DNA: I'm All Split Up

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GRADE LEVELS:
7^{th} – 10^{th} grade

TIME ALLOTMENT:
3 – 45 minute blocks

OVERVIEW: Students will discover that Watson and Crick discovered the DNA's double-helix structure. Their "twisted ladder" model of a DNA molecule provided the basis for further research into how DNA controls the formation of proteins, the mechanism of heredity. The students will identify two general functions of DNA in a cell: 1) to replicate itself for the creation of new cells and 2) to direct the synthesis of proteins.

SUBJECT MATTER:
Science

LEARNING OBJECTIVES:

Students will be able to:

- Relate genetic material to the formation of cell proteins.
- Use the term DNA to describe the genetic material in a cell.
- See how each single strand of the DNA molecule acts as a template for making an exact copy of its opposite single strand.
- Use the term replication to describe the process by which DNA molecules are copied.
- Use the term transcription to describe the process they are modeling.
- Define the term *codon* as the fundamental unit of the genetic code.
- Discover that three consecutive bases constitute one unit of the code.
- Differentiate between mRNA and DNA.

STANDARDS:

State Standards:
The objectives listed may be used in part to address the Virginia Standards of Learning at http://www.pen.k12.va.us

- The students will investigate and understand that organisms reproduce and transmit genetic information to new generations. VA SOL LS 13
- The student will investigate the role of DNA. VA SOL LS 13
- The student will investigate genetic engineering. VA SOL LS 13

- The student will investigate and understand common mechanisms of inheritance and protein synthesis. VA SOL BIO 6
- The student will investigate the events involved in the construction of proteins. VA SOL BIO 6

MEDIA COMPONENTS:

Video:
Cell Biology (Program #6) "The Genetic Code: Transcription, Protein Synthesis, Mutation."

Web Site:
http://www.dnai.org/index.htm Dolan DNA Learning Center – Genes in Education. DNA Interactive.
At this site students will view a portion of an interview with James Watson, the partner of Francis Crick, who first described the DNA strand in a double helix. Students will also watch, in real time, the process of transcription and replication of DNA and RNA respectively. Students will transcribe a segment of DNA.

MATERIALS:

- Television
- VCR
- Video: *Cell Biology: Program 6*
- Computer
- 1 set of playing cards for each group of students. (2 or 4 in a group)
- 1 small box of paper clips
- Two worksheets for every student (This will be also be used as a study guide for a quiz.)

PREPARATION FOR TEACHERS:

1. Prior to teaching the unit, bookmark the Web sites.
2. Copy the script from the virtual movies and paste them into Word. The teacher may then guide the students as they view the movie and read the script on the web site.
3. Cue your videotape for the correct starting point.
3. Photocopy all student worksheets for distribution as needed during the lesson.
4. Make sure you go through the instructions from the student materials worksheets to make certain that you understand and are familiar with the lesson format and what the students need to do or understand for the lesson.
5. When using media, always provide the students with a **Focus for Media Interaction**, which is a specific task to complete during or after viewing video segments, web sites, or other media material.
6. Prior to this lesson, students should know:
   - Cell organelles and their roles in the cell
   - Define DNA and RNA

- The basic pairing rule of DNA (In DNA, there are two "long bases, called adenine (A) and guanine (G), and two "short" bases, called thymine (T) and cytosine (C). The sides of the ladder are made from sugars and phosphates, which form the "backbone" of the DNA molecule.)
- Have a working definition of *protein synthesis*.
- Define *nucleotide* as a single base attached to a sugar-phosphate unit.
- The teacher should copy the script from the virtual movies and paste them into Word and print. The teacher may then prompt the students with questions as they view the movie and read the script on the web site.

INTRODUCTORY ACTIVITY: SETTING THE STAGE

DNA Card Trick

This game will allow students to discover that only four chemicals can create all the life forms on the Earth.

1. Pass out a deck of 52 playing cards to each group of students (2 or 4 in a group).
2. Tell students each suit (diamonds, spades, hearts, clubs) in the deck of cards is a DNA chemical.
3. Shuffle the deck and deal a row of four cards.
4. This row stands for the DNA code of a life form.
5. Deal another row below the first row.
6. **Ask:** "Does the order of the suits match the first row?" Answer: (It's not very likely.)
7. Deal more rows of four cards until one matches the first row or the deck runs out.
8. Tell the students, "Finding a match isn't easy, even with just four cards. The DNA of real life forms can be millions of chemicals long. The chance of two unrelated life forms having the same DNA code is very, very unlikely."

LEARNING ACTIVITIES:

Video:

1. **Provide a Focus for Media Interaction** by saying, "Students, I'm going to show you segments of a video that demonstrates *transcription, and replication* of DNA. You will be recording your answers on the 'Video Worksheet' that I am passing out. DNA has two general functions in a cell: 1) to replicate itself for the creation of new cells and 2) to direct the synthesis of proteins. (Have students record this information on the worksheet for question #1. The formation of mRNA is call *transcription*. Transcription of DNA to mRNA occurs in the nucleus, and the mRNA then takes the information to the ribosomes. The narrator mentions three proteins. In this first segment, identify the category of the first protein and what it is responsible for." **Start** *Cell Biology,* Series #6. The words "The Genetic Code: Transcription and Protein Synthesis" are shown on the screen. **Pause** after the narrator says "…internal framework" and a one-celled organism with beating cilia is seen. **Ask**, "What kind of protein was identified and what is it responsible for?" (Structural protein. It makes up

skin, hair and in all cells an internal framework. Have students record on worksheet, question #2.

2. **Focus for Media Interaction**: Say, "In this next segment, listen for the second type of protein and what it is responsible for." **Resume** the video and **Pause** when the narrator says "…for general movement of materials within cells" and a picture of an alga is seen (looks like a conveyor belt). **Ask**, "What was the second protein and what was is it responsible for?" (Motor protein. They are responsible for the bending action of flagella and cilia; they make up the threads that arrange chromosomes during mitosis. They are responsible for the general movement of materials within cells.) Have students record on worksheet, question #3.

3. **Focus for Media Interaction:** Say, "When this next clip is over, I want you to identify the third protein and it's responsibilities. **Resume** and **Pause** when you hear "…while others are builders." There will be a chain of multi-colored balls on the screen. **Ask**, "What is the third type of protein and what are its responsibilities?" (Enzymatic proteins. They control the chemical process necessary for life. Some, like digestive enzymes, break down molecules while others are builders.) Have students record on worksheet, question #4.

4. **Focus for Media Interaction**: Say, "In this next segment be prepared to explain what proteins are made of and how many kinds are there?" **Resume** and **Pause** just after the narrator says "…twenty kinds" and twenty kinds of amino acids are listed on the screen. **Ask**, "What is a protein made of and how many kinds are there?" (Proteins are made of amino acids. There are twenty amino acids.) Have students record on worksheet, question #5.

5. **Focus for Media Interaction**: (**Fast Forward** until you see the words, "DNA Transcription to mRNA" on the screen: 15-30 seconds). **Say**, "I want you to watch this next segment and be able to explain how the amino acid sequence for each of the thousands of proteins is written out on the DNA." **Start** and **Pause** when you hear "…building block in the protein." The words *amino acid* will appear under a diagram. **Ask**, "How is the amino acid sequence for each of the thousands of proteins written out on the DNA?" (The amino acid sequence for a protein is spelled out on one of the strands of DNA. The order of the bases forms a code. The code determines which protein will be made. Each set of three consecutive bases forms one symbol in the code. This instruction strand carries a sequence code for the order of the amino acid that will make up the protein. An amino acid is represented by a set of three nucleotides.) Have students record on worksheet, question #6.

6. **Focus for Media Interaction:** Say, "In this segment, I want you to identify how the DNA code is transcribed." **Resume** and P**ause** when you hear "…instruction strand

of DNA." For the second time, there will be a pairing of nucleotides on the screen. **Ask**, "How is the DNA code transcribed?" (When a special enzyme, RNA polymerase, encounters a coded start signal on the DNA, the doubled stranded DNA molecule is broken apart and the polymerase begins pairing RNA nucleotides to the instructional strand of DNA.) Have students record on worksheet, question #7.

7. **Focus for Media Interaction**: Say, "In this segment, be able to explain what rule does the transcription of DNA to mRNA follow and what is the exception to the rule?" **Resume** and **Pause** when the word *urasil* is on the screen and the narrator says "…closely related molecule urasil." **Ask,** What is the rule that transcription of DNA to mRNA follows and what is the exception to the rule?" (Base pairing rule of DNA. The molecule urasil is used instead of thymine.)
   ***Remind students**: "The bases pair up according to certain rules. First a short base can pair only with a long base and vice versa. The long bases are G and A. The short bases are T and C. The second rule governing the way in which bases pair in DNA is that not every long and short base can join together: A pairs only with T, and G pairs only with C. Because the bases always pair the same way, the new strands are identical to the parent strands and so the code is conserved from one generation of cell to the next." Have students record on worksheet, question #8.

8. **Focus for Media Interaction**: Say, "In this segment, tell me what the three letter code words are called that make up the sequence of the amino acids that appear in the proteins?" **Resume** and **Pause** when you see the word *codon* on the screen. **Ask**, "What is the word used for the three letter code that make up the sequence of the amino acids that appear in the proteins?" (mRNA code words are called codons.)
   ***Remind students:** "The order of the bases forms a code. The code determines which protein will be made. Each set of three consecutives bases forms one symbol in the genetic code. They carry the information for one amino acid. On an mRNA strand, three adjacent bases that carry this information are called a *codon*. Each codon carries the information for one amino acid in a protein." Have students record on worksheet, question #9.

9. **Focus for Media Interaction**: Say, "In this last segment, what stops the mRNA polymerase enzyme from transcribing and what happens next?" **Resume** and **Stop** the video when you see the words "Protein Synthesis" on the screen. **Ask**, "What stops the mRNA polymerase enzyme from transcribing and what happens next?" (It continues to transcribe until it reaches a coded stop signal on the DNA. The mRNA strand is then released.) Have students record on worksheet, question #10.

Web Site Instructions:

***Note**: The teacher should copy the script from the virtual movies and paste them into Word and print. The teacher may then prompt the students with questions as they view the movie and read the script on the web site.

The teacher will assist the students as they work their way through the Web Site.

- **Tell students**, "Today you are going to visit a website that will allow you the opportunity to look and listen to the one of the scientists who discovered the structure of DNA, James Watson. You will also witness the extraordinary process of transcription and replication of DNA."
- Have students follow the directions on the worksheet under the heading *Web Site Instructions.*

Note: (This activity can be done in a classroom with a single computer. The image can be played on the TV screen or projected with an LCD. Students can then take turns performing the steps.)

CULMINATING ACTIVITY

1. Every student must complete the worksheet as they watch the video and work through the web activity.
2. Rearrange the questions on the worksheet and give as a quiz.
3. Have students make a DNA model of some predetermined length and then make the corresponding mRNA to one of the strands.
4. Write a mRNA sequence that would form from each DNA sequence. (Make a sequence of DNA in combinations of threes using A, T, G, and C. Then generate the mRNA sequence using A, U, G, and C.)
5. Give each group the same playing cards used in the introductory activity.
   - Deal 10 cards in a column. The four suits stand for the four base chemicals of DNA: A, T, G, and C.
   - A always pairs with T. So pair up each heart (adenine) in your column with a diamond (thymine) from the deck. Pair up each diamond (thymine) with a heart (adenine) from the deck. G always pairs up with C. So pair up clubs (guanine) with spades (cytosine) and spades (cytosine) with clubs (guanine) from the deck.
   - A chemical "unzips," or breaks apart, the DNA double helix. Move apart your two columns of cards.
   - Each strand pairs up with new base chemicals. Again, pair up hearts with diamonds, and clubs with spades from the deck. You should have two double columns, each a copy of your original double column! (**Note**: Remind students that in the copy (mRNA) there is no thymine. Students should indicate uracil by placing a paper clip on the suite of diamonds as they find them in the deck.)

Cross-Curricular Activities

Art:
Students can build large, colorful DNA models that can be hung from the ceiling as mobiles.

Language Arts:
Students may read James Watson's book, *The Double Helix.*

Science and Health:
Have students research common genetic disorders. Students should find the specific cause, symptoms, and effects of each disorder. Are there any treatments available? What racial or ethnic groups are most often affected?

Science:
Have students extract DNA from strawberries, bananas, onions, etc. (Students may also extract their own DNA from cheek cells. Kits can be ordered from most supply companies for a nominal cost.)

Math:
Graph the information found in the Science and Health activity. What genetic disorders affect the most people, children, or ethnic group?

Community Connection:

- Have a Geneticist as a guest speaker.
- Ask a local politician to discuss the political views of genetic research. Should we clone humans? Is cloning OK if it's for organs and tissues for sick people? Will clones be discriminated against?
- Ask a farmer to talk about genetically engineered crops. Scientist can arm many crops with pest-killing genes. Is there a down side? Are we eating genetically engineered food?
- Have a law enforcement officer talk about how DNA from criminals is being used to create a data base. The military headquarters in Washington, D.C. has the DNA of every American soldier on file.

Quiz (Key)

1. 1) What are the two general functions of DNA in a cell?
   (a)_____
   (To replicate itself for the creation of new cells.)
   (b) _____
   (To direct the synthesis of proteins.)

2. What is the first step in transcription? _____
   (The first step in transcription is the "unzipping" of the DNA to form an open ladder.)

3. What makes up a codon? _____ (Three bases.)

4. In what ways is mRNA different from DNA?
   (a) _____
   (mRNA has only one strand, DNA has two)
   (b) _____
   (mRNA has the base U, DNA has T.)
   (c) _____
   (mRNA works in the cytoplasm, while DNA works in the nucleus.)

5. James Watson and Francis Crick identified the structure for DNA. The ladder structure of DNA winds around to form a cylindrical shaped called a _____. (double helix)

6. What are the two long bases? _____ and _____
   [Adenine (A) and Guanine (G)]

7. What are the two short bases? _____ and _____
   [Thymine (T) and Cytosine (C)]

8. Base A can pair only with _____. (Thymine)

9. Base C can pair only with _____. (Guanine)

10. What do the sides of the ladder consist of? _____
    (sugars-phosphate units)

11. What do the rungs or steps of the ladder consist of? _____(paired bases)

12. In a cell, each base is attached to a sugar-phosphate unit. This forms a _____. (Nucleotides)

13. Where in the cell does replication occur? _____ (In the nucleus)

Web Site Worksheet

1. Click on the bookmark your teacher instructs you to go to. (http.//www.drai.org/index.htm)
2. Click on Dolan DNA Learning Center – Genes in Education
3. Choose DNA Interative and click on *code*.
4. Click on Copying Code.
5. Choose Players.
6. Move mouse across the film strip and choose Watson and Crick.
7. Choose Central Dogma and then choose *Large.* Clip will start playing.
8. What note did Watson make on a little piece of paper and tape to his desk? _____ (He wrote that their must be some system by which the information is transferred from DNA to RNA and then RNA provides the information, it is the direct template for protein synthesis.)
9. Choose *What does RNA do* and view the clip.
10. What is RNA? _____ (It's a template.)
11. What happens to the DNA strand when separated? _____ (When the DNA stand is separated, instead of making another strand of DNA, it makes a strand of RNA.)
12. Choose *Putting it together.*
13. Choose *Transcription* and view the clip. *Answer the following questions by scrolling through text.*
14. What's DNA most extraordinary secret? _____ (A simple code is turned into flesh and blood.)
15. What is a gene? _____ (A length of DNA instructions)
16. What is the blue molecule racing down the DNA doing?

(a) _____ (Reading the gene)
(b) _____ (It unzips the double helix)
(c) _____ (It copies one of the DNA strands)

17. What is the yellow chain? _____ (It's a copy of the DNA. It's mRNA.)
18. What building blocks are used to make the RNA? _____, _____, _____, _____ (A, T, G, U)
19. What is this process called? _____ (Transcription)
20. Choose *Replication* and view the clip. Ans. questions by scrolling through text.
21. What effect does the helicase have on the DNA strand? _____ _____ (It spins the DNA and unwinds the double helix into two strands.)
22. What happens to each strand?

(1) _____ (One strand is copied continuously)
(2) _____ (The other strand must be copied backwards, one section at a time.)

23. What is the product of this process? _____ (Two new DNA molecules have been created.)

Quiz

Name: _____ Date: _____

1. What are the two general functions of DNA in a cell?
   (a)_____
   (b) _____
2. What is the first step in transcription? _____
3. What makes up a codon? _____
4. In what ways is mRNA different from DNA?
   (a) _____
   (b) _____
   (c) _____
5. James Watson and Francis Crick identified the structure for DNA. The ladder structure of DNA winds around to form a cylindrical shaped called a _____.
6. What are the two long bases? _____ and _____
7. What are the two short bases? _____ and _____
8. Base A can pair only with _____.
9. Base C can pair only with _____.
10. What do the sides of the ladder consist of? _____
11. What do the rungs or steps of the ladder consist of? _____
12. In a cell, each base is attached to a sugar-phosphate unit. This forms a _____.
13. Where in the cell does replication occur? _____

Web Site Worksheets

Name: _____ Date: _____

1. Click on the bookmark your teacher instructs you to go to. (http.//www.drai.org/index.htm)
2. Click on Dolan DNA Learning Center – Genes in Education
3. Choose DNA Interative and click on *code*.
4. Click on Copying Code
5. Choose Players.
6. Move mouse across the film strip, choose Watson and Crick.
7. Choose Central Dogma. Choose *Large* and clip will start. Ans. following questions.
8. What note did Watson make on a little piece of paper and tape to his desk? _____
9. Choose *What does RNA do* and view the clip.
10. What is RNA? _____
11. What happens to the DNA strand when separated? _____
12. Choose *Putting it together.*
13. Choose *Transcription* and view the clip. *Ans. questions by scrolling through the text.*
14. What's DNA most extraordinary secret? _____
15. What is a gene? _____
16. What is the blue molecule racing down the DNA doing?

(a) _____
(b)_____
(c) _____ _____

17. What is the yellow chain? _____
18. What building blocks are used to make the RNA? _____, _____, _____, _____
19. What is this process called? _____
20. Choose *Replication* and view the clip. Ans. questions by scrolling through text.
21. What effect does the helicase have on the DNA strand? _____ _____
22. What happens to each strand?

(1) _____
(2) _____

23. What is the product of this process? _____

Video Worksheet
Transcription and Replication of DNA

Name: _____ Date: _____

1. What are the two general functions of DNA in a cell?

(a)_____

(b) _____

2. In the video segment, what is the first protein identified and what is it responsible for?

_____ _____

3. Name the second protein mentioned and what it is responsible for.

_____ _____

_____

4. Name the third protein and what it is responsible for.

_____ _____

_____

5. What are proteins made of and how many kinds are there?

_____

6. How is the amino acid sequence for each of the thousands of proteins written out on the DNA?

_____

_____

_____

_____

7. How is the DNA code transcribed? _____

_____

_____

_____

_____

8. What is the rule that transcription of DNA to mRNA follows? _____

_____

What is the exception to the rule? _____

_____

9. What is the three letter code words called that make up the sequence of the amino acids that appear in the proteins? (Tell the students that a sequence of three consecutive bases is called a codon.)

_____

_____

_____

10. What stops the mRNA polymerase enzyme from transcribing?

_____

_____

_____

What happens after the mRNA polymerase enzyme stops transcribing?

_____

_____

Video Worksheet (KEY)
Transcription and Replication of DNA

Name: _____ Date: _____

1. What are the two general functions of DNA in a cell?

(a) *To replicate itself for the creation of new cells.*

(b) *To direct the synthesis of proteins.*

2. In the video segment, what is the first protein identified and what is it responsible for?

Structural protein. It is responsible for making skin, hair and in al cells an internal framework.

3. Name the second protein mentioned and what it is responsible for.

Motor protein. It is responsible for the bending action of flagella and cilia. They make up threads that arrange chromosomes during mitosis. They are responsible for the general movement of materials within a cell.

4. Name the third protein and what it is responsible for.

Enzymatic protein. They control the chemical process necessary for life. Some, like digestive enzymes, break down molecules while others are builders.

5. What are proteins made of and how many kinds are there?

Proteins are made of amino acids. There are twenty amino acids.

6. How is the amino acid sequence for each of the thousands of proteins written out on the DNA?

(Note to teacher: You can go into as much detail as you would like.) *The amino acid sequence for a protein is spelled out on one of the strands of DNA. The order of the bases forms a code. The code determines which protein will be made. Each set of thee consecutive bases forms one symbol in the code. This instruction strand carries a sequence code for the order of the amino acid that will make up the protein. An amino acid is represented by a set of three nucleotides.*

7. How is the DNA code transcribed?

When a special enzyme, RNA polymerase, encounters a coded start signal on the DNA, the doubled stranded DNA molecule is broken apart and the polymerase begins pairing RNA nucleotides to the instructional strand of DNA.

8. What is the rule that transcription of DNA to mRNA follows?

Base pairing rule of DNA

What is the exception to the rule?

The molecule urasil is used instead of thymine. The bases pair up according to certain rules. First a short base can pair only with a long base and vice versa. The long bases are G and A. The short bases are T and C. The second rule governing the way in which bases pair in DNA is that not every long and short base can join together: A pairs only with T, and G pairs only with C. Because the bases always pair the same way, the new strands are identical to the parent strands and so the code is conserved from one generation of cell to next.

9. What is the three letter code words called that make up the sequence of the amino acids that appear in the proteins? (Tell the students that a sequence of three consecutive bases is called a codon.)

mRNA code words are called codons. (Remind students: "The order of the bases forms a code. The code determines which protein will be made. Each set of three consecutives bases forms one symbol in the genetic code. They carry the information for one amino acid. On an mRNA strand, three adjacent bases that carry this information is called a codon. Each codon carries the information for one amino acid in a protein.)

10. What stops the mRNA polymerase enzyme from transcribing?

The enzyme stops the mRNA polymerase enzyme from transcribing when it reaches a coded stop signal on the DNA.

What happens after the mRNA polymerase enzyme stops transcribing?

The mRNA stand is then released.