Teaching DNA, Proteins, and Protein Synthesis with the MIT Edgerton Center Models and Curriculum

PART 2: DNA/RNA
Introduction to DNA Activity

Teacher will clarify DNA features using the model.

Help students take note of these features. Point out the features on the DNA model

• Why is DNA referred to as the “Double Helix”?
• What is the sugar phosphate backbone?
• How are the two strands connected?
• What are the 3 parts in a DNA nucleotide?
The model helps to show....

1. The word “helix” means a spiral or coiled shape.

2. DNA is called a “double helix” because 2 DNA strands spiral around each other.

3. Each strand has a sugar-phosphate backbone.

4. Bases are joined in pairs to connect the 2 strands.

5. Subunits called **nucleotides** are joined end to end to make the DNA strands. A nucleotide includes a base, a sugar, and a phosphate.
Teacher Demo of Pinching Technique

Remember to pinch and pull up on the 2 DNA strands to separate.

Nucleotide Intro Video will play next....
Play Video: “Introduction to Nucleotides”

https://www.youtube.com/watch?v=lvWucdTQJbc

This video can be shown before or after the lesson. Video is ~ 1 minute long
Please open DNA/RNA Booklet 1

DNA/RNA
Booklet 1:
Introduction to Structure and Function

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Graphics by Amanda Mayer.
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edgerton.mit.edu/dna-proteins-sets
Explain Booklet Instructions. Demonstrate how to keep 2 pages open at a time.

Using Your Booklet and Kit

**Q: = Helpful Questions**  (answers on Page 29)

**Bold type = required actions**

**Underlined = new vocabulary**

1. **Open the kit. Count the gray DNA pieces in the small compartments.** Each compartment should have 4 similar DNA pieces. Check that the colors are in the correct places. There are:
   - 12 red (T)
   - 12 yellow (A)
   - 12 green (C)
   - 12 blue (G)

2. **Count the orange RNA pieces in the large compartment.** Similar RNA pieces should be joined together in groups of six. There are:
   - 6 brown (U)
   - 6 yellow (A)
   - 6 green (C)
   - 6 blue (G)

3. **Identify and count the pieces in the last compartment.** There are:
   - 6 gray cylinders (phosphates)
     - 4 with single pin
     - 2 with double pin
   - 3 white markers
   - 6 black clips (methyl)
   - 4 red clips (oxygen)
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RNA nucleotides are orange. For now use only DNA nucleotides – no orange!

PART I: STRUCTURE

Introducing the Nucleotides

DNA is the abbreviation for deoxyribonucleic acid. RNA is the abbreviation for ribonucleic acid. The pieces shown below are the building blocks of DNA and RNA. These small molecules are nucleotides.

Look at the photos and the figures. There are 2 kinds of nucleotides.

Q: Which nucleotides are orange? Which nucleotides are gray?
Remember on this page to instruct students to...

- Pick out any DNA nucleotide from the kit (no orange!)
- Hold it up by the phosphate group, then by the sugar, then by the base.
- Recognize what makes one nucleotide different from another: the base.
- Explain why the bases are different sizes.

Have all students build a 4 nucleotide DNA ladder - then show common results.
Students discover the famous base pairing rule: A-T and C-G and realize that DNA is antiparallel (note arrows!)

7. Look at the top photo. This is one way to build a DNA ladder from 4 nucleotides. However, this DNA structure is not correct. To make it correct, you must always pair a big nucleotide with a small nucleotide. This will keep the sides parallel.

8. Look at the arrows on your DNA. In nature, the sides of the DNA ladder run in opposite directions. The arrows on one side should point in one direction and the arrows on the other side should point in the opposite direction.

9. Fix your DNA molecule so it looks like the bottom photo:
   - Pair big nucleotides with small nucleotides.
   - The sides should be parallel.
   - The arrows should point in opposite directions.

Q: Which bases always pair together in DNA?

You have just discovered the famous base-pairing rule!

Building Double Helix Video will play next....
Play Video: “Building a DNA Double Helix”

https://www.youtube.com/watch?v=SFzKCbDeGjs
Now that you know the base pairing rules - build the double helix! Watch for directionality with the arrows.

Building a Double Helix

1. Build the DNA exactly as shown in the photo below. Notice the direction of the arrows.

2. Finish building the top DNA strand using these rules:
   - Bases that pair together are A-T and C-G.
   - Top and bottom DNA strands are parallel.
   - DNA strands run in opposite directions.
3. Check your DNA molecule. It should look like the photo below.

4. Twist the DNA to make a double helix.

DNA is called a double helix because the two strands of DNA twist around each other in a spiral shape.
Practice pinching the DNA strands open several times. This demonstrates hydrogen bonding between the bases.

5. Unsnap the DNA by pinching and pulling up on the sides of the DNA ladder as shown in the photo on the right. The two DNA strands will pop apart easily.

6. Snap your DNA strands back together again.

The ball and socket joints in the model represent hydrogen bonds. Hydrogen bonds hold DNA base pairs together.

Hydrogen bonds can be easily created and easily broken. This is useful because the two DNA strands must separate to create new DNA.

7. Practice opening and closing the DNA strands a few more times. Remember to unsnap the DNA by pinching and pulling up on the sides of the DNA ladder. Always open your DNA using this technique.

Replication Video will play next....
Play Video: “Replication”

https://www.youtube.com/watch?v=jurXCq7vk14
Do basic replication first for understanding. Add white markers to your DNA before replicating.

**Replicating DNA**

The process of copying a DNA molecule is called **DNA replication**. Let’s try it!

1. **Use the DNA from the previous activity. Orient your DNA as shown in the photo.** The bottom strand should have the arrows pointing to the right. The top strand should have the arrows pointing to the left.

2. **Add a white marker to both strands as shown in the photo.** Now we can follow what happens to the original strands.
Pinch apart the left side of the DNA molecule.

Begin the process of DNA replication!

3. Unsnap your DNA strands from one end, as shown in the photo. Remember to pinch and pull up to pop apart the DNA strands.
4. Add the correct nucleotides to make new strands. Check the arrows on the new strands. They should match the photo below.
5. Continue un-snapping the DNA strands and adding nucleotides until you have two complete DNA molecules.

Congratulations! DNA replication is complete.

6. Look carefully at your two molecules of DNA. Notice the white markers on the molecules. Remember you marked the original DNA strands before replication began.

Q: Are the two DNA molecules identical? Was the copying perfect? Where did the original strands end up?

This process of copying DNA is called semiconservative replication. One strand is conserved (or kept) in the copying process. There is one original strand in each new molecule.
Review of DNA Structure

1. DNA is made of nucleotide subunits.
2. Each nucleotide has 3 parts: phosphate group, sugar, and base.
3. The phosphate groups and sugars connect to make the backbone.
4. There are 4 bases: A, T, G, C. The A and G bases are larger.
5. The bases are joined together by hydrogen bonds to connect the 2 strands. A pairs with T, G pairs with C.
6. DNA is antiparallel - the 2 DNA strands run in opposite directions.
7. DNA replication is semiconservative. One original strand ends up in each new molecule.
End of DNA/RNA Booklet 1
Lesson 1 PPT