LESSON 2: INTRODUCTION TO GENES AND DECODING DNA

Lesson Guide
Page 14-21 of DNA /RNA Booklet 1

LEARNING GOALS

The student will be able to…

1. Describe and build a DNA codon as a sequence of 3 nucleotides, indicating a specific amino acid.
2. Describe why DNA is an important molecule. DNA stores the codes/instructions for making proteins.
3. Build and decode a gene, a sequence of DNA nucleotides that specifies the order of the amino acids in a protein chain.
   - » Novice students can utilize a DNA Codon Chart in the booklet (P21) to decode the DNA codons. This chart needs no instruction.
   - » Advanced students can utilize the RNA Codon Charts (p26 or P27). (RNA Charts require instruction. Not all students find them easy to interpret.)
4. Build and decode a gene where one nucleotide has been changed and a different protein will be produced.
5. Build and decode a gene where one nucleotide has been changed but in this case a different protein will not be produced. It remains the same. Mistakes in the DNA do not always create a new protein.
6. Demonstrate a short chromosome by adding two or more genes end to end.
7. Describe a genome as all the genes needed to produce a living organism.

VOCABULARY

NOTES ABOUT VOCABULARY

Vocabulary on P17 can be introductory for students in the middle school grades. It is not included on most state's middle school science standards.

Use the terms **strand** and **chain** in a consistent manner.

- » Use **strand** only for nucleotides e.g. DNA or RNA **strands**.
- » Use **chains** only for proteins e.g. protein chains.

SET UP FOR LESSON 2

1. **Create a DNA molecule** from your teacher DNA kit (#14) beforehand. Make the model at least 12 base pairs long for a good twist. You will need this model to review Lesson 1 at the beginning of class.
2. **Optimize student work space. Plan ahead on seating two students to a team and have them use the same kit # each day if possible. Remember the following:**
   - » **Seat the partners adjacent to each other.** Students share materials. Both students need to read instructions in the booklet and have access to the kit. Do not let partners sit across the table.
   - » **Have students clear the table of books and personal items before building!** Today they will need space to work with a DNA/RNA kit, a booklet, and a gene strip 36 inches long.
3. **Organize the classroom materials.**
   - » Put a Lost & Found box in the same place for easy exchange of extra or missing nucleotides.
   - » Keep a space in the room where the kit materials are accessible. Today each team for Lesson 2 will require:
     - **1 DNA/RNA kit** (The Kit Care Record remains folded up inside.)
     - **1 DNA/RNA Booklet #1**
     - **1 Gene Strip** per team. Make sure one of each kind of gene is represented in the room: alpha, alpha mutated, beta, beta mutated.
     - **1 Codon Card pack**. Always have the students shuffle the 12 cards before returning them to the bag. One pack has:
     - 6 Yellow: Cys, Met, Pro,Val, Leu, Ala
     - 3 Green: Ser, Gln, Thr
     - 1 Blue: Arg
     - 1 Red: Glu
     - 1 Stop

BEST PRACTICES # 1-4

Remember hands-on teaching is different. It requires a lot more back and forth. There will be periods of time for student hands-on work and times for listening to the teacher. Please Review these Best Practices #1-4 before each lesson.

#1

Direct the students' attention.

- » Students should open the kits only when directed and not beforehand.
- » For lively or large classes, it is helpful to use a hand-bell or other signal so teams will know to when to stop working. (Try it!?) Be sure to wait for silence. Do not let students continue to work.
- » To focus student listening, cue the students for new directions. Say, for example: "Please listen for new directions now. Look at page 7. Each person on your team will build this DNA molecule."

#2

Keep the class together. Compliment good teamwork.

- » Tell students to stop when they finish each activity. Tell quicker teams to double check their work.

#3

Circulate throughout the room to observe and correct building in progress.

- » Students often forget to make DNA strands anti-parallel. Catch this as soon as possible because it takes a lot of valuable time to correct. Each nucleotide must be separated and turned around.
- » Say repeatedly, "Remember to use the pinch technique! Release those hydrogen bonds!"

#4

Check for misconceptions. Ask questions. Also encourage students to ask you questions.

- » Use the yellow-highlighted questions in the booklet during the lesson.
- » Summarize at the end of the lesson. You can select appropriate questions from "Check your Understanding" at the back of the booklet.

LESSON GUIDE: DNA /RNA BOOKLET 1

45 minutes is the minimum time, 55-60 min better

1. REVIEW OF PREVIOUS LESSON

Minimum time: 3 minutes | Total class time spent: 03

PURPOSE

Use the DNA model to focus the students' attention for a review exercise and to refresh students' memory on the vocabulary and content of Lesson 1. This review helps students who were absent to catch up and gives other students practice in recalling the recently acquired knowledge.

BOOKLET PAGES

N/A
Review

DESCRIPTION

☞ **Hold up the model of DNA to focus students' attention and to help students recall the structural information. Review Lesson 1 vocabulary to be ready to move on.**

In this review, either 1. Create an atmosphere of a snappy or rapid fire question /answer activity over the following vocabulary and content; or 2. Have students raise their hands and provide some 'wait time' before choosing a student to answer. The latter method encourages more students to think about the questions. Letting students immediately call out denies some students the opportunity to reflect and participate.

Q: Why is this called a double helix?

Q: What are parts of a nucleotide?

Q: What are base pairing rules (A-T) and (C-G)

Optional: How can you remember this? (Example: A &T are straight-sided letters. C & G are curvy letters.)

Q: How should we open up the DNA strands? What is the name of the weak bond?

Q: What is the name of the process where DNA makes a complete copy of itself?

A: Replication

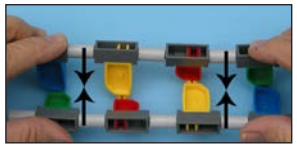
Q: When does the cell need to have double its normal amount of DNA?

A: Before the cell divides into two cells. (..before mitosis because each cell needs its own DNA)

MEDIA

N/A
Introduction

Teacher holding up double helix



Pinch technique

2. KIT CHECK

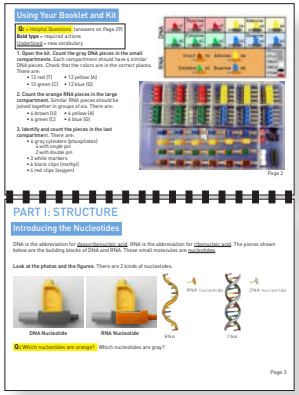
Minimum time 7 min | *Total class time spent: 12 minutes*

PURPOSE

Teams verify kit contents. The kit check is competed prior to the start to ensure that the lesson won't be interrupted by a missing piece. Teams will be checking the previous team's use, not their own.

BOOKLET PAGES

2-3


Using Your Booklet and Kit

PART I: STRUCTURE

Introducing the Nucleotides

DIRECTIONS

☞ **Hand out materials or have one student from the team pick up their own kit # and booklet. Remind students to keep both top and bottom pages visible.**

Have students open kits.

» Student teams now check kit contents using the diagram on p 2 or the kit's inner label.

» Teams complete "Team Kit Care Record".

» Mention the location of the Lost & Found Box for any extra piece found in the kits.

MEDIA

PDF
Team Kit Care Record

3. CELL DIAGRAM

Minimum time 3 min | Total class time spent: 13 minutes

PURPOSE

Help students recognize size relationships of cell to molecules.

Connect the DNA model with prior knowledge about the nucleus and chromosomes. Add the new vocabulary word gene.

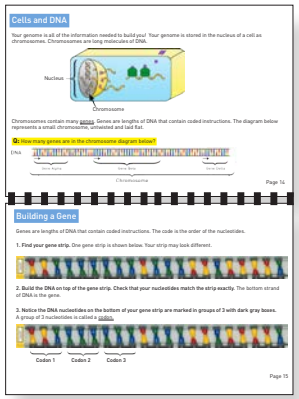
Reminders

» Keep this part of the lesson short. Students will need time to work with the model.

» The full new list of DNA vocabulary will be summarized on p 16.

» DNA vocabulary will also be reviewed for the student with a catchy stop action video.

PAGES: 14-15



DIRECTIONS

Begin the lesson. Ask students to turn to P14.

» Note: Don't get into details of protein synthesis steps yet. These steps are provided later on 17.

» Use the diagram (P14) to put the DNA models into context inside the cell.

» The diagram shows that cells are made up of molecules and that molecules are smaller.

» The point here is to help students recognize that chromosomes and genes are located inside the nucleus.

Q: To create focus, ask, "What parts of the cell are labeled in the diagram?"

A: Nucleus, chromosome.

Optional: See if students can interpret the diagram. Mention "DNA stays locked up in the nucleus." Ask, "What about the mRNA? (Review the distinction between nucleotides if needed: DNA = gray, RNA = orange in the diagram.) The orange mRNA is leaving the nucleus shown through a pore in the diagram.

Now look at the diagram of a chromosome below the yellow highlighted question and ask.

Q: What is a gene?"

A: A gene is length of DNA containing coded instructions.

You may want to add that a chromosome contains many genes joined together, end to end. In reality, one chromosome can contain 100s to 1,000s of genes. The diagram has been simplified greatly and only shows 3 genes. You can explain that the name "alpha," "beta," and "delta" are not specific and are often used in biology as general names.

Next the students will build a gene.

MEDIA

Demonstration Video
How to do gene strips
Video to come

4. BUILDING A GENE AND SUMMARIZING DNA VOCABULARY

Minimum time 10 min | Total class time spent: 23 minutes

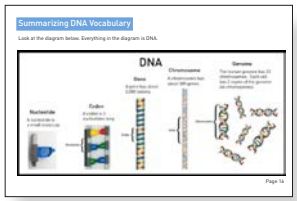
PURPOSE

Students create hands-on models to help define genes as messages in the DNA.

This activity helps to set the stage to teach about DNA function. Students will discover a key concept. Changes in the nucleotide order can affect the proteins that the cell will produce.

BOOKLET PAGES

15-16



DIRECTIONS

Announce to students,"We are moving on to P 15." Explain what is next.

"You can see from the booklet that each team will build a gene from the DNA nucleotides. Remember that genes are coded messages. The code is formed by the order of the nucleotides."

"To make the coding interesting, different teams are getting different genes to build. Your team will need to build the gene very carefully. That is why I am handing out these gene strips."

Cue students about building: "Listen to these specific building instructions: To make the gene correctly, you should place each nucleotide on top of its picture. Double check your work, too! Remember to be careful with the arrows. Any questions? You may begin."

☞ **Hand out gene strips.** Make sure to hand out least 1 alpha, 1 alpha mutated, 1 beta, and 1 beta mutated. You will need all 4 strips of genes, built to teach the class in the next activity.

As students are finishing up, have them quickly double check by comparing their work with the gene strips. Call attention to the black bars on the bottom of the gene strip.

Q: How many nucleotides are there in each group?

A: (3) A group of 3 nucleotides is called codon. The codons are important. They instruct the cell how to make a protein.

Q: How many codons do you have in your gene?

A: All the gene strips are 7 codons long.

Summarize the DNA vocabulary by asking questions about the diagram on P16. Begin with the nucleotide on the left. Use the video as a review activity for students.

» The genome includes all DNA instructions needed to create an organism. Specifically, the genome includes one chromosome from each pair of chromosomes since the second is redundant.

MEDIA

Teacher Training Video
Building different genes using the gene strips.
Video to come

5. THE IMPORTANCE OF DNA

Minimum time 4 min | *Total class time spent: 27 minutes*

PURPOSE

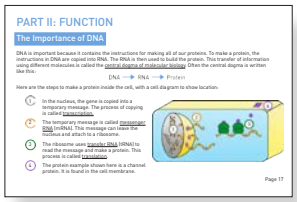
Emphasize that DNA is important because DNA carries the information for building proteins.

The purpose of this page is to point out that there are many steps to making a protein from the DNA. For example, the codes must be copied into RNA and must leave the nucleus.

Make it clear that the class is not going to do all these steps right now. Instead the task will be to learn how to read the DNA coding system.

BOOKLET PAGES

17


PART II: FUNCTION

The Importance of DNA

DNA is important because it contains the instructions for making all of our proteins. To make a protein, the instructions in DNA are copied into RNA. The RNA is then used to build the protein. This transfer of information using different molecules is called the central dogma of molecular biology. When the central dogma is written like this:

DNA → RNA → Protein

Here are the steps to make a protein inside the cell, with a cell diagram to show location.

1. In the nucleus, the gene is copied into a temporary message. The process of copying is called transcription.
2. The temporary message is called messenger RNA (mRNA). This message can leave the nucleus and attach to a ribosome.
3. The ribosome uses transfer RNA (tRNA) to read the message and make a protein. This process is called translation.
4. The protein example shown here is a channel protein. It is found in the cell membrane.

Page 17

DIRECTIONS

This should be an overview. Introduce the idea that information is transferred from DNA to RNA to protein. These steps are referred to as the central dogma of molecular biology.

» Read through the steps of protein synthesis and review where they take place in the cell.

» Tell students they will model this process later!

Right now they will learn how to decode the instructions in their gene for making a protein.

MEDIA

Demonstration Video #4
Building the double helix
Building a gene on top of the strip and decoding.
Video to come

6. DECODING A GENE

Minimum time 7 min | *Total class time spent: 34 minutes*

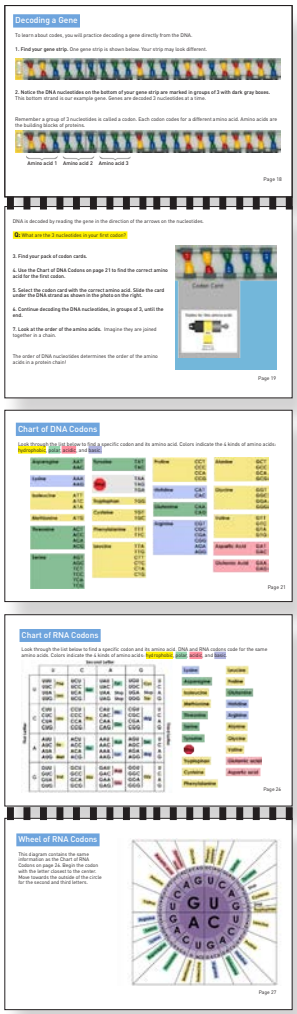
PURPOSE

Teach how to decode a gene from the DNA codons and visualize the protein chain the gene can create.

Learning about the triplet code concept prior to translation on the ribosome is advantageous. It reduces translation complexity. However be sure no student takes this activity literally. (Amino acids are not assembled on the DNA strand!) Also help the students appreciate that they are reading nature's amazing code. This code is universally used by all living things like plants, animals, and bacteria.

BOOKLET PAGES

18-19, 21, 26-27



DIRECTIONS

☞ Hand out the Codon Card packs, one to each team.

Lead the class, keeping them all together with you. Decode the first DNA codon together as a class so that every team will have experienced success on how to decode and can then do the rest on their own.

Q: What do you have for the first three nucleotides in your gene?

A: (ATG)

Q: Does everyone have a first codon that reads ATG?

A: Yes. All gene strips have ATG as the first codon. ATG is the start codon for making proteins.

"**OK. Let's look up the codon and see what it means on P21**.

Q: Can you find ATG?

Q: What is the name of the amino acid that goes with ATG?

A: Scan down the 3 letter codes and find Methionine. It is yellow.

» For novice DNA students, use the DNA reference chart for amino acids P21.

» There is a huge advantage in using this DNA chart although it may be unfamiliar to you. A teacher does not have to interrupt the flow of learning to teach students how to interpret this codon chart. The students just search with their eyes. No training necessary! (Use it, it works!)

» For students already familiar with RNA charts, instruct them to use references on p 26 (or 27) Chart of RNA Codons. Students will need to know to substitute U for T and follow the different charts' look-up procedures.

"**So we now know the 'ATG' codon in DNA always means place a Methionine molecule here in the protein chain. Let's show that with our codon cards.**"

MEDIA

Teacher Training Video #3
Decoding a gene
Video to come

Demonstration Video
Decoding a gne
https://www.youtube.com/watch?v=PwivW9iVDEU

6. DECODING A GENE (CONT'D)

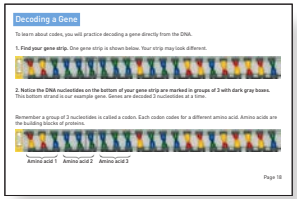
Minimum time 7 min | Total class time spent: 34 minutes

PURPOSE

See previous page

BOOKLET PAGES

19-


Decoding a Gene

To learn about codes, you will practice decoding a gene directly from the DNA.

1. **Find your gene strip.** One gene strip is shown below. Your strip may look different.

2. **Notice the DNA nucleotides on the bottom of your gene strip are marked in groups of 3 with dark gray boxes.** This bottom strand is our example gene. Genes are decoded 3 nucleotides at a time.

Remember a group of 3 nucleotides is called a codon. Each codon codes for a different amino acid. Amino acids are the building blocks of proteins.

Amino acid 1 Amino acid 2 Amino acid 3

Page 18

DIRECTIONS CONT'D

☞ **Find the Codon Card in your pack with the picture of an amino acid called Methionine or Met. Slide the card under the gene strip. Position it exactly under the first codon, the black bar with the nucleotides 1-2-3. "**

☞ **Instructors should show the Met Codon Card. Demonstrate sliding the Codon Card under the gene strip at the first codon position. Make sure to mention that the amino acid's picture should remain visible. This is because when all cards are in position , the cards will be used will show the order of the amino acids in the protein.**

» Be sure to explain the Codon Cards use as shown the training videos. Students should understand they are translating a code and the cards only show the meaning of the code. Be clear, the DNA does not do this. There is a long process for making proteins as shown on P17 in the booklet that they will learn later.

» Tell students to continue and decode the rest of the gene.

» Circulate around the room to help teams place the cards correctly. When all the teams are ready, then the instructor will guide the students in interpreting the results.

MEDIA

Teacher Training Video #3
Decoding a gene
Video to come

Demonstration Video
Decoding a gne
https://www.youtube.com/watch?v=PwivW9iVDEU

7. GENES FOR DIFFERENT PROTEINS

Minimum time 5 min | Total class time spent: 39 minutes

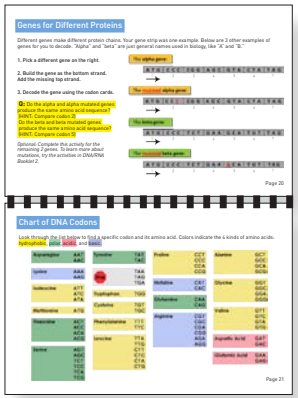
PURPOSE

NOTICE! Ignore the instructions on P20 that call for building 3 additional genes! In the classroom setting, all 4 genes have been built by the student teams. You will call on different teams to illustrate the lesson. (P20 contains information needed for the independent learner who must complete all 4 genes to learn this content.)

» Help students to interpret this activity with the normal and mutated genes they have decoded.

BOOKLET PAGES

20-21



DIRECTIONS

NOTICE! All four genes have already been built in the classroom. Therefore **do not** have teams build the different genes on P20 as directed. There is no need for this! All four of the genes strips have been completed and decoded in the classroom.

Now is the time to interpret the results from all four genes by calling on different teams. First clarify the following:

"Under the gene (the bottom DNA strand) you can see the amino acids, arranged in order. It takes a very complex process inside the cell to assemble and link amino acids together

» Emphasize: Today we are not going to show you all the steps to assemble the protein! Today we are just looking at how the DNA codes for making the proteins.

» "Let's compare some genes. The name of your gene is in a box on the left end of the gene strip. First let's look for differences between beta and the beta mutated gene. Everyone can look at the two beta genes on p 20."

Q. What is the difference between these two genes?

A. Codon 5

Q. Which nucleotide ... in what number codon is different?

A. In codon 5 the beta gene has a G. In codon 5 the beta mutated gene has an A.

Hint for students: Look for the box around a nucleotide on the gene strip.

MEDIA

Independent Learners please watch this teacher training video for summary.

Teacher Training Video #4
How mutations affect proteins
Video to come

7. GENES FOR DIFFERENT PROTEINS (CONT'D)

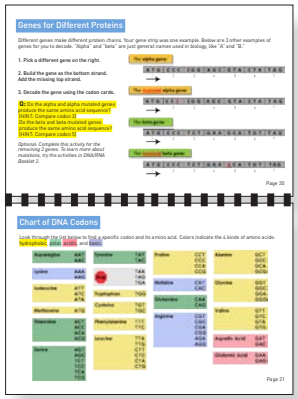
Minimum time 5 min | *Total class time spent: 39 minutes*

PURPOSE

Se previous page

BOOKLET PAGES

20-21


Genes for Different Proteins

Different genes make different protein chains. Your gene strip was one example. Below are 3 other examples of genes for you to decode. "Alpha" and "beta" are just general names used in biology, like "A" and "B."

1. Pick a different gene on the right.

2. Build the gene as the bottom strand. Add the missing top strand.

3. Decode the gene using the codon cards.

Optional: Complete this activity for the remaining 2 genes. To learn more about mutations, try the activities in *DNA/RNA Booklet 2*.

Page 20

Chart of DNA Codons

Look through the list below to find a specific codon and its amino acid. Colors indicate the 4 kinds of amino acids: hydrophobic, polar, acidic, and basic.

Page 21

DIRECTIONS CONT'D

» Ask the team(s) with beta gene(s) to raise their hand and give their amino acid sequence. Then compare the amino acid sequence with mutated beta – identifying that the mutation in codon 5 changes the amino acid in the sequence (Ala becomes Thr). Conclude that one nucleotide in DNA can change a protein into completely different protein!

Next, continue in the same way, comparing amino acid sequences for alpha and mutated alpha – Identify the mutated nucleotide first. (Previously a C, mutated now to T) in codon 2.

» Then ask for the amino acid sequence. Students may be surprised when both amino acid sequences are the same! After establishing there isn't a mistake, ask the students to figure out why this mutation in the DNA did NOT change the amino acid sequence.

» Amino acids can be coded for in several different ways. Example: CCC and CCT both code for Proline. Another way of saying this is: Some amino acids have more than one codon. Ask the students to find another example. Look on P21. (Numerous answers… the most extreme include Serine, Leucine and Arginine with each having 6 different codons. Methionine has the least number. Only 1 codon.)

Summarize:

» The order of the DNA nucleotides predicts the order of the amino acids in the protein chain. (Amino acids are the building blocks of proteins). So now we know the function of the DNA, to give the order of the amino acids in the protein.

» A DNA change is called a mutation. A DNA nucleotide sequence change can create a different protein. A mutation can have a bad effect, or good effect, or no effect at all on an organism.

MEDIA

Teacher Training Video #4
How mutations affect proteins
Video to come

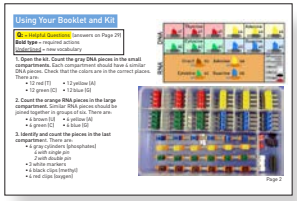
8. ADDITIONAL CONNECTIONS

Minimum time 3min | Total class time spent: 42 minutes

PURPOSE	BOOKLET PAGES	DIRECTIONS	MEDIA
Connect Mendel's genes and traits with modern biology's molecular details about genes and proteins. It's important to connect these new molecular concepts with students' prior knowledge about chromosomes and inheritance. Observable traits are actually caused by proteins.	N/A	**Transition by saying, "Let's connect this information to what you know about genes and traits."** » Ask students to name examples of observable traits? » Emphasize that proteins are responsible for traits – for example, eye color is mostly created by the amount of melanin deposited by a protein. Here's the key concept. Genes produce observable and non-observable traits through protein production. This will help students connect Mendel's genes and traits with modern molecular biology.	N/A

9. CLEAN UP

Minimum time 3 min | Total class time spent: 45 minutes

PURPOSE	BOOKLET PAGES	DIRECTIONS	MEDIA
Clean up/kit responsibility	*2*  	**Time for students put away all materials**. » Ask students to shuffle the order of the Codon Cards and return the cards to the bag. » Remind students to pinch open their DNA before taking it apart; bring extra pieces to the Lost & Found Box; and hunt in the Lost & Found for any pieces that they may be missing. ☞ **Collect all kits, booklets, gene strips, and Codon Cards.**	N/A

10. ADDITIONAL SUMMARY / REVIEW OR HOMEWORK OPTION

Use questions 6-8 on page 28 to check understanding.