INVESTIGATING DNA

INSTRUCTIONS

Overview:

Students will identify the central hypothesis of molecular biology by simulating transcription and translation.

Objectives:

Students will create a model of DNA and successfully complete a simulation of transcription and translation and successfully interpret the Universal Genetic Code Chart.

Targeted Alaska Grade Level Expectations:

Science

[11] SC1.1 The student demonstrates an understanding of how science explains changes in life forms over time, including genetics, heredity, the process of natural selection, and biological evolution by relating the structure of DNA to characteristics of an organism.

Vocabulary:

base pair – nitrogenous bases hydrogen bonded to complementary bases in strands of DNA. DNA contains four base pairs: adenine (A), thymine (T), guanine (G) and cytosine (C). In DNA, A always bonds with T, and G always bonds with C.

codon- a sequence of three nucleotides that code for a specific amino acid

transcription – the synthesis of an mRNA molecule from DNA protein

translation - mRNA molecule travels out of the nucleus and attaches to a ribosome and produces a protein

DNA – deoxyribonucleic acid that consists of two long chains of nucleotides twisted together in a double helix. DNA contains cells genetic information.

messenger RNA (mRNA)- used as a template during transcription that copies a gene and caries the code to a ribosome to produce a protein

transfer RNA (tRNA) – an RNA molecule that transports amino acids to ribosomes for protein production during translation

ribosome- a small particle located in cells that is the site of protein synthesis

universal genetic code- the genetic instructions for a polypeptide chain are written in the DNA as a series of nonoverlapping, three-nucleotide words

amino acid- small molecules that are the building blocks of proteins there are approximately 20 amino acids, 10 of which humans synthesize, the remaining 10 must be obtained in diet

protein- the fundamental component of living cells, includes substances such as enzymes, hormones, and antibodies. Proteins are composed of amino acids.

Materials:

- Red Licorice (Twizzlers) 1 per group
- Black licorice (Twizzlers) 1 per group
- Toothpicks (24 per group)
- Multicolored mini-marshmallows or small foam balls (24 per group)
- STUDENT INFORMATION SHEET: "Codon and Amino Acid Chart"
- STUDENT WORKSHEET: "Amino Acid Bingo"
- STUDENT WORKSHEET: "Building, Transcribing and Translating DNA"

INVESTIGATING DNA

INSTRUCTIONS

Whole Picture:

Each cell of a living organism contains DNA and/or RNA. This genetic information has the potential to produce an individual E coli bacteria, a human, or a ptarmigan depending on the arrangement of four base pairs; adenine (A), thymine (T), guanine (G) and cytosine (C). In DNA, A always bonds with T, and G always bonds with C. In RNA, thymine is replaced by uracil (U), which is chemically similar to thymine. With a few exceptions, such as organisms that reproduce asexually or monozygotic twins, individuals have unique traits caused by unique arrangements of these base pairs. Genetic information can be paired down to the functional level of genes. Every gene code has a unique and specific protein. Each protein has a specialized role within the cell or used elsewhere in the organism. It is important to understand that DNA does not directly code for proteins such as blood type or how much insulin to produce. Instead, there is two step process called transcriptions and translation.

Transcription begins in the cell's nucleus where a strand of messenger RNA (mRNA) copies a segment of DNA called a gene. The mRNA then travels out of nucleus into the cytoplasm of the cell and attaches to a ribosome. Every three base pairs that code for an amino acid are called codons.

Translation occurs outside of a cell's nucleus in the cytoplasm. The mRNA attaches to a small structure composed of protein and RNA called a ribosome. The ribosome then'reads' the mRNA molecule. Transfer RNA (tRNA) floating in the cytoplasm read the mRNA's codon and match up the appropriate amino and then are linked together. These linked amino acids are form a polypeptide. After the ribosome has finished reading the mRNA, the polypeptide molecule joins with other polypeptide molecules and folds into a three-dimensional structure called a protein.

The mRNA codon AUG is the 'on switch' that starts the translation process. Additionally, the translation process ends with the mRNA codon UAA, UGA or UAG, called stop codons. Every living organism from bacteria to whales use the same universal genetic code. See teacher handout, "Universal Genetic Code". These amino acids are arranged in unique sequences to produce protein, which in turn produces genetic traits.

Pre-Assessment:

Quick-write

1. Write on the board: "Why does mRNA copy DNA so DNA doesn't need to leave the nucleus?"
2. Students take 3 minutes to brainstorm. They should write down every idea that they think of.
3. In the last two minutes of the activity, have students take their brainstorm ideas and answer the questions in two complete sentences.
4. Have students share their ideas with their shoulder partner.
5. Have one partner from each pair come to the board and write down one answer to either question.

Activity Procedure:

1. Display overhead of Universal Genetic Code and show students how to read the chart that given a codon (three base pairs) they can produce a specific amino acid.
    a. Point out the codons to start protein synthesis is (AUG, Met) and to stop protein synthesis are, (UAA, UAG, UGA). This means the code for every protein in every organism starts with AUG and ends with UAA, UAG or UGA.
2. Review the process of transcription and translation
3. Instruct students that they will first build a short gene (a segment of DNA that codes for specific protein) and transcribe the information to an mRNA molecule and then finally translate their code to produce a protein.
4. Instruct students to work in groups of two to three
5. Hand out STUDENT WORKSHEET: "Building, Transcribing and Translating DNA" and STUDENT INFORMATION SHEET: "Codon and Amino Acid Chart"

6. Review student instructions from STUDENT WORKSHEET: "Building, Transcribing and Translating DNA"
7. Circulate through student groups and assist when needed
8. Check students work
9. After completing the transcription and translation activity, review student knowledge by playing Amino Acid bingo.
10. Handout STUDENT WORKSHEET: "Amino Acid Bingo". Students should write one unique amino acid or the abbreviation in each box. There are 16 boxes and 20 amino acids, so they should use an amino acid only once.
11. Review the importance of the Universal Genetic Code which all organisms use to produce proteins. Tie this idea in with common decent.
12. Write on the board three random mRNA base pairs (U,A,C,G). Students should use their STUDENT INFORMATION SHEET: "Codon and Amino Acid Chart" to translate the codon into an amino acid.
13. Give students several seconds for each codon.
14. After a student has a bingo, have them write the amino acid or abbreviation next to the codon on the board.
15. Repeat the game. If students require more practice, using the chart.

Extension Ideas:

For more practice with transcription and translation go to this University of Utah's learn genetics page.

Students type in the appropriate mRNA base, choose the correct amino acid for the codon, and produce a short amino acid.

http://learn.genetics.utah.edu/content/begin/dna/transcribe/

Students prepare a 5-slide PowerPoint presentation investigating a genetic disorder. Presentation should include a discussion of the gene or genes involved in the disorder and the biological functions the disorder disrupts. Students should also describe how the disorder is acquired, recessive genes, a mutation etc. And finally, any current research on treatment for the disorder. The University of Utah has a website that details several genetic disorders. Students would choose a disorder and conduct further research.

http://learn.genetics.utah.edu/content/disorders/whataregd/

More advanced students may use the Basic Alignment Search Tool (BLAST) to identify genes based on amino acid sequences. From the main page choose Protein BLAST from the center menu.

Resources:

http://evolution.berkeley.edu/evolibrary/home.php

http://learn.genetics.utah.edu/content/begin/dna/transcribe/

http://nobelprize.org/educational/medicine/dna/index.html

Campell and Reece, Biology 7th edition, 2005

NAME: _____ STUDENT WORKSHEET

AMINO ACID BINGO

1. Write one amino acid in each of the squares in the table below. You may also write "Start" or "Stop" in a square. Do not use an amino acid twice
2. Your teacher will call out a codon (three base pairs)
3. Use your codon chart to determine which amino acid is produced from that codon and put an X through your box.
4. If you cover four across, four down or four diagonal you have a BINGO!

NAME: _____

BUILDING, TRANSCRIBING AND TRANSLATING DNA

In this activity you will:

- construct a short gene that consists of a 12 base pair segment of DNA; and
- simulate transcription by producing the complimentary mRNA molecule and finally Simulate translation by producing a protein.

Building your Gene:

1. Take a red licorice; this is the sugar phosphate backbone of the DNA molecule.
2. Insert 12 toothpick evenly distributed in a straight line along the licorice.
3. Now it is time to add base pairs to the sugar phosphate backbone. In this exercise mini marshmallows or small foam balls will by your base pairs. If you are using mini marshmallows use the following code;

a. White marshmallows = A

b. Pink marshmallows = T

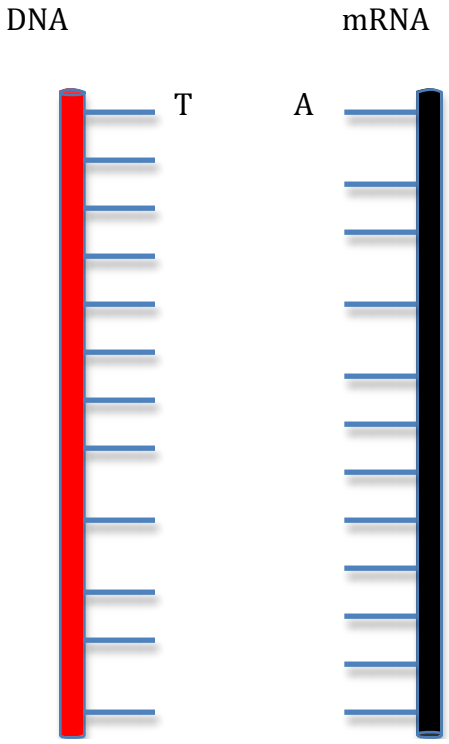
c. Blue marshmallows = C

d. Yellow marshmallows = G

4. If you are using foam balls you will need to label your base pairs as either A, T, C or G.
5. The first three base pairs of your DNA molecule will be T, A, C
6. Choose the next six base pairs and affix them to your DNA molecule.
7. The last three base pairs will be A, T, and C.
8. This is a small gene that is only 12 base pairs out of a full DNA molecule. But is very efficient because when your cell needs the instructions to make a protein it doesn't need to copy the entire DNA molecule, only the gene. The first base is done for you

Transcription:

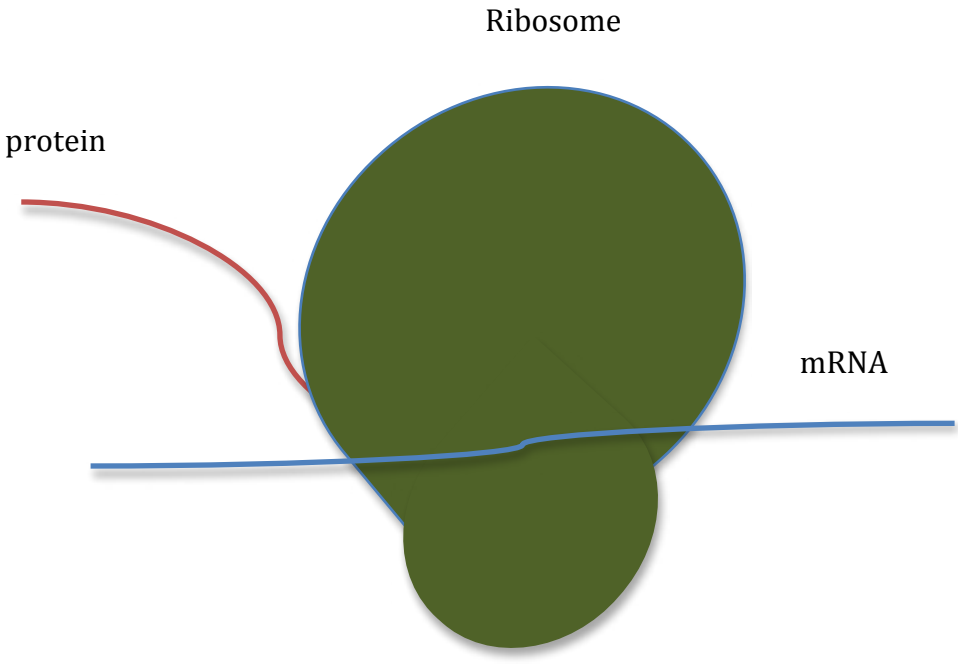
1. In order for your gene to produce a protein it must now be transcribed or copied by a strand of messenger RNA (mRNA). DNA never leaves the nucleus so the messenger RNA must make a copy and carry it out of the cell much like a messenger might copy a part of a building plan and carry it to the construction site.
2. Take a piece of black licorice and Insert 12 toothpick evenly distributed in a straight line along one side. This is the sugar phosphate backbone of your mRNA molecule.
3. The mRNA molecule will match up with your DNA molecule using complimentary base pairs. Remember mRNA molecules substitute uracil (U) for thymine (T) so for an RNA molecule: A=U and C=G. So use the appropriate color of marshmallow or properly labeled foam ball.
4. Make your mRNA molecule with corresponding base pairs. The first base is done for you.



Translation:

1. Take your mRNA molecule and translate it into a protein.
2. Use the STUDENT INFORMATION SHEET: "Codon and Amino Acid Chart" to translate the codons into amino acids.
3. Write your amino acids in the spaces below.

Codon 1 Codon 2 Codon 3 Codon 4



CODON AND AMINO ACID CHART

Second Base of Codon

Universal Genetic Code Chart

First Base of Codon	U	C	A	G	Third Base of Codon
U	Phe	Ser	Tyr	Cys	U
					C
	Leu		STOP		A
			STOP		
				Trp	
					G
C	Leu	Pro	His	Arg	U
					C
			Gin		A
					G
A	Ile	Thr	Asn	Ser	U
					C
			Lys	Arg	A
	Met				G
G	Val	Ala	Asp	Gly	U
					C
			Glu		A
					G

Universal Genetic Code Chart

Second base of codon

First base of codon	U	C	A	G	Third base of codon
U	UUU, UUC — Phenylalanine phe UUA, UUG — Leucine leu	UCU, UCC, UCA, UCG — Serine ser	UAU, UAC — Tyrosine tyr UAA, UAG — STOP codon	UGU, UGC — Cysteine cys UGA — STOP codon UGG — Tryptonphan trp	U C A G
C	CUU, CUC, CUA, CUG — Leucine leu	CCU, CCC, CCA, CCG — Proline pro	CAU, CAC — Histidine his CAA, CAG — Glutamine gin	CGU, CGC, CGA, CGG — Arginine arg	U C A G
A	AUU, AUC, AUA — Isoleucine ile AUG — Methionine met {start codon}	ACU, ACC, ACA, ACG — Threonine thr	AAU, AAC — Asparagine asn AAA, AAG — Lysine lys	AGU, AGC — Serine ser AGA, AGG — Arginine arg	U C A G
G	GUU, GUC, GUA, GUG — Valine val	GCU, GCC, GCA, GCG — Alanine ala	GAU, GAC — Aspartic acid asp GAA, GAG — Glutamic acid glu	GGU, GGC, GGA, GGG — Glycine gly	U C A G

Amino Acid Abbreviation Chart

Amino Acid Name	Abbreviation
Alanine	Ala
Arginine	Arg
Asparagine	Asn
Aspartic acid	Asp
Cysteine	Cys
Glutamic Acid	Glu
Glutamine	Gln
Glycine	Gly
Histidine	His
Isoleucine	Ile
Leucine	Leu
Lysine	Lys
Methionine	Met
Phenylalanine	Phe
Proline	Pro
Serine	Ser
Threonine	Thr
Tryptophan	Trp
Tyrosine	Tyr
Valine	Val