KCS @ home

Summer Edition

Biology

Activity 1

knoxschools.org/kcsathome

KCS@home

Biology Activity 1 - How does DNA affect who we are? **Name: _____**

LEARNING TARGETS
- Explain how protein formation results in phenotypic variation.
- Discuss how changes in DNA can lead to somatic or germline mutations.
- Obtain, evaluate and communicate information on how molecular biotechnology may be used in a variety of fields.

This worksheet is designed to complement the KCS@Home Biology Summer Content Activity 1. In the blanks provided below, complete the sentences or answer the questions with information from the video.

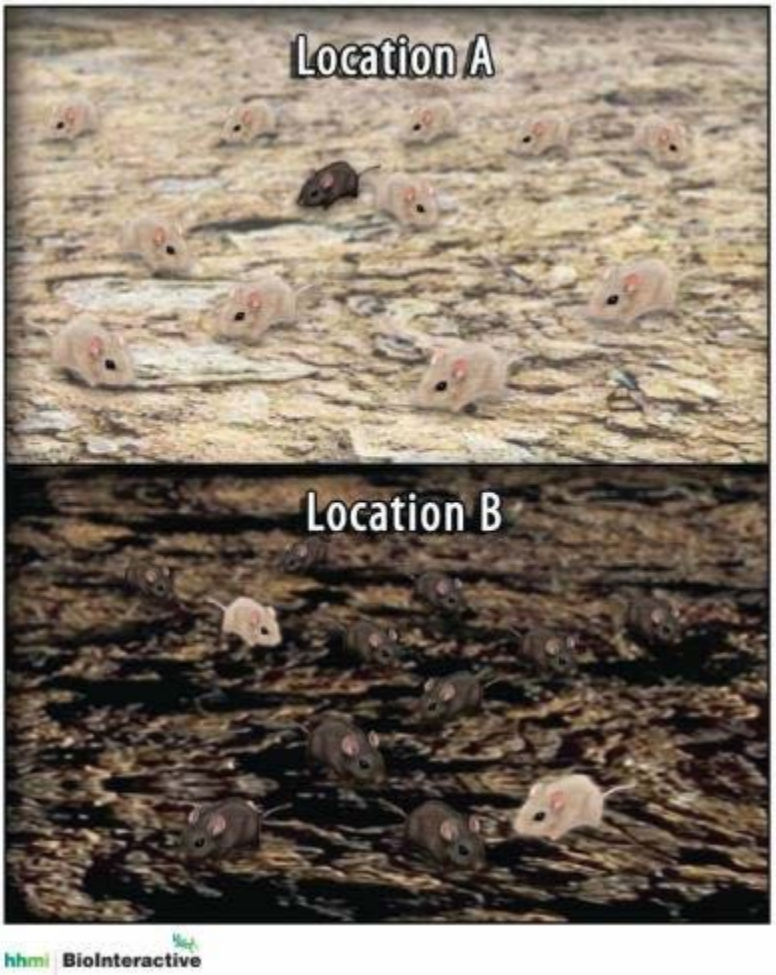
Start the video

1. First, go to the quizlet link (or here https://bit.ly/35XD0cu) and let's see what you know about DNA and proteins. Complete the quizlet with flashcards, matching, quiz, as you review.
   *Optional resources: https://bit.ly/3cyXhaV, https://bit.ly/2X6Q8be

Restart the video

2. **What do you think?** Use this link (or here https://bit.ly/3btetx3) to watch the beginning of "Natural Selection and the Rock Pocket Mouse".

   All of the mice shown in the picture are Rock Pocket mice living in the desert in New Mexico. Why do you think most of the Rock Pocket mice living on light colored sand look different than most of the Rock Pocket mice living on the dark rocks formed from the lava flows?



Restart the video

3. The role of DNA is to _____, _____, and _____.

4. Let's review! DNA is a nucleic acid and its information is stored in the sequence of its nitrogen bases. _____ binds with _____ and _____ binds with _____.

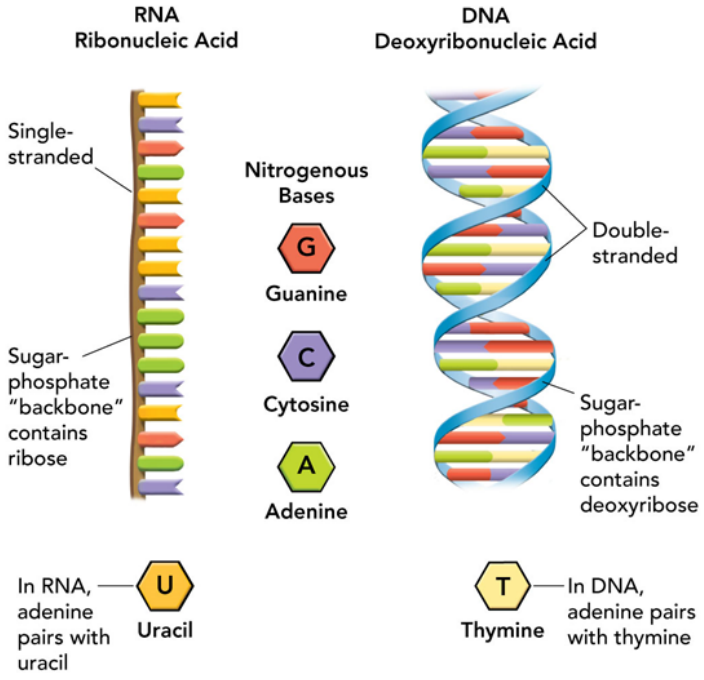
5. The central dogma of molecular biology states that biological information has directional flow from:

_____ TO _____ TO _____

6. Why are proteins important to organisms?

Restart the video

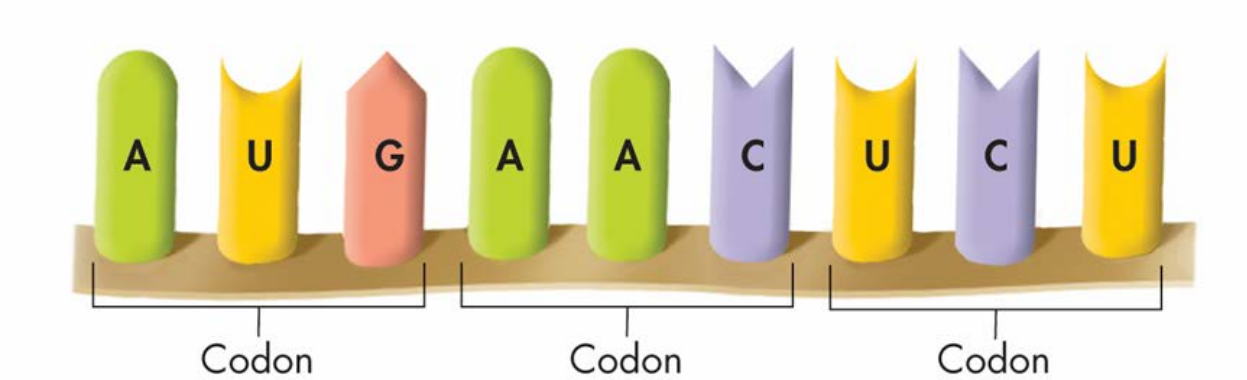
7. Study the diagram below and list the differences and similarities between DNA and RNA.



DNA	BOTH	RNA

Restart the video

8. Use the codon wheel to find the amino acids specified by the following codons:



Codon	AUG	_____	_____
Amino Acid	METHIONINE	_____	_____

Restart the video

9. **Let's go back to the desert!** Use this link (or here https://bit.ly/3cLWdjS) to watch the beginning of "Natural Selection and the Rock Pocket Mouse". Read the following excerpt from HHMI Biointeractive.org.

MOLECULAR GENETICS OF COLOR MUTATIONS IN ROCK POCKET MICE

INTRODUCTION

THE ROCK POCKET MOUSE

The rock pocket mouse, *Chaetodipus intermedius*, is a small, nocturnal animal found in the deserts of the southwestern United States. Because most rock pocket mice have a sandy, light -colored coat, they are able to blend in with the li ght color of the desert rocks and sand that they live on. But populations of primarily dark -colored rock pocket mice have been found living in areas where the ground is covered in a dark rock called basalt, which was caused by geologic lava flows thousands of years ago. Scientists have collected data from a population of primarily dark -colored mice living in an area of basalt in Arizona's Pinacate lava flow, as well as from a nearby light -colored population. Researchers analyzed the data from these two popu lations to search for the genetic mutation responsible for the dark coat color. Through their analyses, they discovered a mutation in the *Mc1r* gene that is involved in coat -color determination.

THE *MC1R* GENE

The coat color of rock pocket mice is primarily determined by two pigments: eumelanin, which is dark colored, and pheomelanin, which is light colored. The synthesis of these pigments is controlled by the products of several genes, including the *Mc1r* gene. This gene encodes a protein called melanocortin 1 receptor (MC1R). This receptor is found embedded in the membrane of melanocytes, which are cells specialized for pigment production. The melanocytes of wild -type (nonmutant) mice produce more pheomelanin than eumelanin. The result is a sandy -colored mous e. The mutated version of the *Mc1r* gene, however, triggers melanocytes to increase the production of eumelanin, resulting in the dark coat -color phenotype.

GENE MUTATION

A gene mutation is any change in the DNA sequence of a gene. Gene mutations can change the structure of the resulting protein. A change in protein structure can change, negate, or have no effect on function. There are

several types of mutations, and several results that mutations can have on the amino acid sequences of proteins.

Restart the video

10. **Let's Practice! Transcription & Translation:** Use the codon wheel on the next page to find the sequences of mRNA and amino acids coded for by the following Mc1R gene segments.

WILD-TYPE *Mc1R* GENE (LIGHT-COLORED COAT PHENOTYPE)

	015									024	
DNA	TTG	AGG	TGG	GCG	TGT	CCG	CAA	GGA	GTG	GAG	Extra-cellular Domain I
mRNA											
Amino Acid											

MUTANT *Mc1R* GENE (DARK-COLORED COAT PHENOTYPE)

	015									024
DNA	TTG	AGG	TGG	ACG	TGT	CCG	CAA	GGA	GTG	GAG
mRNA										
Amino Acid										

11. Let's Practice!

WILD-TYPE *Mc1R* GENE (LIGHT-COLORED COAT PHENOTYPE)

	208				212	
DNA	CAC	GTG	TAC	GAA	CGT	Transmembrane V
mRNA						
Amino Acid						

MUTANT *Mc1R* GENE (DARK-COLORED COAT PHENOTYPE)

	208				212
DNA	CAC	GTG	TAC	GAG	CGT
mRNA					
Amino Acid					

Restart the video.

12. Let's Practice!

WILD-TYPE *Mc1R* GENE (LIGHT-COLORED COAT PHENOTYPE)

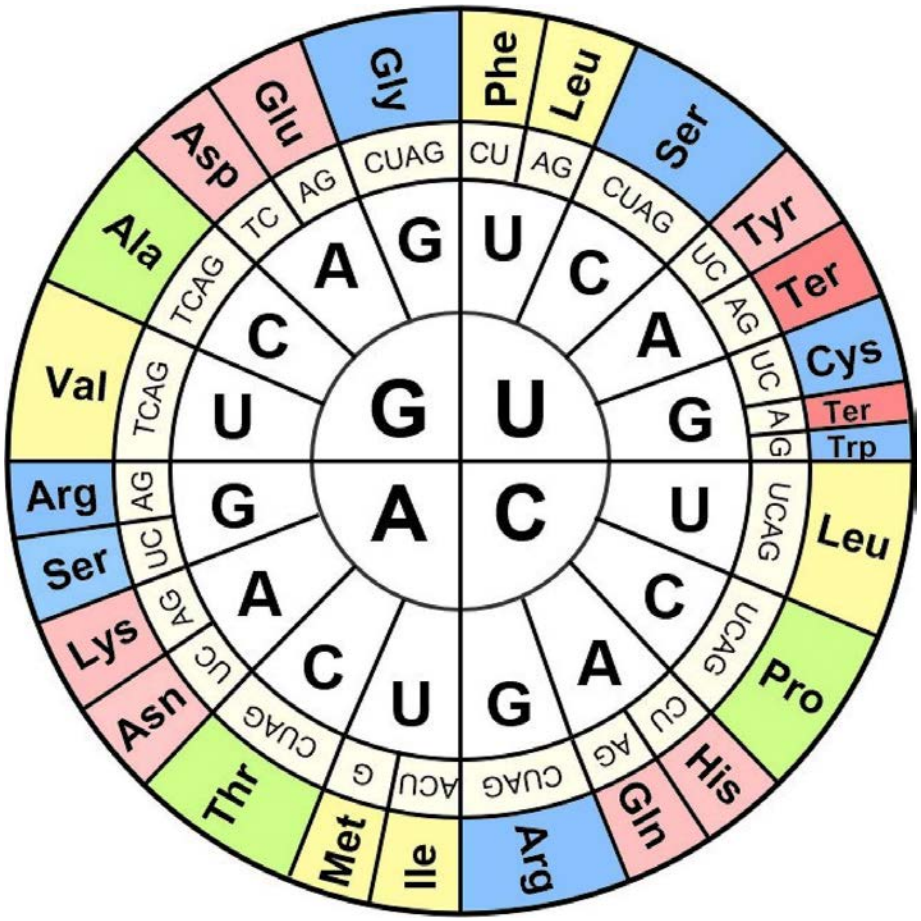
	230								239	
DNA	GAA	CAG	GTG	GTT	CCA	AAG	GCT	GAG	TTT	CCG	Intra-cellular Domain III
mRNA											
Amino Acid											

MUTANT *Mc1R* GENE (DARK-COLORED COAT PHENOTYPE)

230								239

DNA	GAA	CAG	GTG	GTG	CCA	AAG	GCT	GAG	TTT	CCG	
mRNA											
Amino Acid											

The inner circle of the genetic code chart represents the first letter of the codon followed by the second and third ring. Find the corresponding amino acid located in the outer circle.



Types of Mutations

- Substitution mutation: The replacement of one nucleotide of DNA for another. Mutations that affect a single nucleotide are called point mutations.
- Insertion mutation: The addition of one or more nucleotides to the DNA gene sequence. The insertion of nucleotides can result in frameshift mutations.
- Deletion mutation: The loss of one or more nucleotides from the DNA gene sequence. The deletion of nucleotides can result in frameshift mutations.

Potential Results a Gene Mutation Has on a Protein

- Silent mutation: This mutation does not cause a change in the amino acid sequence of the protein; therefore, there is *no* change in the resulting protein.
- Missense mutation: This mutation causes an amino acid in the sequence to be changed to another amino acid. This type of mutation causes a change in the primary structure of the protein (the linear sequence of amino acids), which typically results in a chan ge in the three -dimensional conformation of the protein.

- Nonsense mutation: This mutation causes the protein to be truncated (cut short) due to the incorporation of a "stop" signal into the DNA sequence. This results in translation being stopped before the amino acid sequence of the protein is completed.

Restart the video.

13. Which of these mutation types do you think is most likely to be harmful? Explain your answer.

14. There are three mutations in the segments of the dark-color Mc1r mutant gene shown above. Compare the DNA sequence of the wild-type Mc1r gene with the DNA sequence of the mutant Mc1r gene. Indicate the locations of the three mutations by circling the three DNA nucleotide triplets that are mutated in the mutant Mc1r gene segments. After reading the above information about types of mutations, determine whether each of these mutations is a silent, missense, or nonsense mutation.

    a. Using the mutant Mc1r gene data, shade in the columns (including DNA, mRNA, and amino acid) in the mutant segment that contain a silent mutation. Use a **BLUE** colored pencil to do this.
    b. Likewise, use a **RED** colored pencil to shade in the columns that contain a missense mutation.
    c. Shade any columns that contain nonsense mutations by using a **GREEN** colored pencil.

15. What type of mutation is found in #10 Mc1r gene segment (015-024)?
    a. substitution
    b. deletion
    c. insertion

16. What type of mutation is found in #11 Mc1r gene segment (208-212)?
    a. substitution
    b. deletion
    c. insertion

17. What type of mutation is found in #12 Mc1r gene segment (230-239)?
    a. substitution
    b. deletion
    c. insertion

18. What type of effect does the mutation found in #10 Mc1r gene segment (015-024) have?
    a. silent mutation
    b. missense mutation
    c. nonsense mutation

19. What type of effect does the mutation found in #11 Mc1r gene segment (208-212) have?
    a. silent mutation
    b. missense mutation
    c. nonsense mutation

20. What type of effect does the mutation found in #12 Mc1r gene segment (230-239)have?
    a. silent mutation
    b. missense mutation
    c. nonsense mutation

21. Recall that the sequence of amino acids is what allows a protein to fold into its proper shape, and proteins only function correctly when they are folded correctly. Explain the link between DNA sequence, amino acid sequence, and protein structure and function.

22. Explain why the mutation found in #11 Mc1r gene segment (208-212) is not as significant as the other mutations.

23. Mutations are a source of genetic variation. In the film, Dr. Carroll says that mutations occur randomly. What does that mean?

24. Recall the difference between somatic mutations (mutations that occur in body cells that are NOT sperm or egg) and germ-line mutations (mutations that occur in germ cells: sperm or egg). Was the mutation that occurred in the Mc1r gene of the rock pocket mice a somatic mutation or a germ-line mutation? How do you know?

25. It is a common misconception that "all mutations are bad." Use the example of rock pocket mice to explain why this is not true. In your answer, explain how the dark coat color mutation can be an advantage to some mice and a disadvantage to others.

After the video

26. Visit Science News for Students to read the article "The many efforts to lick cat allergies" (https://bit.ly/2Lv5fG6) and answer the following questions.

Before Reading:

27. What does it mean to be allergic to something? What happens when someone comes into contact with the thing to which they are allergic?

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29. What does “hypoallergenic” mean?

30. What is Fel d1? How do people get exposed to it?

31. How do allergy shots work?

32. What percent of people are thought to be allergic to cats?

33. What is the “allergen-plus” treatment? What is one downside of it, as described in the story?

34. How might the cat food being developed by researchers at Nestlé Purina help people who are allergic to cats?

35. By how much did the vaccine given to cats reduce their secretion of Fel d1?

36. How is Tom Lundberg producing cats that have low levels of Fel d1?

37. What do the genes Ch1 and Ch2 do in a cat?

After Reading:

38. CRISPR/Cas9 genetic engineering is a technique that can be used to precisely edit genes. Is it responsible to edit the genes of organisms like cats so that people can enjoy them as pets without allergies? Does it make a difference ethically if the gene is edited in a somatic cell vs. a germ-line cell? Explain your reasoning. Keep researching and write a claim, evidence, reasoning based paragraph for your claim. You can learn more about CRISPR here:
    a. https://bit.ly/3fUr8g3.
    b. https://bit.ly/2yd0vC8
    c. https://bit.ly/2y6MXb5
    d. https://bit.ly/3dOJ2iq

**This lesson was modified from the online resources listed below:*
https://quizlet.com/LISA_JACOBS27/folders/biology-activity-1/sets
https://www.biointeractive.org/
https://www.sciencenewsforstudents.org/
https://www.pearsonrealize.com/index.html#/

KCS@home

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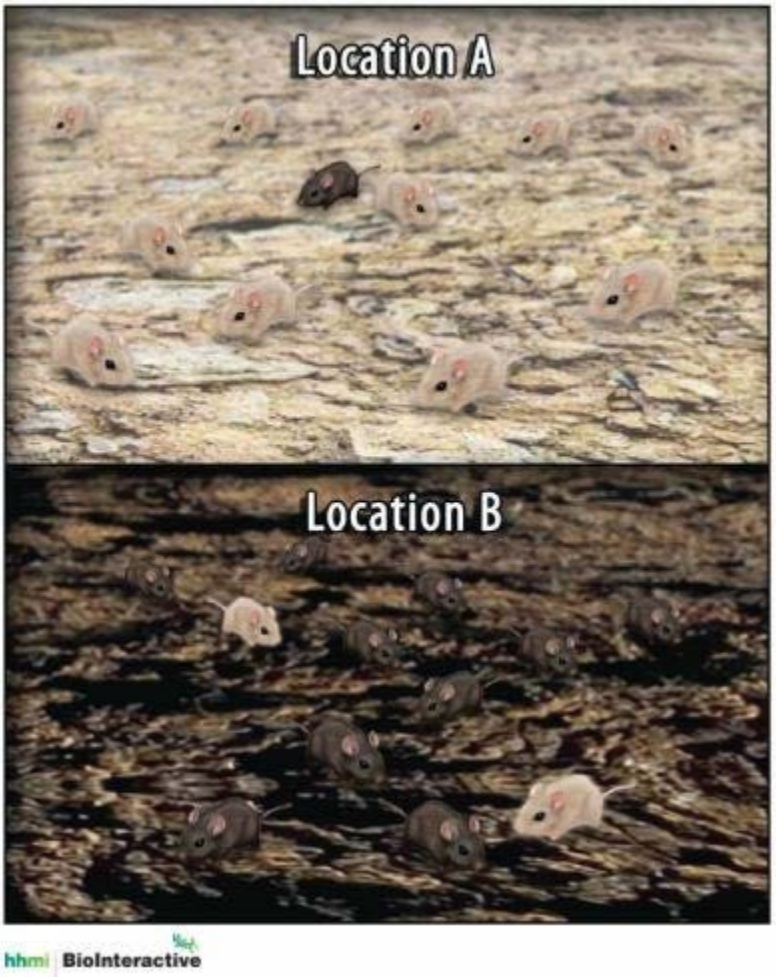

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3. The role of DNA is to Store genetic information, copy itself, and put genetic information to work (express).

4. Let's review! DNA is a nucleic acid and its information is stored in the sequence of its nitrogen bases. Adenine binds with Thymine and Cytosine binds with Guanine.

5. The central dogma of molecular biology states that biological information has directional flow from:

DNA TO RNA TO Protein

6. Why are proteins important to organisms?

Proteins have many functions in organisms such as regulating cell processes, controlling reaction rates, transporting substances, helping to fight diseases, and forming structures.

Restart the video

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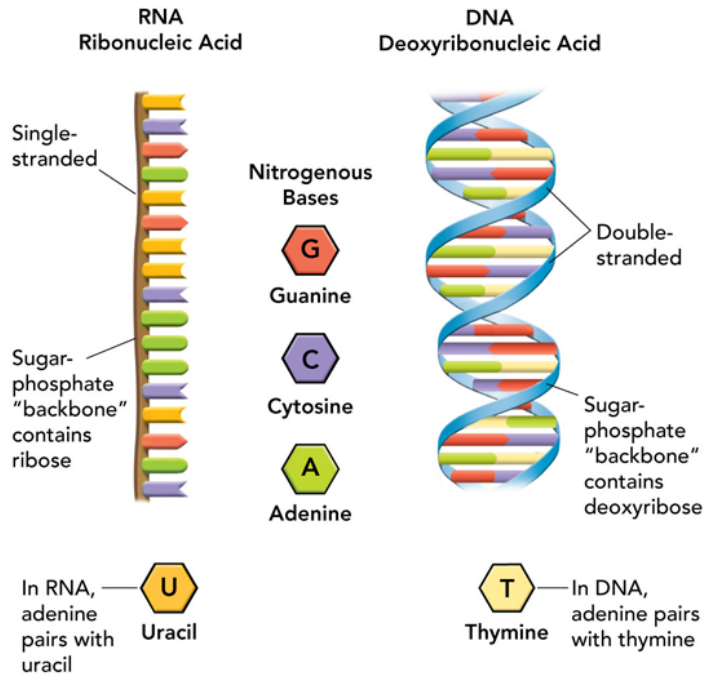

DNA	BOTH	RNA
double stranded	Phosphate-sugar backbone	single stranded
sugar = deoxyribose	guanine	sugar = ribose
thymine pairs with adenine	cytosine	uracil pairs with adenine
	adenine	

Restart the video

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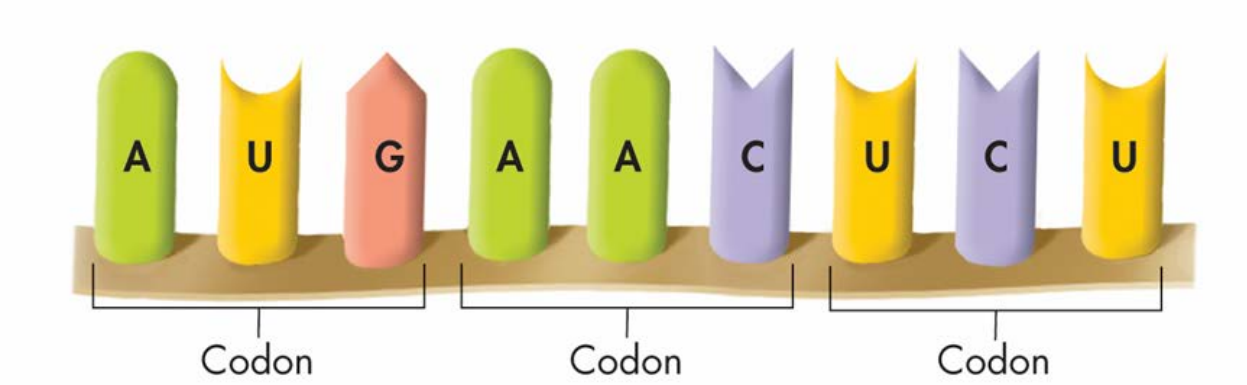

Codon	AUG	AAC	UCU
Amino Acid	METHIONINE	Asparagine	Serine

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	015									024	
DNA	TTG	AGG	TGG	GCG	TGT	CCG	CAA	GGA	GTG	GAG	Extra-cellular Domain I
mRNA	AAC	UCC	ACC	CGC	ACA	GGC	GUU	CCU	CAC	CUC	
Amino Acid	ASN	SER	THR	ARG	THR	GLY	VAL	PRO	HIS	LEU	

MUTANT *Mc1R* GENE (DARK-COLORED COAT PHENOTYPE)

	015									024	
DNA	TTG	AGG	TGG	ACG	TGT	CCG	CAA	GGA	GTG	GAG	
mRNA	AAC	UCC	ACC	UGC	ACA	GGC	GUU	CCU	CAC	CUC	
Amino Acid	ASN	SER	THR	CYS	THR	GLY	VAL	PRO	HIS	LEU	

11. **Let's Practice!**

WILD-TYPE *Mc1R* GENE (LIGHT-COLORED COAT PHENOTYPE)

	208				212	
DNA	CAC	GTG	TAC	GAA	CGT	Transmembrane V
mRNA	GUG	CAC	AUG	CUU	GCA	
Amino Acid	VAL	HIS	MET	SER	ALA	

MUTANT *Mc1R* GENE (DARK-COLORED COAT PHENOTYPE)

	208				212	
DNA	CAC	GTG	TAC	GAG	CGT	
mRNA	GUG	CAC	AUG	CUC	GCA	
Amino Acid	VAL	HIS	MET	SER	ALA	

Restart the video.

12. Let's Practice!

WILD-TYPE *Mc1R* GENE (LIGHT-COLORED COAT PHENOTYPE)

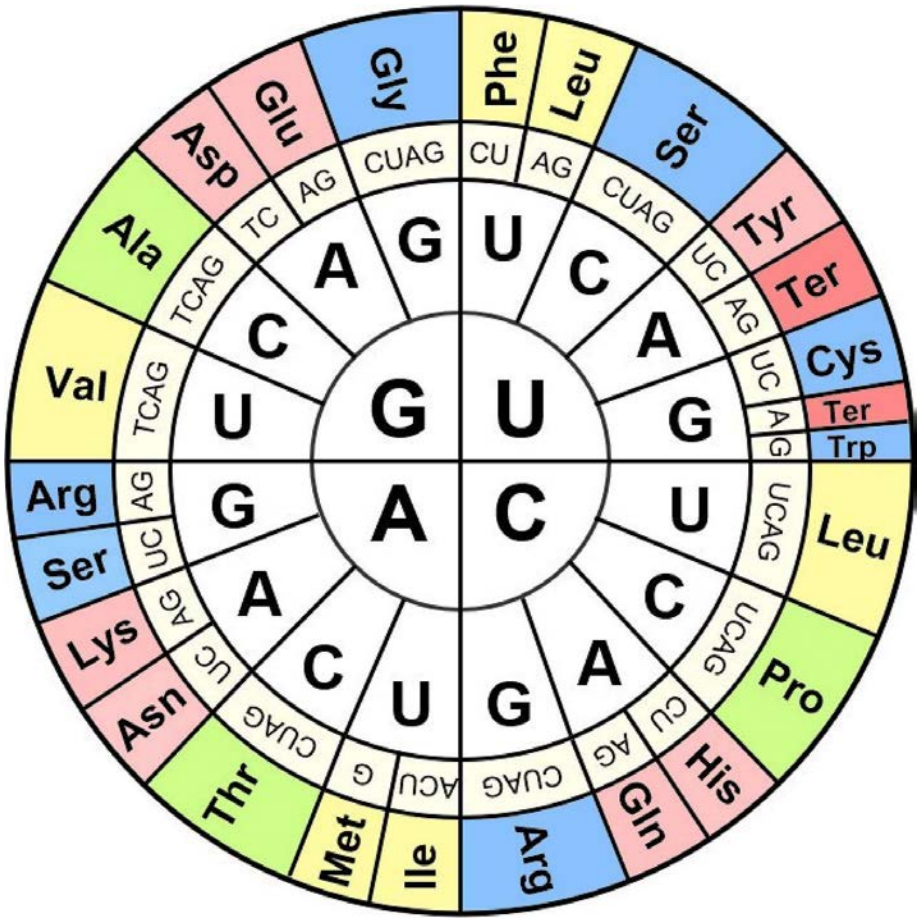
	230									239	
DNA	GAA	CAG	GTG	GTT	CCA	AAG	GCT	GAG	TTT	CCG	Intra-cellular Domain III
mRNA	CUU	GUC	CAC	CAA	GGU	UUC	CGA	CUC	AAA	GGC	
Amino Acid	LEU	VAL	HIS	GLN	GLY	PHE	ARG	LEU	LYS	GLY	

MUTANT *Mc1R* GENE (DARK-COLORED COAT PHENOTYPE)

230	239

DNA	GAA	CAG	GTG	GTG	CCA	AAG	GCT	GAG	TTT	CCG	
mRNA	CUU	GUC	CAC	CAC	GGU	UUC	CGA	CUC	AAA	GGC	
Amino Acid	LEU	VAL	HIS	HIS	GLY	PHE	ARG	LEU	LYS	GLY	

The inner circle of the genetic code chart represents the first letter of the codon followed by the second and third ring. Find the corresponding amino acid located in the outer circle.



Types of Mutations

- Substitution mutation: The replacement of one nucleotide of DNA for another. Mutations that affect a single nucleotide are called point mutations.
- Insertion mutation: The addition of one or more nucleotides to the DNA gene sequence. The insertion of nucleotides can result in frameshift mutations.
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Potential Results a Gene Mutation Has on a Protein

- Silent mutation: This mutation does not cause a change in the amino acid sequence of the protein; therefore, there is *no* change in the resulting protein.
- Missense mutation: This mutation causes an amino acid in the sequence to be changed to another amino acid. This type of mutation causes a change in the primary structure of the protein (the linear sequence of amino acids), which typically results in a change in the three -dimensional conformation of the protein.

- Nonsense mutation: This mutation causes the protein to be truncated (cut short) due to the incorporation of a "stop" signal into the DNA sequence. This results in translation being stopped before the amino acid sequence of the protein is completed.

Restart the video.

13. Which of these mutation types do you think is most likely to be harmful? Explain your answer.

Insertions and deletions are more likely to be harmful because the frameshift causes all codons after the mutation to be read incorrectly usually resulting in more than 1 amino acid change in the sequence. Insertions and deletions are more likely to result in missense or nonsense mutations.

14. There are three mutations in the segments of the dark-color Mc1r mutant gene shown above. Compare the DNA sequence of the wild-type Mc1r gene with the DNA sequence of the mutant Mc1r gene. Indicate the locations of the three mutations by circling the three DNA nucleotide triplets that are mutated in the mutant Mc1r gene segments. After reading the above information about types of mutations, determine whether each of these mutations is a silent, missense, or nonsense mutation.

    a. Using the mutant Mc1r gene data, shade in the columns (including DNA, mRNA, and amino acid) in the mutant segment that contain a silent mutation. Use a **BLUE** colored pencil to do this.
    b. Likewise, use a **RED** colored pencil to shade in the columns that contain a missense mutation.
    c. Shade any columns that contain nonsense mutations by using a **GREEN** colored pencil.

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    a. substitution
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c. nonsense mutation

20. What type of effect does the mutation found in #12 Mc1r gene segment (230-239)have?
    a. silent mutation
    b. missense mutation
    c. nonsense mutation

21. Recall that the sequence of amino acids is what allows a protein to fold into its proper shape, and proteins only function correctly when they are folded correctly. Explain the link between DNA sequence, amino acid sequence, and protein structure and function.

DNA sequence provides the code for the amino acid sequence. The amino acid sequence determines the structure of the protein, which affects the function of the protein.

22. Explain why the mutation found in #11 Mc1r gene segment (208-212) is not as significant as the other mutations.

It is a silent mutation, so the amino acid in that position does not change, nor does the structure of the protein. This is important because a protein's structure relates to its function. No change in the structure suggests that there is no change in the function of the protein.

23. Mutations are a source of genetic variation. In the film, Dr. Carroll says that mutations occur randomly. What does that mean?

It means that mutations do not occur for a purpose or for any predetermined result.

24. Recall the difference between somatic mutations (mutations that occur in body cells that are NOT sperm or egg) and germ-line mutations (mutations that occur in germ cells: sperm or egg). Was the mutation that occurred in the Mc1r gene of the rock pocket mice a somatic mutation or a germ-line mutation? How do you know?

The mutation must have been in a germ-line cell because the trait of dark fur is passed down from parent mice to their offspring and only germ-line mutations can be passed down.

25. It is a common misconception that "all mutations are bad." Use the example of rock pocket mice to explain why this is not true. In your answer, explain how the dark coat color mutation can be an advantage to some mice and a disadvantage to others.

Mutations can result in new traits. The selective advantage provided by a trait depends on the environment. For example, on a light substrate, individuals with dark-colored coats would be at a disadvantage because they would stand out more than individuals with light colored coats, making them easier for predators to spot. However, in the dark lava flow habitat, those same dark colored individuals would have a selective advantage because they would be better camouflaged than light-colored individuals. So the statement that "mutations are bad" is incorrect, because there are different selective

pressures on the traits produced by mutations depending on the habitat. There are also silent mutations that do not change the resulting protein; these are neutral, neither good nor bad.

After the video

26. Visit Science News for Students to read the article "The many efforts to lick cat allergies" (https://bit.ly/2Lv5fG6) and answer the following questions.

Before Reading:

27. What does it mean to be allergic to something? What happens when someone comes into contact with the thing to which they are allergic?

When a person is allergic to something it means their immune system overreacts to a normally harmless substance (allergen). When a person comes in contact with an allergen, an allergic reaction occurs. This can include increased mucus production, itchiness, hives, rash, shortness of breath, and in severe cases anaphylactic shock which includes a closing airway.

28. Do you have any pets? What do you like about having them around? What do you not like? Do those bad aspects outweigh the good? Why?

Answers will vary.

During Reading:

29. What does "hypoallergenic" mean?

Hypoallergenic describes something that is unlikely to cause an allergic response.

30. What is Fel d1? How do people get exposed to it?

Fel d1 is a small protein produced in the salivary and sebaceous glands of cats. Scientists believe it might be a pheromone. It can be found in flakes of dead skin (dander) and spreads to the fur as a cat licks itself.

31. How do allergy shots work?

Allergy shots are a form of immunotherapy. The shot exposes the immune system to small amounts of allergens. This causes the body to make antibodies that block part of the allergic response

32. What percent of people are thought to be allergic to cats?

10%-20% of the population is estimated to be allergic to cats.

33. What is the "allergen-plus" treatment? What is one downside of it, as described in the story?

The goal of the "allergen-plus" treatment is to block a substance that plays a role in starting the immune response by combining small amounts of Fel d1 with an antibody. The downside is that patients would need periodic boosters frequently.

34. How might the cat food being developed by researchers at Nestlé Purina help people who are allergic to cats?

The cat food would contain antibodies to Fel d1 that would make it "almost impossible for the human immune system to recognize the allergen".

35. By how much did the vaccine given to cats reduce their secretion of Fel d1?

The secretion of Fel d1 by vaccinated cats was reduced by more than half.

36. How is Tom Lundberg producing cats that have low levels of Fel d1?

Tom Lundberg breeds Siberian cats. He tests Fel d1 levels in the kittens and breeds cats with the lowest levels.

37. What do the genes Ch1 and Ch2 do in a cat?

Ch1 and Ch2 instruct cells in a cat on how to make Fel d1.

After Reading:

38. CRISPR/Cas9 genetic engineering is a technique that can be used to precisely edit genes. Is it responsible to edit the genes of organisms like cats so that people can enjoy them as pets without allergies? Does it make a difference ethically if the gene is edited in a somatic cell vs. a germ-line cell? Explain your reasoning. Keep researching and write a claim, evidence, reasoning based paragraph for your claim. You can learn more about CRISPR here:
    a. https://bit.ly/3fUr8g3.
    b. https://bit.ly/2yd0vC8
    c. https://bit.ly/2y6MXb5
    d. https://bit.ly/3dOJ2iq

Answers will vary.

**This lesson was modified from the online resources listed below:*
https://quizlet.com/LISA_JACOBS27/folders/biology-activity-1/sets
https://www.biointeractive.org/
https://www.biointeractive.org/classroom-resources/
https://www.sciencenewsforstudents.org/
https://www.pearsonrealize.com/index.html#/