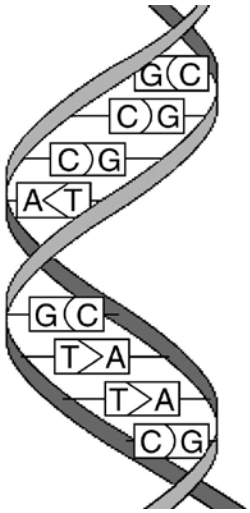
Lab 15. Mutations in Genes: How Do Different Types of Mutations in Genes Affect the Function of an Organism?

Introduction

During reproduction, information for traits is passed from the parent organisms to the offspring. This transfer of trait information from parents to offspring is known as *inheritance*. The factors with the trait information are found in all living things and are called *genes*. All of the genes passed on during reproduction contain information needed to create a new organism. Genes are made of a molecule known as *DNA*, which stands for deoxyribonucleic acid. Figure L15.1 shows a section of a DNA molecule. DNA is made of two strands of molecules with a sugar/phosphate side and a base side. The base sides interact with the base sides of another strand to connect the two strands together. There are only four types of bases in DNA, called *A*, *G*, *C*, and *T*. These four bases will bond in only two ways: an A on one strand will only bond to a T on the other strand, and a C on one strand will only bond to a G on the other strand. As these bases pair up, the two strands stay connected, forming larger molecules of DNA.

FIGURE L15.1

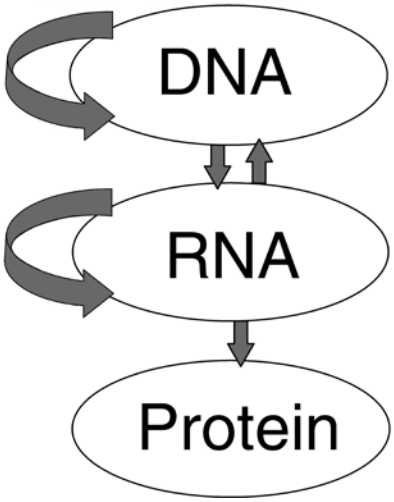
Section of a DNA molecule



The chemical structure of the DNA molecule allows it to store information. Genes are made up of long units of DNA. The order of the bases in a strand contains a code for the structure of other molecules in organisms. A section of a strand of DNA, like TACCGATGATTCCGG, has a code that tells an organism's cells how to build other molecules. The DNA in genes is read by special molecules, called enzymes, which use the code in DNA to build an *RNA* molecule. RNA, which stands for ribonucleic acid, is a single-stranded molecule similar to DNA that also contains a sequence of bases. The RNA molecule made from a specific gene is then used to make a *protein* molecule (see the next paragraph). Figure L15.2 shows the connections between DNA, RNA, and proteins.

FIGURE L15.2

Connections between DNA, RNA, and proteins

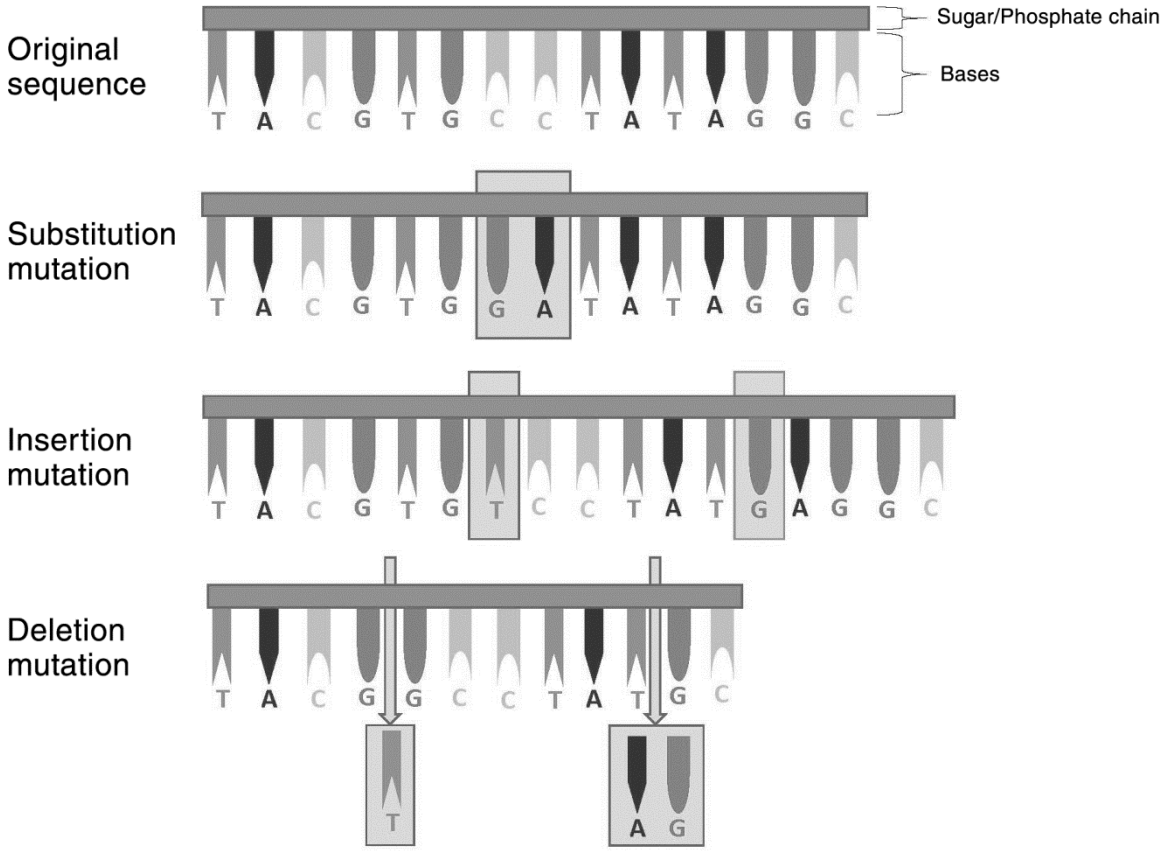


Proteins are molecules that perform all kinds of functions in cells. A protein's function is determined by the way it is shaped, and that shape is determined by the order of *amino acids* that make up a protein's structure. Amino acids are small molecules that make up larger protein molecules, much like the sugar/phosphate + base molecules make up DNA and RNA. Thus, in all of these large molecules, the order structure of the smaller molecules that form them determine the functions the larger molecules perform.

Changes to the order of those small molecules are called *mutations*. There are several types of mutations that can occur to the order of bases in DNA. *Substitution mutations* happen when pairs of bonded bases in a double strand of DNA get replaced with different pairs. An example of a substitution mutation is having an A-T base pair replaced by a G-C pair or a T-A pair. *Insertion mutations* happen when extra base pairs are included in an existing DNA sequence. *Deletion mutations* happen when base pairs in an existing DNA molecule get removed from it. Figure L15.3 shows each type of mutation using the same original DNA sequence. For all of these mutations, the location in the order of bases in DNA is important. Some mutations will not change the amino acid coded for by a specific sequence, but others will.

FIGURE L15.3

Types of DNA-level mutations



Your Task

Examine the effects of different types of mutations in a DNA sequence on the resulting RNA and protein molecules. Since these molecules are not easy to work with in a classroom, you will be using a computer simulation to investigate the effect of mutations.

The guiding question of this investigation is, **How do different types of mutations in genes affect the function of an organism?**

Materials

You will use an online simulation called *Mutations* to conduct your investigation. You can find the simulation by going to the following website: *http://concord.org/stem-resources/mutations*.

Safety Precautions

Follow all normal lab safety rules.

Investigation Proposal Required? ☐ Yes ☐ No

Getting Started

To answer the guiding question, you will use a simulation to observe the impact of different mutations on the resulting protein. To accomplish this task, you must first determine what type of data you need to collect, how you will collect it, and how you will analyze it. To determine *what type of data you will need to collect*, think about the following questions:

- What type of data can you collect from the simulation?
- What types of mutations can you make using the simulation?

- What type of measurements or observations will you need to record during your investigation?

To determine *how you will collect your data*, think about the following questions:

- What will serve as a control (or comparison) condition?
- How will you make sure that your data are of high quality (i.e., how will you reduce error)?
- How will you keep track of the data you collect and how will you organize the data?

To determine *how you will analyze your data*, think about the following questions:

- What type of calculations will you need to make?
- What type of graph could you create to help make sense of your data?

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

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

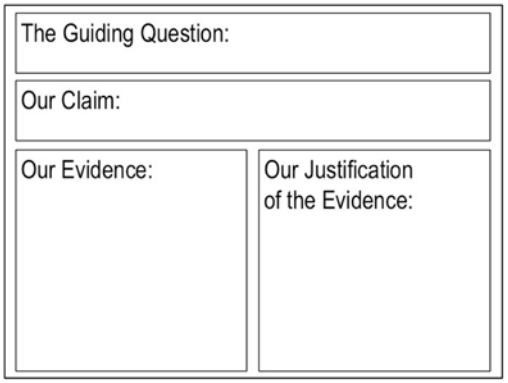
- how different actions in living things happen on different scales of size and time,
- how organisms' structures are related to the functions they perform,
- the different roles theories and laws play in science, and
- how imagination and creativity are necessary for developing scientific knowledge.

Initial Argument

Once your group has finished collecting and analyzing your data, you will need to develop an initial argument. Your argument must include a claim, evidence to support your claim, and a justification of the evidence. The claim is your group's answer to the guiding question. The evidence is an analysis and interpretation of your data. Finally, the justification of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L15.4.

FIGURE L15.4

Argument presentation on a whiteboard



Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations one at a time to listen to and critique the arguments developed by their classmates. This is similar to how scientists present their arguments to other scientists at conferences. If you are responsible for critiquing your classmates' arguments, your goal is to look for mistakes so these mistakes can be fixed and they can make their argument better. The argumentation session is also a good time to think about ways you can make your initial argument better. Scientists must share and critique arguments like this to develop new ideas.

To critique an argument, you might need more information than what is included on the whiteboard. You will therefore need to ask the presenter lots of questions. Here are some good questions to ask:

- What did your group do to collect the data? Why do you think that way is the best way to do it?
- What did your group do to analyze the data? Why did your group decide to analyze it that way?
- What other ways of analyzing and interpreting the data did your group talk about?
- Why did your group decide to present your evidence in that way?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those other ideas?
- How sure are you that your group's claim is accurate? What could you do to be more certain?

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. The 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!