The Monster Mash

A lesson about transcription and translation

By Michelle Kelly, Donald Huesing, & Heather Miller

Focus on Inquiry

The students will model the process of protein synthesis and then model how those proteins result in phenotypic changes. Students will also be able to explain the function of models in science.

Lesson Content Overview

Students will explore how variations in DNA sequences produce varying phenotypes. Students will complete transcription and translation of DNA and RNA and then determine phenotypes produced based on amino acid sequences while completing hands on activity. During this lesson, students will create a factious organism by rolling a dice to determine which DNA sequence it will receive. Students will then perform transcription and translation. Finally, students will determine the phenotype of the organisms by comparing its amino acid sequence to a key that will be provided. Lastly, students will create a picture of the fictitious organism.

Duration	Setting	Grouping	PTI Inquiry Subskills
Two class periods	Classroom	Groups of 2	3.4, 5.2, 5.3, 5.8, 7.2, 7.3

Lesson Components	Estimated Time	Inquiry Subskills Used	Technology Used	Level of Student Engagement	Brief Description
Engage	10 minutes	7.2	Device and internet connection	2	Students will watch a video introducing protein synthesis. Students will answer preview questions using the Kagan structure Think-Pair-Share. The video is located at: https://www.youtube.com/watch?v=suN-sV0cT6c
Explore	20 minutes	5.2, 5.3, 5.8, 3.4	Device and internet connection	2, 3	Students will play the following game: http://biomanbio.com/GamesandLabs/LifeChemgames/Protsynth.html or will model the process of mRNA transcription.
Explain	10 minutes	5.2, 7.2, 7.3	none	2	Student will answer two higher order thinking questions on white boards and have a whole class discussion using a pairing & sharing structure.
Expand/Elaborate	30-45	5.2, 5.3, 5.8, 3.4	none	3	Students will complete the monster mash worksheet which has them translating codons and creating a monster using the phenotypes that are translated.
Evaluate	5 minutes	7.3	none	3	The drawing produced during this activity will serve as an exit/ or entrance ticket. There is also a 6 question summative assessment.

Level of Student Engagement

1	Low	Listen to lecture, observe the teacher, individual reading, teacher demonstration, teacher-centered instruction
2	Moderate	Raise questions, lecture with discussion, record data, make predictions, technology interaction with assistance
3	High	Hands-on activity or inquiry; critique others, draw conclusions, make connections, problem-solve, student-centered

Next Generation Science Standards – Inquiry

NGSS Practice 2: Developing and Using Models
NGSS Practice 3: Planning and Carrying Out investigations
NGSS Practice 6: Constructing explanations
NGSS Practice 8: Obtaining, Evaluating and Communicating Information

Next Generation Science Standards – Life Science

HS-LS3-2.: Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

Florida Science Standards – Nature of Science

SC.912.N.3.5: Describe the function of models in science, and identify the wide range of models used in science.

Florida Science Standards – Life Science

SC.912.L.16.5 Explain the basic processes of transcription and translation and how they result in the expression of genes.

Materials and Advance Preparation

Materials List

Class Materials:

- Six sided dice (enough for at least 1 per pair of students)
- White boards and dry erase markers (enough for at least 1 per pair of students)
- Internet Access
- Crayons/colored pencils

Student materials:

- Exploring Transcription & Translation (**Blackline Master #1**) – 1 per student or pair
- Codon Chart (**Blackline Master #2**) - 1 per student or pair
- Monster Mash Handout (**Blackline Master #3**) – 1 per student or pair

Blackline Masters

1. **Blackline Master #1 (optional):** Exploring Transcription and Translation
2. **Blackline Master #2:** Codon Charts
3. **Blackline Master #3:** Monster Mash Student Activity Packet
4. **Blackline Master #4:** Monster Mash Assessment
5. **Blackline Master #5:** Answer Keys

Advance Preparation

1. Make copies of the Transcription & Translation Activity (**Blackline Master #1 – optional)**, the Codon Charts (**Blackline Master #2**), and the Monster Mash Student Activity Packet (**Blackline Master #3)** (1 each per student or pair)
2. Ensure that technology is functionally properly.
3. Ensure video plays properly.
4. Have one set of dice for each student or pair.
5. Have at least 1 whiteboard and marker for each student or pair.

Lesson Information

Learning Objectives

1. Students will be able to explain the process of transcription and translation and how they result in the expression of genes.
2. Students will be able to demonstrate how transcribing and translating a series of genes results in phenotypic differences in organisms.
3. Students will be able to model the process of protein synthesis and explain the role of models in science.

Prior Knowledge Needed by the Students

Students should have a basic knowledge of genetics and base pairing at both the middle and high school levels:

SC.7.L.16.1: Understand and explain that every organism requires a set of instructions that specifies its traits, that this hereditary information (DNA) contains genes located in the chromosomes of each cell, and that heredity is the passage of these instructions from one generation to another.

SC.912.L.16.3: Describe the basic process of DNA replication and how it relates to the transmission and conservation of the genetic information.

SC.912.L.16.9: Explain how and why the genetic code is universal and common to almost all organisms.

Background Information:

Genes are the units that determine inherited characteristics, such as hair color or blood type. Genes are a segment of the DNA molecule that determines the structure of polypeptides (proteins) and thus a specific trait. The sequence of nucleotides in the DNA determines the sequence of amino acids in the polypeptides, and thus the structure of the proteins.

In a process called *transcription*, which takes place in the nucleus of the cell, messenger RNA (mRNA) reads and copies the DNA's nucleotide sequence in the form of a complementary RNA molecule. Then the mRNA carries this information

in the form of a code out of the nucleus and to the ribosome, where protein synthesis takes place. The code in DNA and RNA, specifies the order in which amino acids are joined together to form a polypeptide. The code words in mRNA, however are not directly recognized by the corresponding amino acids. Another type of RNA called transfer RNA (tRNA) is needed to bring the mRNA and amino acids together. As the code carried by the mRNA is "read" on a ribosome, the proper tRNAs arrive in turn and give up amino acids they carry to the growing polypeptide chain. The process by which information from DNA is transferred into the language of proteins is known as *translation*.

In this investigation, the student will model the mechanism of protein synthesis and thereby determine the traits inherited by their fictitious organism.

Lesson Procedure

Engage

1. Students will watch a video (3:35): https://www.youtube.com/watch?v=suN-sV0cT6c
    a. ***NOTE:*** *If there is an advertisement at the beginning of the video, please fast forward or "Skip" through the ad if available. Make sure to display the video full screen (arrows to the right of video time bar at the bottom of the screen) so that the web page advertisements and other suggested videos are not seen. Watch for and close any pop-up ads that may occur during the video.*
2. At the conclusion of the video, students will answer the question, "What cellular processes or structures did you recognize in the video? How might changes in the cell or cell processes affect physical appearances in individuals?" using the Kagan structure Think-Pair-Share. Link to the directions for the Think-Pair-Share structure: http://www.readingrockets.org/strategies/think-pair-share
    a. *Student responses to the preview question will vary depending on what they derived from the video and what their prior knowledge is.*
3. Students can record their thoughts in their notebook, on a piece of paper, or on a whiteboard.

Explore

1. Students will practice transcribing and translating genes using one of the two resources:
    a. For students to practice transcription and translation online, go to the following website: http://biomanbio.com/GamesandLabs/LifeChemgames/Protsynth.html
    b. For students to practice transcription and translation in a hands-on manner, use the activity on **Blackline Master #1**.
        i. Students will use their knowledge of base pairing to transcribe a strand of DNA, and then will translate their mRNA in protein synthesis.
        ii. Students will need a copy of the Codon Charts to complete this activity, as well as the Expand activity (**Blackline Master #2**).

Explain

1. Student will answer one of two higher order-thinking questions on white boards:
   A: How can variation within a DNA sequence produce different phenotypes? *Student responses may vary but should include that differences in DNA result in differences in genes and protein synthesis which would result in different colored skin, hair, eyes, etc.*
   B: If a scientist is given a specific protein, could they determine the DNA code that produced it? *Student responses may vary but should include that scientists could reverse code the protein to identify the mRNA that coded for it, and then identify the DNA that resulted in the mRNA transcription.*
2. Student will be assigned as student A or B.
    - student A will answer question A
    - student B will answer question B
3. All students who were assigned question A will be paired together and share their answers. All students who were assigned question B will be paired together and share their answers. You could use the Stand Up, Hand Up, Pair Up structure to accomplish these pairings. Directions to structure: https://www.kaganonline.com/free_articles/research_and_rationale/330/The-Essential-5-A-Starting-Point-for-Kagan-Cooperative-Learning
4. Students will return to their seats and share their responses with their shoulder partner: A sharing with B, and B with A.
5. **Whole class discussion:**

a. Engage students in a discussion about modeling the transcription and translation process by asking, "Why is modeling important in science?" *Student responses will vary but should include that modeling allows scientists to demonstrate concepts that are abstract or too difficult to experience in reality.* "Why might it be important to model the processes of transcription and translation?" *Student responses will vary but should include that modeling these processes allows scientists and learners to understand the processes which are abstract and microscopic and not easily available to witness.*

Expand

1. Students will complete the Monster Mash Activity (**Blackline Master #3**).
    a. Students will role a dice for each trait. The number on the dice with correlate with the DNA sequence for the fictitious monster they are creating.
    b. Students will transcribe and translate the genes using their DNA sequences, their knowledge of base pairing rules, and the Codon Chart (**Blackline Master #2**).
    c. Students will determine the phenotype of the monster based on the amino acid sequences determined from translating their mRNA.
    d. Students will create a drawing of the monster based on their monster's phenotype.

Evaluate

INFORMAL EVALUTION

- Students will create a drawing of their monster based on the phenotypes that have been determined as they completed the Monster Mash Activity (**Blackline Master #3**).
- Drawing and worksheet can be handed in as proof of mastery.

FORMAL EVALUATION

- 5 question summative assessment

Wrap Up

- The pictures of the monsters will be displayed around the room on the following day.
- A five minute gallery walk will take place in which students will view other monsters created by students who participated in the same activity.
- A discussion could follow about why everyone's monsters look different (phenotypic differences) and how genetics play a role in those differences.

Supplementary Resources

Teacher

Clancy, S. & Brown, W. (2009). Scitable: Translation: DNA to mRNA to Protein. Retrieved from: http://www.nature.com/scitable/topicpage/translation-dna-to-mrna-to-protein-393
Provides the teacher with background knowledge about DNA, mRNA, and protein synthesis.

Students

BioMan: http://biomanbio.com/GamesandLabs/LifeChemgames/Protsynth.html
Protein Synthesis Race Game for students to practice base pairing, transcription, and translation.

Ducksters: http://www.ducksters.com/science/biology/proteins_and_amino_acids.php
Biology for Kids: Proteins and Amino Acids.

CITATION OF SOURCES.

Boone, B. (2013). mRNA Codon Chart. Retrieved from https://www.flickr.com/photos/97216967@N04/9723142289

Gregorio, F. (2012). Introduction to Protein Synthesis. Retrieved from https://www.youtube.com/watch?v=suN-sV0cT6c

Mouagip. (2009). Amino Acids Table. Retrieved from https://commons.wikimedia.org/wiki/File:Aminoacids_table.svg

__✓__ Yes, I cited all materials and resources used in this lesson. *Michelle Kelly, Donald Huesing, & Heather Miller*

Lesson Authors' Signatures

Blackline Master #1

Exploring Transcription and Translation

First, you will be rolling your dice to identify which nucleotides will be present in your strand of DNA. Roll the dice and use the chart below to create your DNA.

IF you roll a:	Your DNA nucleotide is a:
1	G
2	A
3	T
4	C
5	G
6	A

Example: On my first roll, I rolled a 3. I wrote T as the first nucleotide in my DNA sequence. Next, I rolled a 2, then a 6, then a 3, then a 4. My DNA sequence looks like this so far:

T A A T C

Your DNA Sequence:

Next, you will <u>transcribe</u> your DNA sequence into mRNA. To do this, you will match your DNA nucleotide with it's RNA nucleotide. Remember, the base pairing rules are:

A ➔ U
T ➔ A
G ➔ C
C ➔ G

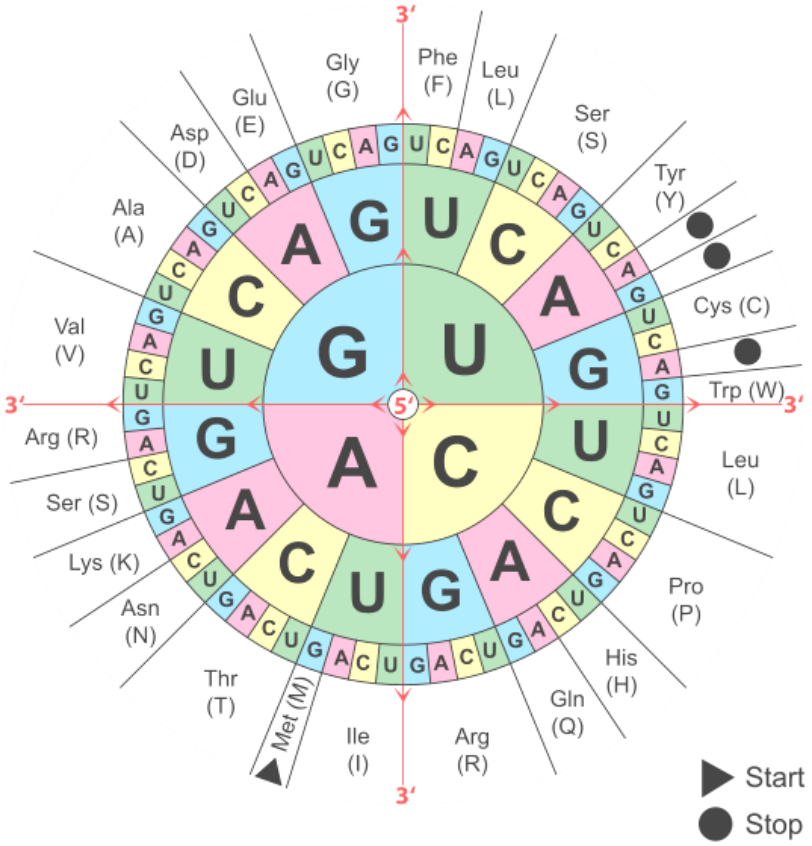
Your mRNA Sequence:

Once the mRNA has been <u>transcribed</u>, it is sent to the ribosomes to be <u>translated</u> into proteins. Proteins are coded in chunks of 3 nucleotides called "codons." Notice in your mRNA sequence that every 3 nucleotides are in boxes of a slightly differnet color? These are codons. Use the codon chart to translate your codons.

Codon			Protein

Codon Charts

FIRST NUCLEOTIDE	SECOND NUCLEOTIDE: U		C		A		G		THIRD NUCLEOTIDE
U	UUU	Phenylalanine (Phe)	UCU	Serine (Ser)	UAU	Tyrosine (Tyr)	UGU	Cysteine (Cys)	U
	UUC		UCC		UAC		UGC		C
	UUA	Leucine (Leu)	UCA		UAA	STOP	UGA	STOP	A
	UUG		UCG		UAG		UGG	Tryptophan (Trp)	G
C	CUU	Leucine (Leu)	CCU	Proline (Pro)	CAU	Histidine (His)	CGU	Arginine (Arg)	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	Glutamine (Gln)	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	Isoleucine (Ile)	ACU	Threonine (Thr)	AAU	Asparagine (Asn)	AGU	Serine (Ser)	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	Lysine (Lys)	AGA	Arginine (Arg)	A
	AUG	Methionine (Met) START	ACG		AAG		AGG		G
G	GUU	Valine (Val)	GCU	Alanine (Ala)	GAU	Aspartic Acid (Asp)	GGU	Glycine (Gly)	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	Glutamic Acid (Glu)	GGA		A
	GUG		GCG		GAG		GGG		G



Blackline Master #3

Monster Mash Student Activity Packet

During this activity, you will be creating a monster using the genotypes provided below. Each trait will determined by rolling a dice. The number on the dice will correspond with the genotype for the chosen trait.

Procedure:

- To determine the DNA sequence (genotype) for each of the traits you will be rolling a dice. The number rolled will determine which DNA sequence you will use for traits that include number of eyes, legs, arms, hair type and color, skin color and a special feature.
- Record the number rolled and DNA sequence on the transcription and translation data worksheet.
- Transcribe the DNA to mRNA.
- Translate the mRNA into an amino acid sequence using the provided codon chart.
- Determine the phenotype of the trait using the amino acid sequence key. If you are unable to determine they phenotype, it is possible that there was an error that occurred while copying the DNA sequence, transcription or translation. Be sure to check your work.
- Repeat until all seven traits have been identified.
- Draw a picture of your monster.

Dice number	**Eyes** DNA Sequence
1	TAC– CTT–CTG– GCA – CGA – AGT – CAC– ATT
2	TAC – GTA – TAA– TGT – CTT– ACC – CAC– TAA – ACT
3	TAC –AGT – TGG – GAA– TAT – GAT– TAG– ACT
4	TAC –CCT – CGA – CGA – AAA –TAG– ACT
5	TAC –CGA–GAT– GAA–TAC – TAA– ACT
6	TAC – CCA – CGA— AAG– AAA – ATT
Dice number	**Legs** DNA Sequence
1	TAC – CTT– CCA – TGG – AGT– TAG– ACT
2	TAC – TAA– AGT – TGG – CCT– ATT
3	TAC – GTT – AAG – TAA– TGT– TCT– ATT
4	TAC – TGG – CCA – GAT– CAG– TAG– ACT
5	TAC – TGG – TGG – GAC– CCT CAA– ATT
6	TAC –GTT – AAT –AAA – TAA– CAC – AGT– TAG– ACT
Dice number	**Arms** DNA Sequence
1	TAC –TAT – CCA – AAT – TCT – AAA – TAT – CTG – AAT – GTA – CAA – ATT
2	TAC –CTA– ACC – TGG – CAC – CTT– CCA– ATT
3	TAC –AGT – TAG– CCA – AAT – ATT
4	TAC – TAG – CCA – TCT – CCC – GCA– TAG– ACT
5	TAC – AAT – CTT– TCT – TAT – ATT
6	TAC – TAG – TCC – CTA– AGT – CTT– AGT– CCC – ATT

Blackline Master #3

Dice number	**Hair Color DNA Sequence**
1	TAC – AGT – AAA – CTT– GAT– CAG – CAT– TAG– ACT
2	TAC – GTT – TGG – TAT – GAT– ATT
3	TAC – GTA – TGG – CAT – CTT– CCT– ATT
4	TAC – AGT – GCA – CGA – CTA– GAT– ATT
5	TAC –GTT– GTA– TAT– TAT – TAG– ACT
6	TAC – GTT– TAT– GTT– TAT– CTA– CTT– ATT
Dice number	**Hair Type DNA Sequence**
1	TAC – AGT – GCA – CAT – CTT– CCT – CGA – GTA – TAG– ACT
2	TAC – TGG – TGT – TAA– TAG– ACT
3	TAC – CTT– GAT– TGG – AAT – GTT – TAG– ACT
4	TAC – GTA – TGG– GAA– TAT – CCA – ATT
5	TAC –TAT – CTT – CCA – ATT
6	TAC – CTA – AGT – TAA– TGT – TAG– ACT
Dice number	**Skin Color DNA Sequence**
1	TAC – GTA – GCA – CAC – CTT– CCC – CGA – ATT
2	TAC – CTT– GAT– TAA– TGT – CTT– ACC – TAG– ACT
3	TAC – CCA – GCA – CGA – AGT – ATT
4	TAC – CCC – CGA – GCA – AAT – TAG – ACT
5	TAC – CCG – CGA – ACC – GTT – ATT
6	TAC – CCT – CTT– TAA– GAA – TAG – ACT
Dice number	**Special Feature Gene: DNA Sequence**
1	TAC – GAT– TGG – CAC – CTT– CCA– TAG– ACT
2	TAC – AAG – TAA– TGT – CTT– ACC– ATT
3	TAC – AAA – AGT – CAA – CAC – CTT– CCT– ATT
4	TAC – TAA– TGT – CTT– ACC– TAG – ACT
5	TAC – GTT – CCT – CGA – CCA – ATT
6	TAC – TAT – GCA – AAA – GAA – ATT

Blackline Master #3

DNA Sequence, Transcription & Translation Data Sheet

Eyes	
Number Rolled	
DNA Sequence: *genotype*	
Transcription: *mRna*	
Translation: *Amino Acid Sequence*	
Trait phenotype:	

Legs	
Number Rolled	
DNA Sequence: *genotype*	
Transcription: *mRna*	
Translation: *Amino Acid Sequence*	
Trait phenotype:	

Arms	
Number Rolled	
DNA Sequence: *genotype*	
Transcription: *mRna*	
Translation: *Amino Acid Sequence*	
Trait phenotype:	

Hair Color	
Number Rolled	
DNA Sequence: *genotype*	
Transcription: *mRna*	
Translation: *Amino Acid Sequence*	
Trait phenotype:	

Hair Type	
Number Rolled	
DNA Sequence: *genotype*	
Transcription: *mRna*	
Translation: *Amino Acid Sequence*	
Trait phenotype:	

Skin Color	
Number Rolled	
DNA Sequence: *genotype*	
Transcription: *mRna*	
Translation: *Amino Acid Sequence*	
Trait phenotype:	

Blackline Master #3

Special Feature Gene	
Number Rolled	
DNA Sequence: *genotype*	
Transcription: *mRna*	
Translation: *Amino Acid Sequence*	
Trait phenotype:	

Drawing of Monster:

Blackline Master #3

Amino Acid Sequence Key for Monster Traits

Eyes	
One Triangle Eye	Methionine – Glutamine – Aspartic Acid – Arginine – Alanine – Serine – Valine – Stop
Two Circle Eyes	Methionine – Histidine – Isoleucine – Threonine – Glutamic Acid – Tryptophan – Valine – Isoleucine Stop
Two Star Shaped Eyes	Methionine –Serine -Threonine– Leucine-Isoleucine – Leucine – Isoleucine– Stop
Three Circle Eyes	Methionine – Glycine – Alanine- Alanine – Phenylalanine - Isoleucine – Stop
Four Circle Eyes	Methionine – Alanine – Leucine – Leucine – Isoleucine - Isoleucine – Stop
The Star Shaped Eyes	Methionine – Glycine – Alanine – Phenylalanine – Phenylalanine - Stop
Legs	
One Short Leg	Methionine – Glutamic Acid – Glycine – Threonine – Serine – Isoleucine - Stop
Two Short Legs	Methionine – Isoleucine – Serine – Tryptophan – Glycine – Stop
Three Short Legs	Methionine – Glutamine – Phenylalanine – Isoleucine – Threonine – Arginine – Stop
One Long Leg	Methionine – Threonine- Glycine – Leucine – Valine - Isoleucine –Stop
Two Long Legs	Methionine – Threonine – Threonine- Leucine – Glycine - Valine – Stop
Three Long Legs	Methionine – Glutamine – Leucine – Phenylalanine – Isoleucine – Valine – Serine – Isoleucine –Stop
Arms	
1 Arm	Methionine – Isoleucine – Glycine – Leucine – Arginine – Phenylalanine – Isoleucine – Aspartic Acid – Leucine – Histidine – Valine – Stop
2 Arms	Methionine – Aspartic Acid – Tryptophan – Threonine – Valine – Glutamic Acid – Glycine – Stop
4 Arms	Methionine – Serine – Isoleucine – Glycine – Leucine – Stop
6 Arms	Methionine – Isoleucine – Glycine – Arginine – Glycine – Arginine – Isoleucine – Stop
2 Wings	Methionine – Leucine –Glutamic Acid – Arginine – Isoleucine – Stop
2 Flippers	Methionine – Isoleucine – Arginine – Aspartic Acid - Serine – Glutamic Acid – Serine – Glycine– Stop

Hair Color	
Purple	Methionine – Serine- Phenylalanine –Proline – Leucine – Valine – Valine – Isoleucine – Stop
Green	Methionine – Proline - Threonine – Isoleucine – Leucine - Stop
Blue	Methionine – Histidine – Threonine – Valine – Glutamic Acid – Glycine – Stop
Orange	Methionine – Serine – Arginine – Alanine – Aspartic Acid – Leucine - Stop
Pink	Methionine –Glutamine – Histidine – Isoleucine – Isoleucine - Isoleucine – Stop
Red	Methionine – Glutamine – Isoleucine – Glutamine – Isoleucine – Aspartic acid – Glutamic Acid – Stop
Hair Type	
Short and straight	Methionine – Serine – Arginine – Valine – Glutamic acid – Glycine – Alanine – Histidine – Isoleucine – Stop
Long and Straight	Methionine – Threonine – Threonine – Isoleucine – Isoleucine – Stop
Short and Spikey	Methionine – Glutamic Acid – Leucine – Threonine – Leucine – Glutamine – Isoleucine – Stop
Long and Wavy	Methionine – Histidine – Threonine – Leucine – Isoleucine – Glycine – Stop
Medium Length and Curly	Methionine – Isoleucine – Glutamic Acid – Glycine – Stop
Long and Spikey	Methionine –Valine– Serine – Isoleucine – Threonine – Isoleucine – Stop
Skin Color	
Yellow	Methionine – Histidine – Arginine- Valine- Glutamine – Glycine – Alanine – Stop
Green	Methionine – Glutamic acid – Leucine – Isoleucine – Threonine – Glutamic Acid – Tryptophan- Isoleucine- - Stop
Blue	Methionine – Glycine – Arginine – Alanine – Serine - Stop
Orange	Methionine – Glycine – Alanine – Arginine – Leucine – Isoleucine – Stop
Red	Methionine – Glycine- Alanine – Tryptophan – Glutamine - Stop
Pink	Methionine Glycine – Glutamic Acid – Isoleucine – Leucine – Isoleucine -Stop
Special Feature Gene	
One Horn	Methionine – Valine – Threonine – Valine – Glutamic Acid –- Glycine – Isoleucine – Stop
Two Horns	Methionine – Phenylalanine – Isoleucine – Threonine – Glutamic Acid – Tryptophan – Stop
Spikes	Methionine – Leucine – Leucine – Threonine – Leucine – Glutamine – Isoleucine – Stop
Tail	Methionine – Isoleucine – Threonine – Glutamine – Tryptophan – Isoleucine - Stop
Large Pointed Teeth	Methionine – Glutamine – Glycine – Alanine - Glycine – Stop
Claws	Methionine – Isoleucine – Arginine – Phenylalanine - Leucine – Stop

Blackline Master #4

Monster Mash Assessment

1. Once the DNA strand "unzips," the RNA polymerase, it
   A. translates the mRNA into proteins.
   B. transfers the mRNA to the ribosomes.
   C. transcribes the DNA strand into mRNA.
   D. makes a copy of the DNA strand for translation.

2. Which statement describes the relationship between transcription and translation?
   A. Ribosomes transcribe the mRNA and then it is translated into DNA.
   B. Ribosomes translate the mRNA and then it is transcribed into DNA.
   C. RNA polymerase transcribes the DNA into mRNA and then it is translated by the ribosomes.
   D. RNA polymerase translates the DNA into mRNA and then it is transcribed by the ribosomes.

3. How does transcription and translation result in the expression of genes?
   A. Transcription makes DNA. Translation uses the DNA to make proteins which expresses the gene.
   B. Translation makes DNA. Transcription uses the DNA to make proteins which expresses the gene.
   C. Transcription reads the DNA to make RNA. Translation uses the RNA to make proteins which expresses the gene.
   D. Translation reads the DNA to make RNA. Transcription uses the RNA to make proteins which expresses the gene.

4. Transcribing and translating a series of genes results in phenotypic differences in organisms. Which of the following is NOT true of these processes?
   A. Specific genotypes as written by codons result in specific phenotypes.
   B. Specific codons code for specific proteins which create phenotypic differences.
   C. When codons are not read exactly as they are written, mutations can cause phenotypic changes.
   D. Codons that have the same nucleotides will code for the same phenotypes, regardless of the order.

5. Why would modeling the process of protein synthesis be important to understanding this concept?
   A. The process of protein synthesis is abstract and microscopic.
   B. The process of protein synthesis is too simplistic to understand without a model.
   C. The process of protein synthesis is best understood through a mathematical model.
   D. The process of protein synthesis can only be represented by a 3-Dimensional model.

6. Why are models important to our scientific understandings? Choose all that apply.
   A. Models can magnify concepts that are too small to witness.
   B. Models remove the danger of studying all scientific concepts.
   C. Models allow us to understand concepts that are very complex.
   D. Models can reduce the size of the phenomenon to a viewable size.

Transcription of Codons Teacher's Key

Dice number	**Eyes** DNA Sequence
1	AUG-GAA-GAC-CGU-GCU-UCA-GUG-UAA
2	AUG-CAU-AUU-ACA-GAA-UGG-GUG-AUU-UGA
3	AUG-UCA-ACC-CUU-AUA-CUA-AUC-UGA
4	AUG-GGA-GCU-GCU-UUU-AUC-UGA
5	AUG-GCU-CUA-CUU-AUG-AUU-UGA
6	AUG-GGU-GCU-UUC-UUU-UAA
Dice number	**Legs** DNA Sequence
1	AUG-GAA-GGU-ACC-UCA-AUC-UGA
2	AUG-AUU-UCA-ACC-GGA-UAA
3	AUG-CAA-UUC-AUU-ACA-AGA-UAA
4	AUG-ACC-GGU-CUA-GUC-AUC-UGA
5	AUG-ACC-ACC-CUG-GGA-GUU-UAA
6	AUG-CAA-UUA-UUU-AUU-GUG-UCA-AUC-UGA
Dice number	**Arms** DNA Sequence
1	AUG-AUA-GGU-UUA-AGA-UUU-AUA-GAC-UUA-CAU-GUU-UAA
2	AUG-GAU-UGG-ACC-GUG-GAA-GGU-UAA
3	AUG-UCA-AUC-GGU-UUA-AUU
4	AUG-AUC-GGU-AGA-GGG-CGU-AUC-UGA
5	AUG-UUA-GAA-AGA-AUA-UAA
6	AUG-AUC-AGG-GAU-UCA-GAA-UCA-GGG-UAA
Dice number	**Hair Color** DNA Sequence
1	AUG-UCA-UUU-GAA-CUA-GUC-GUA-AUC-UGA
2	AUG-CAA-ACC-AUA-CUA-UAA
3	AUG-CAU-ACC-GUA-GAA-GGA-UAA
4	AUG-UCA-CGU-GAU-GUA-UAA
5	AUG-CAA-CAU-AUA-AUC-UGA
6	AUG-CAA-AUA-CAA-AUA-GAU-GAA-UAA
Dice number	**Hair Type** DNA Sequence
1	AUG-UCA-CGU-GUA-GAA-GGA-GCU-CAU-AUC-UGA
2	AUG-ACC-ACA-AUU-AUC-UGA
3	AUG-GAA-CUA-ACC-UUA-CAA-AUC-UGA
4	AUG-CAU-ACC-CUU-AUA-GGU-UAA
5	AUG-AUA-GAA-GGU-UAA
6	AUG-GAU-UCA-AUU-ACA-AUC-UGA

Dice number	**Skin Color** DNA Sequence
1	AUG-CAU-CGU-GUG-GAA-GGG-GCU-UAA
2	AUG-GAA-CUA-AUU-ACA-GAA-UGG-AUC-UGA
3	AUG-GGU-CGU-GCU-UCA-UAA
4	AUG-GGG-GCU-CGU-UUA-AUC-UGA
5	AUG-GGC-GCU-UGG-CAA-UAA
6	AUG-GGA-GAA-AUU-CUU-AUC-UGA
Dice number	**Special Feature Gene**: DNA Sequence
1	AUG-CUA-ACC=GUG-GAA-GGU-AUC-UGA
2	AUG-UUC-AUU-ACA-GAA-UGG-UAA
3	AUG-UUU-UCA-GUU-GUG-GAA-GGA-UAA
4	AUG-AUU-ACA-GAA-UGG-AUC-UGA
5	AUG-CAA-GGA-GCU-GGU-UAA
6	AUG-AUA-CGU-UUU-CUU-UAA

Monster Mash Assessment

1. Once the DNA strand "unzips," the RNA polymerase,
   A. translates the mRNA into proteins.
   B. transfers the mRNA to the ribosomes.
   C. transcribes the DNA strand into mRNA.
   D. makes a copy of the DNA strand for translation.

2. Which statement describes the relationship between transcription and translation?
   A. Ribosomes transcribe the mRNA and then it is translated into DNA.
   B. Ribosomes translate the mRNA and then it is transcribed into DNA.
   C. RNA polymerase translates the DNA into mRNA and then it is transcribed by the ribosomes.
   D. RNA polymerase transcribes the DNA into mRNA and then it is translated by the ribosomes.

3. How does transcription and translation result in the expression of genes?
   A. Transcription makes DNA. Translation uses the DNA to make proteins which expresses the gene.
   B. Translation makes DNA. Transcription uses the DNA to make proteins which expresses the gene.
   C. Transcription reads the DNA to make RNA. Translation uses the RNA to make proteins which expresses the gene.
   D. Translation reads the DNA to make RNA. Transcription uses the RNA to make proteins which expresses the gene.

4. Transcribing and translating a series of genes results in phenotypic differences in organisms. Which of the following is **NOT** true of these processes?
   A. Specific genotypes as written by codons result in specific phenotypes.
   B. Specific codons code for specific proteins which create phenotypic differences.
   C. When codons are not read exactly as they are written, mutations can cause phenotypic changes.
   D. Codons that have the same nucleotides will code for the same phenotypes, regardless of the order.

5. Why would modeling the process of protein synthesis be important to understanding this concept?
   A. The process of protein synthesis is abstract and microscopic.
   B. The process of protein synthesis is too simplistic to understand without a model.
   C. The process of protein synthesis is best understood through a mathematical model.
   D. The process of protein synthesis can only be represented by a 3-Dimensional model.

6. Why are models important to our scientific understandings? Choose all that apply.
   A. Models can magnify concepts that are too small to witness.
   B. Models remove the danger of studying all scientific concepts.
   C. Models allow us to understand concepts that are very complex.
   D. Models can reduce the size of the phenomenon to a viewable size.