

Name: _____ Period: _____ Date: _____

Simulating Protein Synthesis

Pre-Lab Discussion

Genes are the units that determine inherited characteristics, such as hair color and blood type. Genes are lengths of DNA molecules that determine the structure of polypeptides (the building blocks of proteins) that our cells make. The sequence of nucleotides in DNA determines the sequence of amino acids in polypeptides, and thus the structure of 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 sequences in the form of a complementary RNA molecule. Then the mRNA carries this information in the form of a code to the ribosomes, where protein synthesis takes place. The code, in DNA or mRNA, specifies the order in which the 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 mRNA is "read" on a ribosome, the proper tRNAs arrive in turn and give up the amino acids they carry to the growing polypeptide chain. The process by which the information from DNA is transferred into the language of proteins is known as *translation*.

In this investigation, you will simulate the mechanism of protein synthesis and thereby determine the traits inherited by fictitious organisms called CHNOPS. CHNOPS, whose cells contain only one chromosome, are members of the kingdom *Animalia*. A CHNOPS chromosome is made up of twelve genes (A, B, C, D, E, F, G, H, I, J, K and L), each of which is responsible for a certain trait.

Problem

How can the traits on a particular chromosome be determined? How can these traits determine the characteristics of an organism?

Materials

Blue and orange pencils

Procedure

1. To determine the trait for Gene A of your CHNOPS, fill in the information in the box labeled Gene A in the Data Table. Notice the sequence of nucleotides in DNA. On the line provided, write the sequence of nucleotides of mRNA that are complementary to DNA. Then, on the line provided, write the sequence of nucleotides of tRNA that are complementary to mRNA.
2. In order to determine the sequence of amino acids, match each tRNA triplet with the specific amino acid in Figure 1. Using a – (hyphen) to separate each amino acid number, record this information in the appropriate place in the Data Table.
3. Using Figure 2, find the trait that matches the amino acid sequence. Record this information in the appropriate place in the Data Table.
4. Repeat steps 1 through 3 for the remaining genes (B through H).
5. Using all the inherited traits, sketch your CHNOPS in the space provided.

Figure 1	
Amino Acid Sequence	Trait
20-11-13	Hairless
20-12-13	Hairy
20-14-16	Plump
13-14-16	Skinny
16-2	Four-legged
16-11	Two-legged
12-7-8-1	Long nose
5-7-8-1	Short nose
9-8	No freckles
9-4	Freckles
11-3-2	Blue hair
11-3-3	Orange hair
6-6-10	Male
6-6-14	Female
7-4-9	No Horn
7-20-9	One Horn
7-20-13	Two Horns
5-1-3-19	Tail
5-3-3-19	No Tail
19-2-18	Dwarfism
19-10-18	Normal size
18-20-17	Point Ears
14-20-17	Floppy Ears
15-16	Claws
15-20	No Claws

Figure 2	
tRNA Triplet	Amino Acid Number
CCC	1
CGA	2
CGC	3
AAC	4
GGG	5
AUC	6
AGG	7
AAA	8
UUU	9
CUA	10
GGA	11
GGU	12
UAU	13
CUC	14
AUG	15
AGC	16
GAU	17
UUC	18
AAU	19
ACC	20
x	x
x	x
x	x
x	x
x	x

Data Table - Organism A

Gene A DNA <u>ACC GGT TAT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene B DNA <u>AGC CGA</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene C DNA <u>TTT AAC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____
Gene D DNA <u>GGA CGC CGA</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene E DNA <u>GGG AGG AAA CCC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene F DNA <u>ATC ATC CTA</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____
Gene G DNA <u>ACC CTC AGC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene H DNA <u>AGG AAC TTT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene I DNA <u>GGG CCC CGC AAT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____
Gene J DNA <u>AAT CTA TTC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene K DNA <u>TTC ACC GAT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene L DNA <u>ATG AGC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____

Drawing

Data Table - Organism B

Gene A DNA <u>ACC GGT TAT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene B DNA <u>AGC CGA</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene C DNA <u>TTT AAA</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____
Gene D DNA <u>GGA CGC CGC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene E DNA <u>GGT AGG AAA CCC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene F DNA <u>ATC ATC CTC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____
Gene G DNA <u>TAT CTC AGC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene H DNA <u>AGG ACC TAT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene I DNA <u>GGG CGC CGC AAT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____
Gene J DNA <u>AAU CTA TTC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene K DNA <u>TTC ACC GAT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene L DNA <u>ATG ACC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____

Drawing

Data Table - Organism C

Gene A DNA <u>ACC GGA TAT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene B DNA <u>AGC CGA</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene C DNA <u>TTT AAA</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____
Gene D DNA <u>GGA CGC CGA</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene E DNA <u>GGT AGG AAA CCC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene F DNA <u>ATC ATC CTA</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____
Gene G DNA <u>ACC CTC AGC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene H DNA <u>AGG ACC TTT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene I DNA <u>GGG CCC CGC AAT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____
Gene J DNA <u>AAT CTA TTC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene K DNA <u>CTC ACC GAT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene L DNA <u>ATG ACC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____

Drawing

Data Table - Organism D

Gene A DNA <u>ACC GGT TAT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene B DNA <u>AGC GGA</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene C DNA <u>TTT AAA</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____
Gene D DNA <u>GGA CGC CGC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene E DNA <u>GGG AGG AAA CCC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene F DNA <u>ATC ATC CTC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____
Gene G DNA <u>ACC CTC AGC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene H DNA <u>AGG AAC TTT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene I DNA <u>GGG CGC CGC AAT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____
Gene J DNA <u>AAT CTA TTC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene K DNA <u>CTC ACC GAT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____	Gene L DNA <u>ATG AGC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait _____

Drawing

Data Table - Organism E

Gene A DNA <u>ACC GGA TAT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait_____	Gene B DNA <u>AGC CGA</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait_____	Gene C DNA <u>TTT AAA</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait_____
Gene D DNA <u>GGA CGC CGA</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait_____	Gene E DNA <u>GGG AGG AAA CCC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait_____	Gene F DNA <u>ATC ATC CTA</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait_____
Gene G DNA <u>ACC CTC AGC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait_____	Gene H DNA <u>AGG ACC TTT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait_____	Gene I DNA <u>GGG CGC CGC AAT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait_____
Gene J DNA <u>AAT CGA TTC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait_____	Gene K DNA <u>CTC ACC GAT</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait_____	Gene L DNA <u>ATG AGC</u> mRNA _____ tRNA _____ Amino Acid Sequence _____ Trait_____

Drawing

Analysis and Conclusions

1. What is the difference between transcription and translation?
2. Where does transcription occur in the cell?
3. Where does translation occur in the cell?
4. How many tRNA nucleotides form an anticodon that will attach to the mRNA codon?
5. Suppose you knew the makeup of specific proteins in a cell. How would you determine the particular DNA code that coded for them?
6. How could one change in a DNA nucleotide alter the formation of the translated protein? (An example would be the difference between normal and sickle-cell hemoglobin.)