Title: DNA to Phylogeny

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Abstract: DNA is universal. Every living organism on earth shares the same molecules, including DNA. The same processes are used by all living things in order to grow, reproduce, metabolize, etc. The Human Genome project mapped all of our genes and since then we can determine which genes are responsible for which traits. This has led to amazing medical treatments and will continue to do so. Because of the universality of genetics, genes can be swapped between organisms, evolutionary relationships can be seen, medical advancements have been made. Restriction enzymes have been used to cut and paste genes within an organism's genome. DNA can be extracted and used for medical research, forensics and showing evolutionary relationships. All of this can lead to a better understanding of ourselves and how the rest of the living world works.

Grade Level: 9-12

Learning Objectives: At the end of this unit the students will be able to:

- Draw a model of DNA
- Draw a model of Protein Synthesis
- Extract DNA & run through Electrophoresis
- Use BLAST to: Convert Nucleotides to Protein/Protein to Nucleotides
  Compare homologous genes/proteins of several species
  Produce a phylogenetic tree

Timeframe:

Lecture: 2 class periods for DNA Structure and Protein Synthesis
1 class for the Protein Synthesis Activity
1 class for the DNA extraction
1 class for BLAST

List of Materials:

Power Points for DNA Structure & Protein Synthesis, 6 colors of construction paper & tape, DNA structure lab
Cards & Lab Paper for Protein Synthesis Activity
DNA Extraction: 3 different fruits, test tubes, plastic bags, detergent, water, cups, coffee filter, rubbing alcohol, wooden stirrer
Electrophoresis: Purchase a kit of prepared DNA samples to use
Or you can prepare the following solutions on your own: CTAB, 3ml Chloroform (sub), Isopropanol Alcohol (twice the amount of extract), Ethanol Alcohol 3mls, 5ml TRIS, EDTA,
Electrophoresis & Gel pad, agar, salt, stains, masking tape
Lab paper from AP Lab Manual
BLAST: Computers, Lab paper from College Board AP Lab Book

Procedure for Instructor:

1. Power Point for DNA Structure & Protein Synthesis
2. Make copies of the DNA structure lab paper
3. Distribute construction paper, scissors, tape, rulers and DNA Structure & Replication Lab paper
4. Make the cards for Protein Synthesis Activity
   a. This activity is attached at the end of this lesson plan
   b. Two sets of index cards are needed (I use two different colors)
   c. One set will be a DNA sequence
      i. There are 20 different sequences numbered 1-20 to choose from (I have them do 5)
      ii. I spread them out on a table and label the table "Nucleus" – no card can leave the nucleus

iii. Students need to put the number of the cards they choose on their chart – this makes for easy grading – answer key has all the sentences for each strand

d. One set will be tRNA anticodons and the amino acids will be represented by words
   i. I spread these out on a second table
e. The students must first copy one of the DNA sequences and convert to mRNA and then tRNA
   i. The lab paper has a chart for them to write the DNA, mRNA, tRNA sequences and words that form the protein (sentence)
f. Students will match their anticodons to the tRNA cards to find the right amino acid (word) in order to build a protein (sentence)

5. Copy the lab for the DNA extraction from the Google Drive files from UF Tree of Life Workshop

6. Prepare solutions for the DNA extraction
   a. For the buffer solution, mix 100ml Dawn^{R} dishwashing detergent, 5g NaCl, 900ml distilled water
7. Make copies of the Electrophoresis Lab
   a. https://apcentral.collegeboard.org/pdf/bio-lab9-biorestrictionenzymeanalysisofdna.pdf?course=ap-biology
8. Prepare the solutions for the electrophoresis
   a. Buffer to cover gel during electrophoresis: Add a pinch of salt to 1L of distilled water
9. Prepare gel pad for electrophoresis
   a. Add 1g agar to 100ml water in glass flask
   b. Heat solution using microwave on high until it boils – don't let it foam up and boil over
   c. Remove solution and swirl until agar is completely dissolved
   d. Cool until you can comfortably touch the flask
   e. Place tape across the ends of the gel form and place the comb in the form
   f. Pour cooled agar at least half way up the comb teeth
   g. Immediately rinse flask with hot water to dissolve any agar left
   h. When agar has solidified remove the comb and the tape
   i. Fill the chamber with the buffer solution until it covers the gel pad
   j. Fill chambers with samples mixed with dye
   k. Put the lid on and connect electrode leads to power supply (black to negative/red to positive)
   l. Turn on, adjust voltage to 50-100 volts and run for 10 minutes
   m. Turn off, disconnect leads, remove gel pad for analysis
10. Reserve computers for BLAST
11. Make copies of the BLAST Lab
   a. https://apcentral.collegeboard.org/pdf/bio-lab3-comparingdna.pdf?course=ap-biology
   b. This lab will have teacher and student instructions for working through getting sequences through NCBI and using BLAST to compare and build a phylogenetic tree.
   c. This lab also has discussion and questions for the students

Procedure and General Instructions for Students:

DNA Structure & Replication – Partner Activity

1. Work in partners to construct a model of DNA using construction paper and tape
   After DNA strand is complete, separate the strand and each partner should make a complimentary strand to model DNA replication

Protein Synthesis – Individual Activity

1. Choose 5 DNA sequences and copy the sequences on your paper
2. Convert those sequences to mRNA
3. Using the mRNA as a template, write the anticodons for each tRNA
4. Once all the tRNA's are complete, go to the table with the tRNA cards and find the correct tRNA and copy down the word to make your sentences – Sentences are silly but are grammatically correct and make sense.
5. Answer the questions

DNA Extraction - Partners

1. Choose a fruit and mash it in the plastic bag
2. Follow the lab instructions to separate the DNA

Electrophoresis – Partners

1. Follow the lab instructions to perform the electrophoresis comparison

BLAST

1. Follow the directions on the BLAST lab
2. You will choose a protein to compare between different species
3. Find the DNA sequence on the NCBI website
4. Enter the DNA sequence in BLAST to get the protein sequence
5. Use BLAST to see what other species have the same or similar sequence for that protein
6. Use BLAST to create a phylogenic tree

Assessment Questions: All the activities have questions included

1. What is meant by "the Universality of the Genetic Code"
2. Explain 3 things that are possible because of the universality of the genetic code

Name_____Pd_____

Simulating DNA Replication

Goal: Use a model to investigate how one strand of DNA acts as a template for the other.

Build Connections

Body cells in humans have 46 chromosomes. During mitosis, the chromosomes are duplicated, and each daughter cell gets a copy. How is it that the body can continue to copy DNA again and again with such accuracy? The answer lies in the way the copies are made. Each strand of DNA acts as a template. A template is a model or pattern used to make multiple copies of an object.

Materials

Colored Paper Scissors Ruler Tape

Procedure

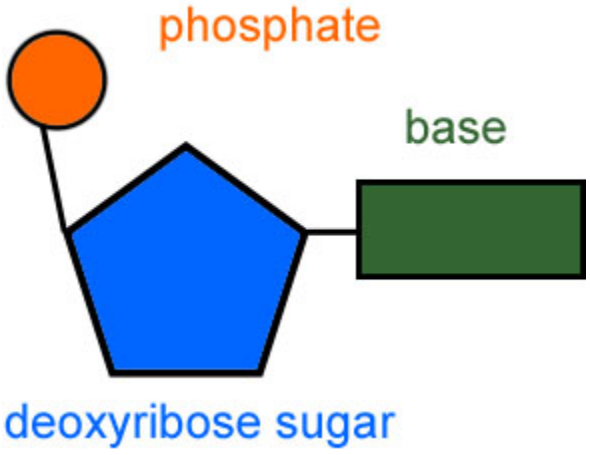
Using the pattern shown below, you will construct paper models of nucleotides to make up a strand of DNA. The pattern is a simplified version of the nucleotide diagram. You will make a single strand of nine nucleotides to use as a template.

Key for Nitrogen Bases

Red = Guanine
Purple = Cytosine
Green = Adenine
Yellow = Thymine

Key for Sugar/Phosphate

Black = Deoxyribose Sugar
Blue = Phosphate



1. Cut out squares and rectangles of colored paper to represent each component of the nucleotides as indicated in the table below:

Component	Color	Number of Pieces	Size
Sugar	Black	36	2 cm x 2 cm
Phosphate	Blue	36	1 cm x 2 cm
Guanine (G)	Red	6	1 cm x 2 cm
Cytosine (C)	Purple	6	1 cm x 2 cm
Adenine (A)	Green	12	1 cm x 2 cm
Thymine (T)	Yellow	12	1 cm x 2 cm

2. Using the pattern above as a guide, tape together 36 nucleotides

3. To model a single strand of DNA, tape the sugar of each nucleotide to the phosphate of the next nucleotide with the nitrogen bases all facing out the same direction, in the following order: G T T A C A A T C

4. Using the strand you made in Procedure #3 make the complimentary strand to make your DNA double stranded.

5. Write "Original" on both of your strands.

6. Separate the strands as DNA does in real life. Make a new complimentary strand for each original strand. Write the word "Duplicate" on each of the new strands.

7. Tape together the strands so that you have 2 exact copies of your DNA.

Conclusion

1. Compare the duplicate strands with the strands in the original DNA molecule. Are their nucleotide sequences identical? How did this happen?

2. Use the models when a cell divides, each daughter cell receives on copy of the original cell's DNA. According to your model, how are the duplicate and original strands divided between the two new daughter cells?

3. Evaluate your model and the simulation of DNA Replication. Identify 3 ways in which what you did simulates the actual process of DNA Replication.

Name _____ Pd _____

Protein Synthesis Lab

Purpose: To demonstrate the process of Protein Synthesis.

Materials:

20 DNA Template Cards: must be kept in the nucleus (teacher's desk)
64 Anti-Codon Cards: taped around the room
Paper to write down the mRNA strand and the tRNA molecules and the sentence
Pen/Pencil

Procedure:

1. Come to the nucleus to retrieve your DNA instructions. YOU MAY NOT TAKE THE DNA INSTRUCTIONS OUT OF THE NUCLEUS.
2. Create a strand of mRNA by writing the RNA sequence to your DNA instructions. Return to your desk.
3. Write out the anti-codon sequence that you will need.
4. Go around the room to find the matching tRNA. Write down the word on the back of the tRNA card.
5. After completing the sentence report to the nucleus to report your sentence. If it is not correct, start over. If it is correct, pick another DNA sequence and repeat the process.

gn.	Card #	Sentence

Evaluation:

1. Explain the role of tRNA.

2. Explain the role of rRNA.

3. What did the words represent?

4. What did the sentence represent?

5. Where was the nucleus? What was in it?

6. Where was the tRNA? What was there?

7. Where did you form the mRNA? Where did you take it?

8. What are 3 things about this activity that simulated Protein Synthesis?

9. What did you do to simulate transcription?

10. What did you do to simulate translation?

11. How did this activity help you understand Protein Synthesis better?

Protein Synthesis Lab

Sentence Key

1. Your mother wears a rubber band.
2. Your mother dresses you funny
3. We have dog breath.
4. The Beatles are the best rock band.
5. An old rubber band breaks when pulled.
6. Biology is the best subject.
7. Drink water every day.
8. I love rock and roll music.
9. We are all demented puppies.
10. Biology is so much fun.
11. Education is the door to the future.
12. Your father wears a dress.
13. Your brother wears nothing.
14. We are all in this together.
15. We must be informed every day.
16. Rock and Roll music is the best.
17. Biology is all around you.
18. Read a little every day.
19. DNA is the code of life.
20. DNA must be read for life.

Protein Synthesis Lab
tRNA

AAA	Your
AUG	In
ACG	Funny
AGA	the
AAU	Dresses
ACA	Breath
AGU	Beatles
AUA	Rock
CUG	Roll
CAA	Old
CAU	Pulled
CCA	When
CCU	Subject
CGA	Drink
CGU	Day
CUA	I
GUG	Brother
GAA	All
GAU	And
GCG	Fun
GCA	So
GGA	Door
GGU	Father
GUA	A
UUG	For
UAA	We
UAU	This
UCG	Be
UCA	Together
UGA	Around
UGU	Little
UUA	DNA
UUC	Code
UUU	Life
UGC	You
UGG	Read
UCC	Must
UCU	Informed
UAC	Promoter (Start)
UAG	Band
GUC	Dress
GUU	Nothing
GGC	To
GGG	Future
GCC	Much
GCU	Education
GAC	Demented
GAG	Puppies
CUC	Love
CUU	Music
CGC	Water
CGG	Every
CCC	Biology
CCG	Is
CAC	Rubber
CAG	Breaks
AUC	Stop Codon (.)
AUU	An
AGC	Best
AGG	Are
ACC	Have
ACU	Dog
AAC	Mother
AAG	Wears

*Key to DNA Fragments (write these sequences on cards):

1. ATGAAAAACAAGGTACACATCTAG
2. ATGAAAAACAATTGCACGTAG
3. ATGTAAACCACTACATAG
4. ATGAGAAGTAGGAGAAGCATAATCTAG
5. ATGATTCAACACATCCAGCCACATTAG
6. ATGCCCCCGAGAAGCCCTTAG
7. ATGCGACGCCGGCGTTAG
8. ATGCTACTCATAGATCTGCTTTAG
9. ATGTAAAGGGAAGACGAGTAG
10. ATGCCCCCGGCAGCCGCGTAG
11. ATGGCTCCGAGAGGAGGCAGAGGGTAG
12. ATGAAAGGTAAGGTAGTCTAG
13. ATGAAAGTGAAGGTTTAG
14. ATGTAAAGGGAATACTATTCATAG
15. ATGTAATCCTCGTCTCGGCGTTAG
16. ATGATAGATCTGCTTCCGAGAAGCTAG
17. ATGCCCCCGGAATGATGCTAG
18. ATGTGGGTATGTCGGCGTTAG
19. ATGTTACCGAGATTCTTGTTTTAG
20. ATGTTATCCTCGTGGTTGTTTTAG