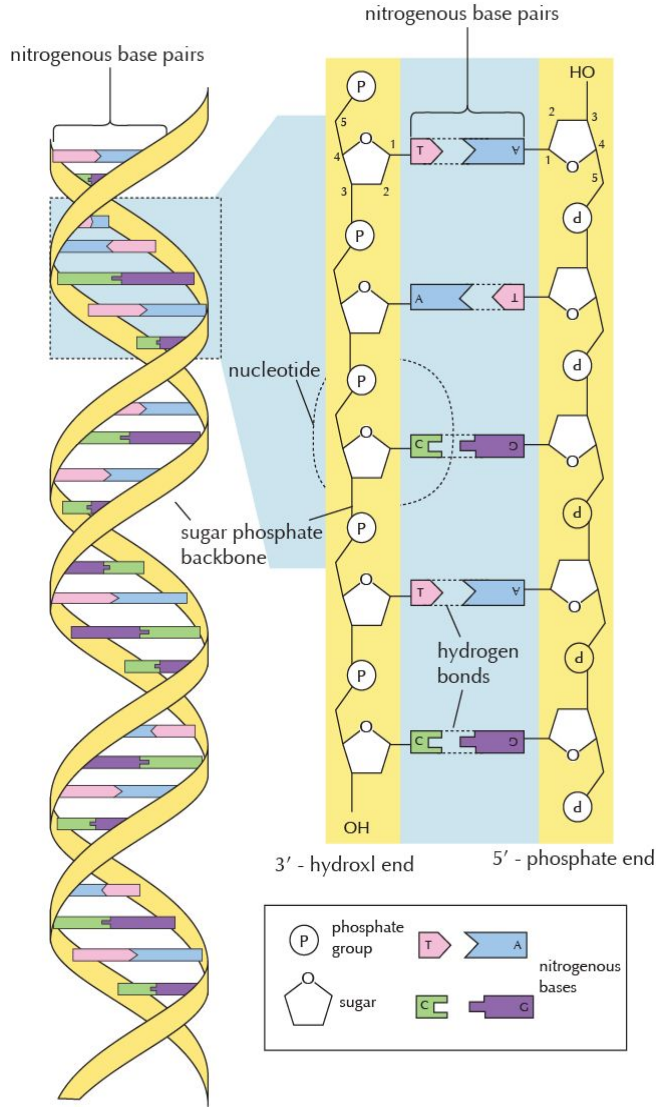
1. Obtain the pipe cleaners for your model. You need two long, black pipe cleaners, and six short pieces of each of the following colors: red, blue, purple, yellow. The pipe cleaners are color-coded. The long, black pipe cleaners represent the sugar-phosphate backbone. The other, shorter length colors represent the four nitrogen bases of DNA. Record the color-code in your Student Journal.

2. You will attach half (12) of the nitrogenous bases to one sugar-phosphate backbone at equal intervals.

3. Using the base-pairing rule, attach the appropriate, complimentary nitrogenous bases to the other sugar phosphate backbone.

4. Once both halves of the DNA model are assembled, join the nitrogenous base pairs together. As you go along, double check to make sure you are obeying the base-pairing rule.

5. Now that your DNA is assembled, gently take both ends of the strand, and gradually twist the model until it spirals into the double helix shape. Repair any connections that may come undone during this process.



Complete Part II of your Student Journal.

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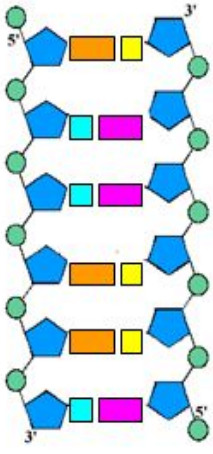
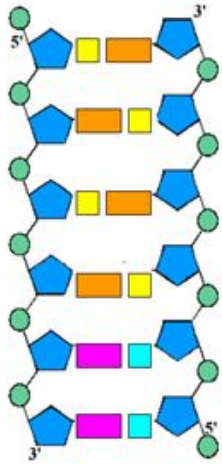
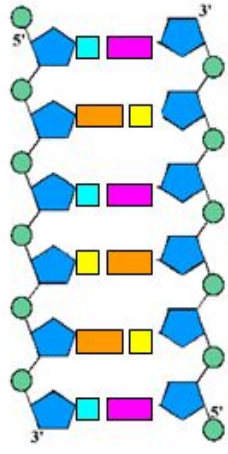
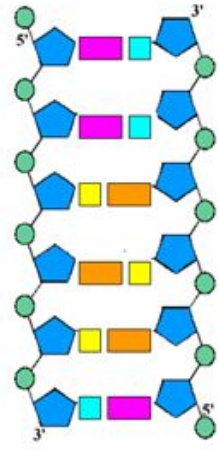
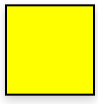
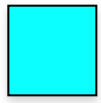
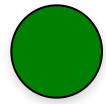
Part III: The Genetic Code

All living things have DNA, but how does the DNA of a single-celled organism have anything in common with you? Use the information from the chart below to answer the questions in your Student Journal.

Organism	**Woodland Strawberry** (*Fragaria vesca*)	**Yeast** (*Saccharomyces cerevisiae*)	**Human** (*Homo sapien*)	**Bacteria** (*Streptococcus pneumoniae*)
# of Base Pairs (approximately)	206 million	12.15 million	3 billion	2.2 million
Short Segment of DNA				

Legend

Adenine	Thymine	Guanine	Cytosine	Phosphate	Sugar	Base Pair (example)
						

Begin Part III of your Student Journal.

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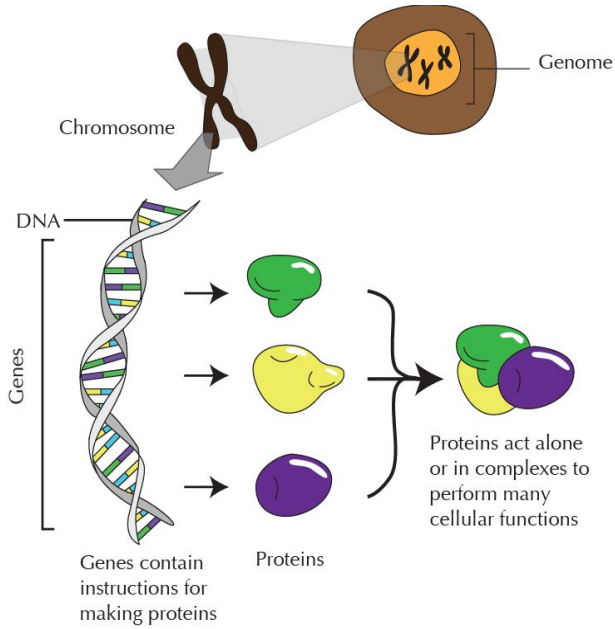
Part III: The Genetic Code, continued

With your DNA model in Part II, you discovered that you had to reuse the same four nucleotides in an ordered pattern. You also found that it was important to correctly match each nucleotide with its corresponding base pair, A-T and C-G. Now let us examine why base pair sequences are so important.

Often, people will refer to genes as if they cause something to happen–a gene for eye color, or a gene for sickle cell trait. This is somewhat misleading as genes themselves do not take direct action. A gene is a segment of DNA that acts as a blueprint for a particular protein. Proteins are responsible for the traits an organism has. In addition, proteins are the essential building blocks for life activities. Hormones, enzymes, and various cell structures are all made of proteins. You may recall that proteins are made of amino acids, and that the combination of amino acids determines the shape and function of a protein. This is where nitrogenous base pairs are important.

Nucleotides operate in codons, or units of three nucleotides. Each codon determines which amino acid is added during a process called protein synthesis. The combination of base-pairs in each codon (A-T-G for example) dictates which amino acid gets used. A gene is a complete set of codons that determines the amino acids used to make a specific protein. Additionally, there are “start” and “stop” signals encoded in DNA that organize the genetic information for each protein. A single amino acid can be encoded by more than one codon, so small changes in base pairs do not necessarily result in changes in the proteins.

Not all segments of DNA are considered genes, however. Some sections of DNA serve structural purposes, or regulate how the genetic information within genes is used. Later, you will learn more about the process your cells go through to translate the DNA code into the various proteins.



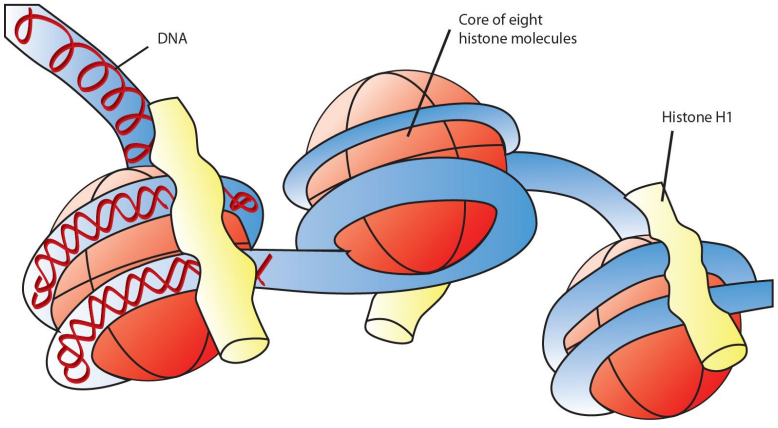
The flow of genetic information is DNA to RNA, RNA to amino acid sequence, amino acid sequence to protein. In this way, DNA specifies expressed traits

Complete Part III of your Student Journal.

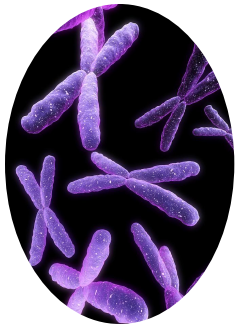
Part IV: DNA Studies Through Time

You know that DNA consists of sequences of nucleotides, that specific sections of each DNA sequence are called genes, and that it is the genes that encode the traits of an organism. You also know that each cell contains the genetic information for that organism. But, did you know that there are approximately 2 meters of DNA inside each human cell nucleus? How can it all fit into a space that is measured in micrometers?

Once again, proteins are the answer. Much like thread that is wrapped around a spool, a double helix strand of DNA is wound around a core of eight special proteins called histones. Strands of DNA wrapped around a histone protein core are called nucleosomes. These nucleosomes are folded in a highly structured way to eventually form chromosomes. Chromosomes consist of a single DNA double helix tightly wound and folded into a condensed superstructure. Each chromosome carries different portions of an organism's genetic information.



The diagram below depicts actual chromosomes (humans have 23 pairs). Taken all together, an organism's chromosomes contain their entire genome, which is the sum of all of their hereditary information. Advances in technology have made it easier to sequence genomes for study, and the field is rapidly expanding. In 2007, the Human Genome Project announced that it had successfully sequenced the entirety of the first human genome, that of James D. Watson, the co-discoverer of the DNA structure!



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Part IV: DNA Studies Through Time, continued

James Watson and Francis Crick first described the 3D, spiraling, double-helix structure of DNA in 1953. Although this was the first clear model (which evidence since then has continued to support as fact) they did not arrive at this model alone. Scientists, both before and after them, contributed to the research and understanding of DNA's structure. In fact, the duo's “discovery” actually relied heavily on work done by others. In Watson's memoir, published 15 years after their discovery, titled *The Double Helix: A Personal Account of the Discovery of the Structure of DNA*, Watson explains how he first glimpsed the nature of DNA.

It was at a conference in Naples, Italy, through a vague image captured by X-ray crystallography in 1952. Later, in a bit of melodrama, Watson saw an even clearer, unpublished picture captured by Rosalind Franklin, who had been working on creating the world's best X-ray diffraction images of DNA. A fellow colleague, Maurice Wilkins, snuck Watson a preview of Franklin's work without her knowing about it. As Watson recalls in his book, “The instant I saw the picture my mouth fell open.” Essentially, that picture revealed several parameters that puzzled together some of the most vital pieces of the model.

Watson and Crick's DNA model was revolutionary, and the field of genetics research and application has flourished ever since. Although scientists still have a lot to learn about DNA, with research and new discoveries often leading to more questions, a lot has become known in understanding heredity and the causes and cures for diseases. In this part of the activity, you will explore the history of DNA discoveries, before, during, and after Watson and Crick's time.

Complete Part IV and the Reflections and Conclusions of your Student Journal.