# Cystic Fibrosis: A DNA Case Study

## DNA Processes

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| **Grade Level** | 9th – 12th Grade | **Time Frame** | 4–5 class period(s) |
| **Subject** | Science | **Duration** | 250 minutes |
| **Course** | Biology | | |

## Essential Question

How are genetic disorders related to DNA processes?

## Summary

Students will use DNA processes such as replication, transcription, and translation to study the differences between healthy individuals and those with a genetic disorder (in this case, cystic fibrosis). Students will apply this knowledge to the inheritance of traits through the use of Punnett squares.

## Snapshot

### Engage

Students watch a 3-minute video on DNA replication, transcription, and translation. Students complete two assessment probes after the video and discuss their responses to each.

### Explore

Students investigate cystic fibrosis by comparing the chest X-rays of a healthy individual and an individual with cystic fibrosis. Students read information on cystic fibrosis and work together to determine the genetic causes of this specific disorder.

### Explain

Students share information discovered about cystic fibrosis through class discussion.

### Extend

Students select a level 1 and a level 2 genetic disorder, then research the disorders and prepare an informational poster for a walk-about.

### Evaluate

Students use academic vocabulary cards to demonstrate conceptual relationships and their understanding of basic DNA processes.

# Standards

*ACT College and Career Readiness Standards - Science (6-12)*

**IOD203:** Find basic information in text that describes a simple data presentation
**IOD302:** Understand basic scientific terminology
**IOD304:** Determine how the values of variables change as the value of another variable changes in a simple data presentation
**IOD403:** Translate information into a table, graph, or diagram
**IOD404:** Perform a simple interpolation or simple extrapolation using data in a table or graph
**IOD505:** Analyze presented information when given new, simple information
**IOD603:** Perform a complex interpolation or complex extrapolation using data in a table or graph
**SIN301:** Understand the methods used in a simple experiment
**SIN404:** Identify similarities and differences between experiments
**SIN502:** Predict the results of an additional trial or measurement in an experiment
**SIN503:** Determine the experimental conditions that would produce specified results
**EMI301:** Identify implications in a model
**EMI401:** Determine which simple hypothesis, prediction, or conclusion is, or is not, consistent with a data presentation, model, or piece of information in text
**EMI402:** Identify key assumptions in a model
**EMI502:** Determine whether presented information, or new information, supports or contradicts a simple hypothesis or conclusion, and why
**EMI503:** Identify the strengths and weaknesses of models
**EMI602:** Determine whether presented information, or new information, supports or weakens a model, and why
**EMI603:** Use new information to make a prediction based on a model
**EMI701:** Determine which complex hypothesis, prediction, or conclusion is, or is not, consistent with two or more data presentations, models, and/or pieces of information in text

*Next Generation Science Standards (Grades 9, 10, 11, 12)*

**HS-LS3-1:** Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
**HS-LS3-3:** Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

*Oklahoma Academic Standards (Biology)*

**B.LS2.5 :** Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
**B.LS3.1 :** Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

# Attachments

- Academic Vocabulary Cards—Cystic Fibrosis A DNA Case Study - Spanish.doc
- Academic Vocabulary Cards—Cystic Fibrosis A DNA Case Study - Spanish.pdf
- Academic Vocabulary Cards—Cystic Fibrosis A DNA Study.docx
- Academic Vocabulary Cards—Cystic Fibrosis A DNA Study.pdf
- Cystic Fibrosis Reading—Cystic FIbrosis A DNA Case Study.docx
- Cystic Fibrosis Reading—Cystic FIbrosis A DNA Case Study.pdf
- Cystic Fibrosis Reading—Cystic Fibrosis A DNA Case Study - Spanish.docx
- Cystic Fibrosis Reading—Cystic Fibrosis A DNA Case Study - Spanish.pdf
- Dogs Puppies More—Cystic Fibrosis A DNA Case Study - Spanish.docx
- Dogs Puppies More—Cystic Fibrosis A DNA Case Study - Spanish.pdf
- Dogs Puppies More—Cystic Fibrosis A DNA Study.docx
- Dogs Puppies More—Cystic Fibrosis A DNA Study.pdf
- Genetic Structure Probe—Cystic Fibrosis A DNA Case Study - Spanish.docx

- Genetic Structure Probe—Cystic Fibrosis A DNA Case Study - Spanish.pdf
- Genetic Structure Probe—Cystic Fibrosis A DNA Case Study.docx
- Genetic Structure Probe—Cystic Fibrosis A DNA Case Study.pdf
- Student Handout 1—Cystic Fibrosis A DNA Case Study - Spanish.doc
- Student Handout 1—Cystic Fibrosis A DNA Case Study - Spanish.pdf
- Student Handout 1—Cystic Fibrosis A DNA Case Study.docx
- Student Handout 1—Cystic Fibrosis A DNA Case Study.pdf
- Student Handout 2—Cystic Fibrosis A DNA Case Study - Spanish.doc
- Student Handout 2—Cystic Fibrosis A DNA Case Study - Spanish.pdf
- Student Handout 2—Cystic Fibrosis A DNA Case Study.docx
- Student Handout 2—Cystic Fibrosis A DNA Case Study.pdf
- Student Handout 3—Cystic Fibrosis A DNA Case Study - Spanish.doc
- Student Handout 3—Cystic Fibrosis A DNA Case Study - Spanish.pdf
- Student Handout 3—Cystic Fibrosis A DNA Case Study.docx
- Student Handout 3—Cystic Fibrosis A DNA Case Study.pdf
- Student Handout 4—Cystic FIbrosis A DNA Case Study.docx
- Student Handout 4—Cystic FIbrosis A DNA Case Study.pdf
- Student Handout 4—Cystic Fibrosis A DNA Case Study - Spanish.doc
- Student Handout 4—Cystic Fibrosis A DNA Case Study - Spanish.pdf

## Materials

- Short DNA processes video (see resources) or a short reading out of the textbook

- Academic Vocabulary Cards (attached)
- Cystic Fibrosis Reading (attached; also see resources for more suggested readings)
- Dogs, Puppies, and So Much More (attached)
- Genetic Structure Probe (attached)
- Student Handouts 1 through 4 (attached)
- Computers with internet access
- Butcher paper or computer access (with software such as PowerPoint or Internet access to create a Prezi) for presentations

# Engage

### Teacher's Note: Background Information

For a visual introduction/overview, watch the "What is a Chromosome?" video. (Note: this is not the same video as the suggested video linked in the next session). DNA makes up the majority of chromosomes. There are 22 pairs of autosomes (body chromosomes) and one pair of sex chromosomes (typically - female: XX and male: XY). A gene is a portion of DNA that codes for specific amino acids to be processed. This chain of amino acids makes up a protein and, when folded correctly, carries out life functions.

There are three major DNA processes: replication, transcription, and translation.

DNA replication occurs inside the nucleus and only involves a portion of DNA; which portion of DNA is involved depends on what protein is to be manufactured.

Once the selected portion of DNA has been replicated, the next process is transcription. This process prepares the replicated DNA section to leave the nucleus and enter the cytoplasm of the cell in the role of RNA, specifically mRNA or messenger RNA.

Once outside the nucleus, translation takes place. Translation is the matching of codons and anticodons to construct the chain of amino acids. Codons are located on the mRNA strand, and anticodons are located on transfer RNA (tRNA), which holds a specific amino acid (for example CCC is the anticodon for glycine).

After translation, the chain of amino acids undergoes a folding process to make up a functional protein. If the protein is incorrectly folded, in embryonic cells, the result can be a non-functioning protein or a malfunctioning protein leading to a genetic disorder. This lesson can be used as a springboard for teaching basic DNA processes, or it can be used to strengthen students' understanding of DNA processes. The teacher's role in this unit should be as a guide on the side, listening to students as they work and assisting when appropriate. The instructor may need to stop the lesson periodically to clarify concepts or have a teaching moment if the lesson is used as a springboard to DNA processes.

**Embedded video**

https://youtube.com/watch?v=xUrlreMaUrs

### Sample Four Corners Student Reasoning

"I agree with Billy because genes make up our traits, and DNA is the molecule of life, so DNA must be on genes."

"I agree with Kyle because genes make up our traits, and we have 23 pairs of chromosomes that do this, so chromosomes must be on genes."

"I agree with Kelly because DNA is very long, and we have a lot of genes, so the long DNA can hold all of the genes."

"I agree with Janet because DNA is very long, and we have 23 pairs of chromosomes on the body that sit on the DNA and do their thing."

### Teacher's Note

The best response is from Kelly because chromosomes are made of DNA, and genes are segments of DNA. This activity will elicit background knowledge and help you identify misconceptions regarding the relationships between chromosomes, DNA, and genes. Tell the class the best choice was Kelly. If the students who chose Kelly have not adequately or accurately explained their reasoning, the teacher should explain why Kelly is the best choice here.

After they return to their seats, give students the **Dogs, Puppies, and So Much More** assessment probe, and allow them time to read and respond to the prompts individually.

While they are reading the probe, go around the room and remove the names "Kyle," "Billy," "Kelly," and "Janet," replacing them with "Kevin," "Tisha," "Ahmad," "Joann," and "Maria" (there are five choices for this probe).

Repeat the same procedure as before, having the students choose the name of the person they believe is the most correct from the probe and then go to that corner.

Give students time to discuss their responses among each other in their groups and prepare a 30-second elevator speech supporting their points of view. An elevator speech is a short oral presentation that mimics the type of quick conversation you may have while on an elevator.

One student from each group should be nominated to give the speech.

Allow each group to give their speeches to the class. Be sure to only allow 30 seconds per speech!

After the speeches have been made, allow students to join another group, if they wish.

### Sample Student Responses

"I agree with Kevin because recessive traits are hidden."

"I agree with Ahmad because if one parent is deaf they usually have deaf offspring, so the trait is dominant. I remember one-fourth as a Punnett square probability."

"I agree with Tisha, because hearing parents can have deaf offspring and recessive traits are hidden—unless both parents have the recessive gene, then there is a one-fourth chance of the babies having the recessive trait."

"I agree with Joann because testing hearing in dogs has to be difficult and partial deafness could be passed on."

"I agree with Maria. The phrase 'runt of the litter' has to have some merit."

### Teacher's Note

The best response is from Tisha because it demonstrates an understanding that half of the puppy's chromosomes come from the egg supplied by the mother and the other half comes from the sperm supplied by the father. Alleles are found on chromosomes and carry the code for dominant or recessive traits. It is the pairing of these alleles that make up a full gene. In this example, hearing is dominant and deafness is recessive. With both parents being heterozygous, having a non-matching pair of alleles for the same gene, there is a 25% possibility of one recessive allele from each parent coming together to create, in this case, a deaf puppy.

### Differentiation for this Phase

During the Engage portion you could change the number of responses the students look at on the handout.

# Explore

Pass out **Student Handout 1** or show the two X-ray images to the class using a projector.

Ask students to examine the two X-rays and explain the differences. They will record their responses in the explanation boxes provided on the handout or in their notebooks.

Briefly have students share out their responses.

### Teacher's Note

Leave the picture on the projector, or tell the students to hang on to the handout with the X-ray images, if you handed out copies. Students will need the lung images after they read the cystic fibrosis article.

Pass out copies of **Cystic Fibrosis Reading**. Have students use a reading strategy such as: CUS and Discuss or Why-Lighting while they read the article to encourage close reading and to make them think about the article critically.

Have students Think-Pair-Share with a partner and discuss the article they just read.

With their partner, students should complete **Student Handouts 2 and 3**.

Monitor students' progress and assist them when needed by using guiding questions or by giving them technical information, if certain material has yet to be covered in class.

# Explain

Lead students through a class discussion going over Student Handouts 1–3 using an Inverted Pyramid strategy.

**Teacher's Note**

At this point in the lesson, students have partners. Tell each pair of students to form a group with another pair of students so there are now four in a group. In groups of four, the students should compare answers. Afterward, a whole-class discussion will take place.

Ask students to answer the essential question: How are genetic disorders related to DNA processes? This can be done individually or in small groups.

Have students share responses to the essential question.

**Teacher's Note**

Handout 4 requires students to match nucleotide bases for replication and transcription. If this has not been covered, you may have to explain base pairing. For replication, Adenine and Thymine (A-T) pair up, and Guanine and Cytosine (C-G) pair up. For transcription (making of mRNA), Thymine is replaced with Uracil so the base pairings are Adenine and Uracil (A-U) and Guanine and Cytosine (C-G). Students will model translation by using the codon chart to determine which amino acid is being used in the chain to form a protein.

# Extend

Using the Inverted Pyramid strategy again, have students attempt **Student Handout 4**, covering nucleotide base pairing.

Start with students in pairs, then groups, then discuss the handout as a whole class.

Once again, ask students to answer the essential question: How are genetic disorders related to DNA processes? This can be done individually or in small groups.

Next, put students in groups and have them select another genetic disorder to investigate. You may have students research on their own, or you may use the information provided from the Learn.Genetics website.

Have each group make a poster, slide presentation, or Prezi including the following information: Name of disorder, brief description, chromosome affected, inheritance of disorder, a possible Punnett Square for the disorder, cause of disorder (such as deletion, insertion, duplication), possible treatments, and interesting facts. Have students do a Gallery Walk. You can have one student from each group remain with the poster to explain, or have a question and answer session after everyone has had a chance to see all of the posters. If a group chooses to make a slide presentation or Prezi, have them present it to the class.

### Differentiation

The requirements in this phase can be lessened, or individual students can be assigned a particular portion of the research to complete.

# Evaluate

Give a set of **Academic Vocabulary Cards** to each pair of students. Have each pair sort the cards in a way that makes sense to them. Give them a few minutes without allowing them to look at the backs of the cards. Then tell them they can flip over five cards to read the back before finalizing their arrangement.

Each pair shares how they arranged their cards and why. You may have students tape or paste their cards on butcher paper to help them show and explain their arrangement.

## Resources


- Genetic Science Learning Center. (n.d.). Genetic Disorders. University of Utah. http://learn.genetics.utah.edu/content/disorders/singlegene (informational texts for various genetic disorders)

- K20 Center. (n.d.) CUS and discuss. Strategies. https://learn.k20center.ou.edu/strategy/162
- K20 Center. (n.d.) Four corners. Strategies. https://learn.k20center.ou.edu/strategy/138
- K20 Center. (n.d.) Gallery walk / carousel. Strategies. https://learn.k20center.ou.edu/strategy/118
- K20 Center. (n.d.) Inverted pyramid. Strategies. https://learn.k20center.ou.edu/strategy/173
- K20 Center. (n.d.). Think-Pair-Share. Strategies. https://learn.k20center.ou.edu/strategy/139
- K20 Center. (n.d.) Why-lighting. Strategies. https://learn.k20center.ou.edu/strategy/128
- red Orbit. (2013, Feb 28). *What is a Chromosome?* [Video]. YouTube. https://www.youtube.com/watch?v=xUrlreMaUrs
- yourgenome. (2015, Jan 7). *From DNA to protein - 3D* [Video]. YouTube. https://www.youtube.com/watch?v=gG7uCskUOrA