Lab 18. DNA Structure: What Is the Structure of DNA?

Introduction

We know that genes are made of DNA because scientists were able to demonstrate that DNA and proteins are found in the nucleus of cells, and, more importantly, that DNA (and not protein) is able to transform the traits of organisms. Oswald Avery, Colin MacLeod, and Maclyn McCarty made this discovery in 1944. Their research showed that it is possible to transform harmless bacteria into infectious ones with pure DNA. They also provided further support for their claim by demonstrating that it is possible to prevent this "'transformation" with a DNA-digesting enzyme called DNase.

However, knowing that genes are made of DNA and that DNA is able to store the genetic information of an individual is a little like having a parts list to a 747 jumbo jet. It tells what is important, but it tells you little about how it works. To figure out how DNA works—that is, how it is able to store genetic information—scientists had to figure out its structure. In this investigation, you will duplicate the work of the two scientists who first figured out the structure of DNA—James Watson and Francis Crick.

Your Task

Use the available data to develop a model that explains the structure of DNA.
The guiding question of this investigation is, **What is the structure of DNA?**

Materials

You may use any of the following materials during your investigation:

- Pop beads (DNA kit)
- Fact sheet about DNA

Safety Precautions

1. Safety goggles or glasses are required for this lab.
2. Wash hands with soap and water after completing this lab.
3. Follow all normal lab safety rules.

Getting Started

To answer the guiding question, you will need to develop a model for the structure of DNA. In science, models are explanations for how things work or how they are structured. Scientists often need to develop models to explain a complex phenomenon or to understand the structure of things that are too small to see (such as the structure of an atom or the structure of a molecule of DNA). Scientists use drawings, graphs, equations, three-dimensional representations, or words to communicate their models to others, but scientists only use these physical objects as a way to illustrate the major components of the model.

You will need to create a three-dimensional representation of your model for the structure of DNA using pop beads. Remember that more than one model may be an acceptable explanation for the same phenomenon. It is not always possible to exclude all but one model—and also not always desirable. For example, physicists think about light as a wave and as a particle, and each model of light's behavior is used to think about and account for phenomena differently.

Investigation Proposal Required? ☐ Yes ☐ No

Connections to Crosscutting Concepts and to the Nature of Science and Scientific Inquiry

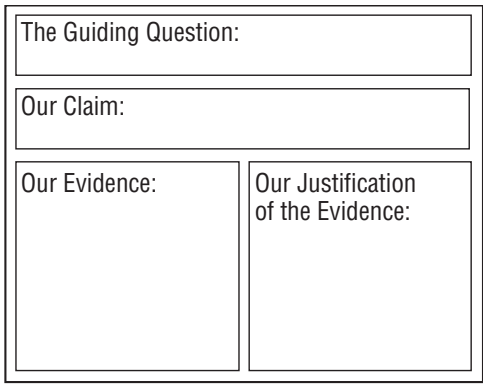
As you work through your investigation, be sure to think about

- the importance of identifying patterns;
- the importance of examining proportional relationships;
- how the way an object is shaped or structured determines many of its properties or functions;
- how science, as a body of knowledge, changes over time; and
- the different methods that scientists can use to answer a research question.

Argumentation Session

Once your group has finished collecting and analyzing your data, prepare a whiteboard that you can use to share your initial argument. Your whiteboard should include all the information shown in the figure to the right.

Argument presentation on a whiteboard



To share your argument with others, we will be using a round-robin format. This means that one member of your group will stay at your lab station to share your group's argument while the other members of your group go to the other lab stations one at a time to listen to and critique the arguments developed by your classmates.

The goal of the argumentation session is not to convince others that your argument is the best one; rather, the goal is to identify errors or instances of faulty reasoning in the arguments so these mistakes can be fixed. You will therefore need to evaluate the content of the claim, the quality of the evidence used to support the claim, and the strength of the justification of the evidence included in each argument that you see. In order to critique an argument, you will need more information than what is included on the whiteboard. You might, therefore, need to ask the presenter one or more follow-up questions, such as:

- What did you do to develop your model?
- Is that the only way to interpret the results of your analysis? How do you know that your interpretation of your analysis is appropriate?
- Why did your group decide to present your evidence in that manner?
- What other models did your group discuss before you decided on that one? Why did your group abandon those alternative ideas?
- How confident are you that your model is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your original argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most valid or acceptable answer to the research question!

Report

Once you have completed your research, you will need to prepare an investigation report that consists of three sections that provide answers to the following questions:

1. What question were you trying to answer and why?
2. What did you do during your investigation and why did you conduct your investigation in this way?
3. What is your argument?

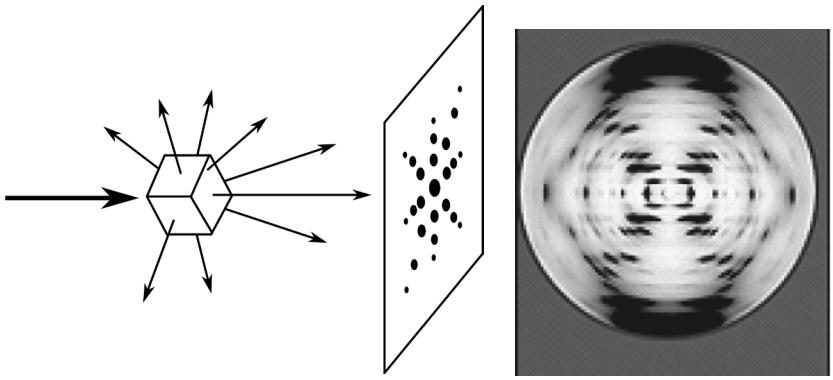
Your report should answer these questions in two pages or less. This report must be typed, and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid.

DNA Fact Sheet

1. DNA is a very long molecule composed of smaller molecules called subunits. You can use the different colored beads to represent the different subunits in your physical representation of DNA.
2. DNA is composed of six different subunits (or smaller molecules):

   Guanine (a base) Phosphate group Thymine (a base)
   Deoxyribose (a sugar) Adenine (a base) Cytosine (a base)
3. DNA consists of two chains that are bonded (connected) together. A subunit from one strand bonds to a subunit on the other.
4. The diameter of DNA is the same along its entire length (exactly four molecules or subunits wide). Rosalind Franklin made this discovery in 1952 by using x-ray diffraction (see the figure below).

X-rays show that DNA has the same diameter along its entire length.



X-ray diffraction DNA x-ray

5. A sugar subunit can only bind with two other subunits: a base subunit and a phosphate group subunit.
6. A base subunit can only bind with two other subunits: a sugar subunit and a base subunit.
7. A phosphate group subunit can only bind with a sugar subunit.
8. In 1950, biochemist Erwin Chargaff examined the proportion of adenine (A), thymine (T), guanine (G), and cytosine (C) molecules in DNA from different types of organisms. His findings, which are shown below, were so important that it led to a fundamental principle about the relative proportion of bases found in the DNA of all organisms; this principle is now known as Chargaff's rules.

Relative proportions (%) of bases in DNA				
Organism	**A**	**T**	**G**	**C**
Human	30.9	29.4	19.9	19.8
Chicken	28.8	29.2	20.5	21.5
Grasshopper	29.3	29.3	20.5	20.7
Sea urchin	32.8	32.1	17.7	17.3
Wheat	27.3	27.1	22.7	22.8
Yeast	31.3	32.9	18.7	17.1
E. coli	24.7	23.6	26.0	25.7