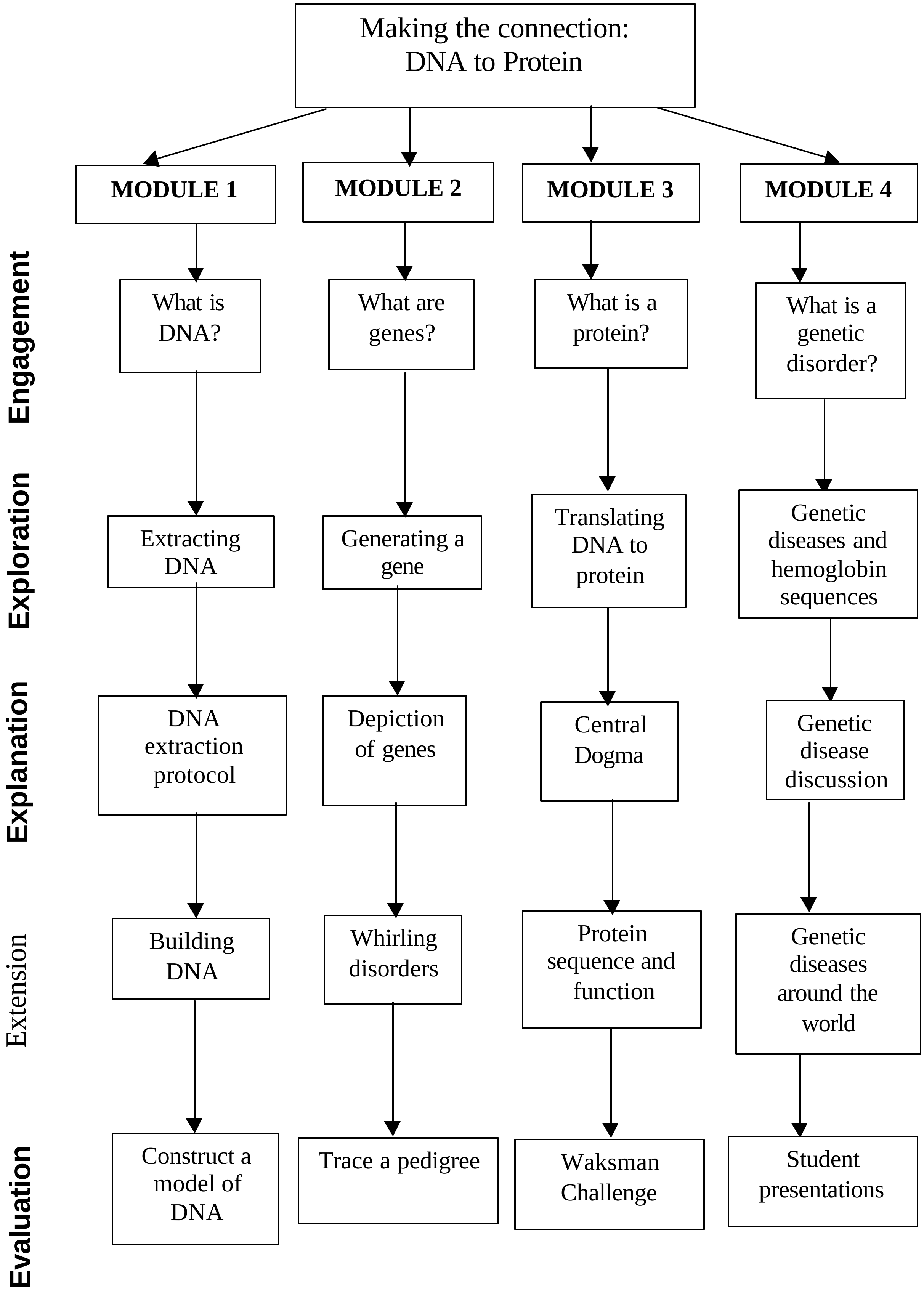

Making the connection:
DNA to Protein
MODULE 1
MODULE 2
MODULE 3
MODULE 4
Engagement
Exploration
Explanation
Extension
Evaluation
What is DNA?
What are genes?
What is a protein?
What is a genetic disorder?
Extracting DNA
Generating a gene
Translating DNA to protein
Genetic diseases and hemoglobin sequences
DNA extraction protocol
Depiction of genes
Central Dogma
Genetic disease discussion
Building DNA
Whirling disorders
Protein sequence and function
Genetic diseases around the world
Construct a model of DNA
Trace a pedigree
Waksman Challenge
Student presentations

Unit Title: Making the connection: DNA to Protein

Unit goal: Students will demonstrate an understanding of the relationships that exist between DNA, genes, and proteins by:

- constructing and implementing a laboratory protocol to extract DNA from the nucleus of an organism.
- describing the structure of the four different nucleotides (sugar, phosphate, base) and how they bond together to form DNA.
- using pedigrees to illustrate genes as pieces of DNA that cause genetic disorders.
- transcribing and translating DNA sequences into protein sequences.
- exploring amino acid sequences of normally functioning proteins and mutated proteins, linking the function of the protein to the amino acid sequence

Grade Level (K-16): High School

General Subject Area(s): Biology (Grades 9-12)

Minimum time required for the unit: 2-3 weeks

Concepts learned across all unit modules:

- Experimental design
- Data organization
- Data analysis
- Central Dogma of Genetics (DNA-RNA-protein) and the application to genetic disorders.

Standards addressed by unit modules: AAAS Project 2061 Benchmarks:

- Genes are segments of DNA molecules. Inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm, or have little or no effect on the offspring's success in its environment (5B, Grades 9-12, 4).

- The work of the cell is carried out by the many different types of molecules it assembles, mostly proteins. Protein molecules are long, usually folded chains made from 20 different kinds of amino-acid molecules. The function of each protein molecule depends on its specific sequence of amino acids and the shape the chain takes is a consequence of attractions between the chain's parts (5C, Grades 9-12, 3).

- The genetic information encoded in DNA molecules provides instructions for assembling protein molecules. The code used is virtually the same for all life forms. Before a cell divides, the instructions are duplicated so that each of the two new cells gets all the necessary information for carrying on (5C, Grades 9-12, 4).

Technology needed in unit modules: Internet Access, Inspiration software, Power Point software

Technology-enhanced instructional strategies employed:

- Technology-enhanced demonstration to explore the cells of the hand to identify where DNA is located (The Tech Museum).
- Technology-enhanced problem solving using Genetic Science Learning Center to trace the gene for a genetic disorder with a pedigree.
- Teleresearch: use of databases and web sites to explore genetic disorders.
- Telecollaboration: use of interpersonal exchange to communicate with subject matter experts such as Francis Crick and to ask questions of medical professionals.

Title of Each Module:

Module 1: Climbing the Ladder of DNA
Module 2: What are genes?
Module 3: Playing a role in protein production!
Module 4: Genetic Disorders- putting the Dogma to work!

Unit Culminating Activity:

This unit is centered around action sequence. Students first must comprehend the individual parts of the genetic system (DNA, genes, protein) and be able to put these parts together by constructing relationships between the them. In the culminating activity, students will comprehend DNA, genes, and protein in a new way by studying a genetic disorder. Students will share their research with the class via electronic means (electronic portfolio, power point, concept mapping using Inspiration, web page, etc.). Once each individual in the class has been given the opportunity to share their work, we will compare and contrast the genetic bases for the diseases. The culminating activity will be assessed by a set rubric.

Unit Author: Heather Pollock

Module Contributors: Peter Petrossian, ED Grid Team (Nicholas Eke, George Morse, Susan Ragan)

MODULE # 1

Module Title: Climbing the Ladder of DNA

Estimated time to complete: 90 minutes

Module objectives:

- Students will construct and implement a laboratory protocol to extract DNA from the nucleus of an organism.
- Students will be able to describe the structure of the four different nucleotides (sugar, phosphate, base) and how they bond together to form DNA.

Concept(s) learned in this module:
The structure of the DNA is arranged in a double helix of paired nucleotide sequences (A-T, C-G). DNA is located in the nucleus of eukaryotic organisms.

Standards addressed in this module (AAAS Project 2061):
The genetic information encoded in DNA molecules provides instructions for assembling protein molecules. The code used is virtually the same for all life forms (5C, Grades 9-12, 4).

Technology-enhanced instructional strategies utilized in this module:

- Electronic Appearance of Francis Crick (http://www.accessexcellence.org/AE/AEC/CC/crick.html)
- The Tech Museum (http://www.thetech.org/exhibits_events/online/genome/intro4.html)
- Genetic Science Learning Center (**GSLC)** (http://www.genetics.utah.edu/section5/sc5afrm.html) Click on: Basic Genetics, What is DNA?
- Inspiration Software (http://www.inspiration.com)

MODULE OVERVIEW

Components	Brief description of module activities	Student Grouping	Materials/ Technology
Engagement	DNA is like a twisting ladder… (Rensberger, Life Itself, 1996). Graphic Organizer constructed using Inspiration. Read a portion of an interview with Francis Crick (web-wacked from www.accessexcellence.com).	Class	Rope ladder and graphic organizer.
Exploration	Guided Inquiry- How can we extract DNA from the nucleus of a cell? Students will hypothesize about which ingredient (detergent, meat tenderizer, alcohol) to use and why. Students	Groups	Detergent Meat Tenderizer Alcohol

	will outline and implement laboratory protocol. <u>DNA Exploration</u>- Explore the cells of the hand to identify where DNA is located (The Tech Museum).		Internet Access
Explanation	<u>Class Discussion</u>- Who was able to successfully extract DNA from a cell? What protocol did you use and why? What does the extract DNA look like? What did the DNA from the hand cells look like under an electron microscope?	Class	
Extension	<u>Building DNA</u>- Students will build a DNA molecule by manipulating nucleotides (GSLC). Students will print out their molecule of DNA along with the answers to the complementary questions.	Individual	Internet Access
Evaluation	<u>DNA Extraction</u>- StudentS will justify why and when they used ingredients to separate DNA from the nucleus of an organism. Lab protocol will be submitted with extracted DNA. <u>Building DNA</u>- Each group of students will receive a smaller version of a rope ladder. Students will convert rope ladder into a model of DNA by attaching sugars, phosphates, and bases.	Groups Groups	 Rope ladders Colored paper Glue

Expected module outcomes:

- Students will have implemented their designed protocol for DNA extraction. Those students who were successful in designing and implementing their protocol will have DNA as a product. Students who were not successful the first time will redesign their laboratory protocol.
- Students will produce a DNA molecule using GSLC. Students will also submit answers to questions that correspond to “Building a DNA molecule”.

Performance-based assessment of module outcomes:

- Students will submit laboratory protocol and extracted DNA.
- Students will construct a model of DNA using a twisted rope ladder as the skeleton on which to put sugars, phosphates, and bases.

MODULE # 2

Module Title What are genes?

Estimated time to complete: 90 minutes

Module objectives:

- Students will describe genes as segments of DNA.
- Students will use a pedigree to trace the gene that is causing a genetic disorder.
- Students will become familiar with using a database to extract information about genomes.

Concept(s) learned in this module:

- The genetic code is contained in the structure of the DNA molecule.
- Genes are the pieces of DNA that code for a specific protein.

Standards addressed in this module (AAAS Project 2061):
Genes are segments of DNA molecules (5b, Grades 9-12, 4).

Technology-enhanced instructional strategies utilized in this module:

- ICanDoThat (http://www.eurekascience.com/ICanDoThat/bacteria_cells.htm)
- National Center for Biotechnology Information (http://www.ncbi.nlm.nih.gov/blast/)
- Genetic Science Learning Center (GSLC) (http://www.genetics.utah.edu/section5/sc5afrm.html click on: genetic disorders/thematic units/deafness/map a gene)

MODULE OVERVIEW

Components	Brief description of module activities	Student Grouping	Materials/ Technology
Engagement	ICanDoThat- Fictional characters will guide students through the world of DNA. The first three sections (Introduction, Structure, and Genes) are a must read. The remaining two sections (Replication and Detail) will add insight are worthwhile if time permits.	Class	Internet Access-eurekascience
Exploration	National Center for Biotechnology BLAST- students will type in a random sequence of nucleotide bases and generate a portion of a gene which produces a significant alignment with the gene of an organism.	Groups	Internet Access-NCBI
Explanation	Power Point presentation using descriptive pictures, gathered from the internet, to depict genes as portions of DNA.	Class	Power Point Presentation

Extension	What is the particular gene that is causing the whirling disorder (as seen in the pedigree)? Students will align puzzles with pedigree to find the gene that leads to the whirling disorder.	Groups	Internet Access-GSLC
Evaluation	Students will be given a unique pedigree and asked to trace the gene that is causing the genetic disorder.	Individual	

Expected module outcomes:

- Students will be able to search the BLAST database for nucleotide sequences and match those sequences to genomes of organisms (all organisms have the same genetic code!!!). The ability to work with, and become aware of, the extensive genetic research that exists in databases will be useful in the next modules.
- Students will use their problem solving skills to trace a gene for a disorder by using a pedigree.

Performance-based assessment of module outcomes:

Students will examine a pedigree and trace the gene that is causing a particular genetic disorder.

MODULE # 3

Module Title: Playing a role in protein production!

Estimated time to complete: 90 minutes

Module objectives:

- Students will be able to describe the process of transcription, including the definition of codon.
- Students will be able to describe translation as mRNA into amino acid sequences.

Concept(s) learned in this module:
DNA is transcribed into mRNA in the nucleus. The single stranded mRNA molecule has slightly different base-pairing rules than DNA (U-T, C-G). When mRNA leaves the nucleus it travels into the cytoplasm to find a free ribosome where translation occurs. mRNA is translated into a string of amino acids.

Standards addressed in this module (AAAS Project 2061):

- Protein molecules are long, usually folded chains made from 20 different kinds of amino-acid molecules (5C, Grades 9-12, 3).
- The genetic information encoded in DNA molecules provides instructions for assembling protein molecules (5C, Grades 9-12, 4).

Technology-enhanced instructional strategies utilized in this module:
Waksman Challenge (http://avery.rutgers.edu/WSSP/Challenge/howitworks.html)

MODULE OVERVIEW

Components	Brief description of module activities	Student Grouping	Materials/ Technology
Engagement	Given a sequence of DNA, can we make a protein? Model- Teacher involves students in the process of transcription and translation by assigning roles (nucleus, ribosomes, cytoplasm, DNA, mRNA, tRNA, etc.)	Class	
Exploration	Inside the Cell – the classroom is set up like a cell. Students will navigate around the cell (classroom) to transcribe and translate DNA into a protein. The end product will be a sentence which will represent a protein.	Individual	
Explanation	Central Dogma (DNA-RNA-protein) *the explanation of transcription and translation may better serve the students if it appears before the exploration.	Class	worksheet

Extension	Waksman: Brain Drain Challenge 2 Protein Sequence and Function.	Individual	Internet Access- Rutgers
Evaluation	Students will be evaluated on translating the given DNA sequence from the Waksman Challenge into an amino acid sequence. Students will deduce the function of this protein by relying on the skills they built by using the genetic databases in module 2.	Individual	Internet Access- BLAST Rutgers

Expected module outcomes:
Students will be able to transcribe and translate a sequence of DNA into a protein. By navigating through the cell (classroom), students will match the organelle with the location of the particular process of transcription and translation.

Performance-based assessment of module outcomes:

- Students will discuss how they translated the DNA sequence, posed by the Waksman Challenge, into an amino acid sequence.
- Students will propose what the function of the protein is by conducting teleresearch using databases and other web-based tools of choice.

MODULE # 4

Module Title: GENETIC DISORDERS: putting it all together!

Estimated time to complete: 3 blocks of 90 minutes

Module objectives:

- Students will explore amino acid sequences of normally functioning proteins and mutated proteins.
- Students will link the function of the protein to the amino acid sequence.
- Student will look indepth at a specific genetic disorder to determine the (symptoms, possible treatments, nucleotide and corresponding amino acid sequences, associations, etc.)

Concept(s) learned in this module:

- Genetic disorders are harmful alterations in a genetic sequence that have been inherited from past generations.
- The genetic information encoded in DNA has assembled a protein with an abnormal amino acid sequence and therefore an altered function.

Standards addressed in this module (AAAS Project 2061):

- Genes are segments of DNA molecules. Inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm, or have little or no effect on the offspring's success in its environment (5B, Grades 9-12, 4).
- The function of each protein molecule depends on its specific sequence of amino acids and the shape the chain takes is a consequence of attractions between the chain's parts (5C, Grades 9-12, 3).
- The genetic information encoded in DNA molecules provides instructions for assembling protein molecules (5C, Grades 9-12, 4).

Technology-enhanced instructional strategies utilized in this module:

Teleresearch- students will explore a genetic disease using the World Wide Web

http://hotbot.lycos.com
http://www.icomm.ca/geneinfo/definitions.html
http://www.kumc.edu/gec/support/
http://www-ed.fnal.gov/help/97/peretz/inherit/biology.html
http://www.cdc.gov/genetics/hugenet/

Databases- Workbench (http://workbench.sdsc.edu/)
NCBI (http://www.ncbi.nlm.nih.gov/entrez/)

MODULE OVERVIEW

Components	Brief description of module activities	Student Grouping	Materials/ Technology
Engagement	Story of boy with sickle cell anemia (Rensberger, Life Itself, 1996).	Class	
Exploration	Direct Instruction- teacher models the research and presentation of a genetic disease (sickle cell anemia). Student Directed- students explore a genetic disease of choice using the outlined rubric.	Class Pairs or Individual	Concept Map Normal and abnormal hemoglobin sequences
Explanation	Students make connections between normal and abnormal nucleotide and amino acid sequences for their disease. What are the resulting symptoms due to the change in amino acid sequence? Are there any treatments available? What associations are available to help people with a genetic disorder?	Pairs or Individual	
Extension	Explore different parts of the world to investigate where the particular genetic disorder is most prevalent? Why might that be?	Pairs or Individual	
Evaluation	Rubric for student presentation.	Pairs or Individual	Electronic Portfolio Power Point Internet Access

Expected module outcomes:

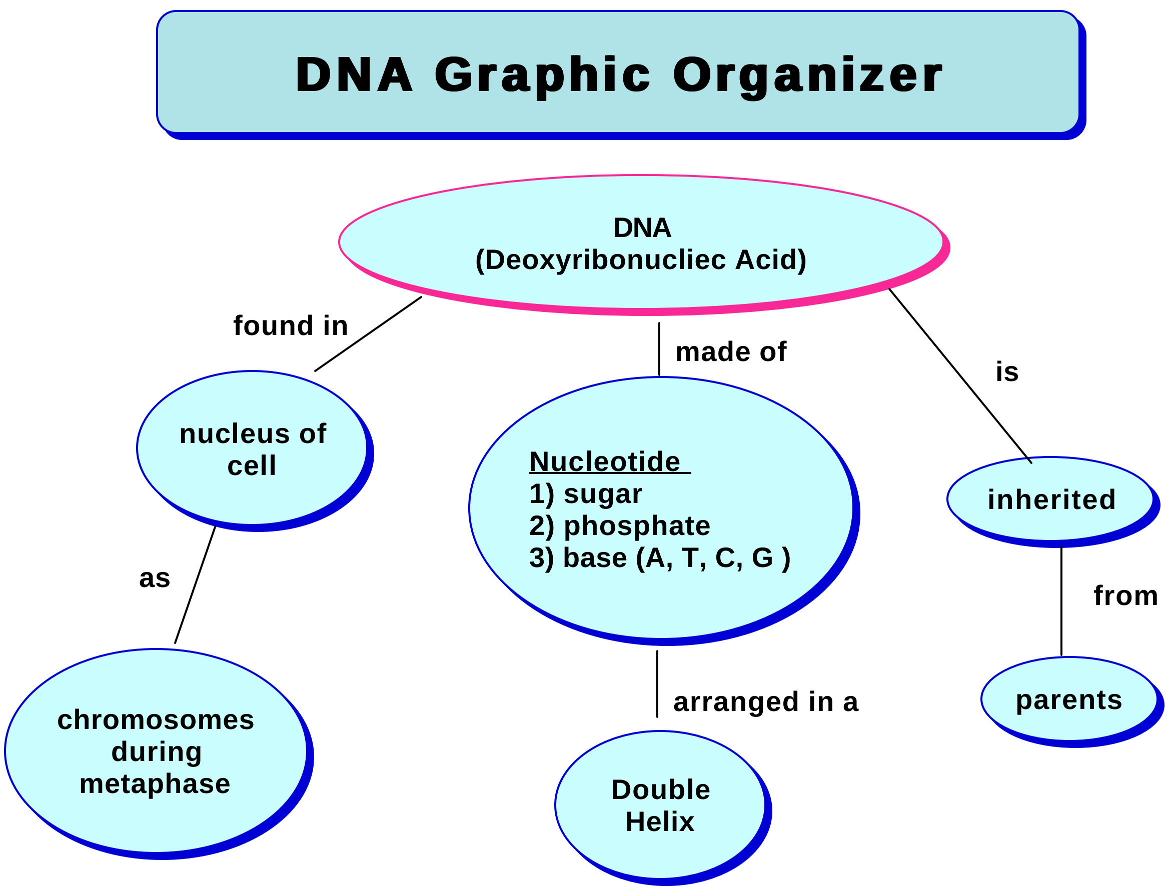
- Students will make the connection between DNA, gene, and protein.
- Students will use this knowledge and apply it to an exploration of a particular genetic disorder.
- Students will compare and contrast sequences of DNA to establish how a change in genetic sequence has profound effects on how proteins function.

Performance-based assessment of module outcomes:
Students will be evaluated on their research and presentation of a genetic disease of choice.

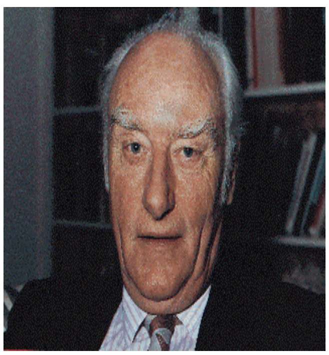
MODULE 1: ENGAGEMENT

DNA is like a twisting rope ladder…

Think of [DNA] like sawing down through the middle of the wooden rungs of a rope ladder. The result is two single ropes with half-rungs hanging off each rope. Only one rope (one strand of the double helix) carries the genetic code. The other usually acts simply as a "keeper", a complimentary strand that fits against the coding strand. In all DNA the rope part of the ladder is the same up and down its length – an alternation of sugar and phosphate molecules. The half-rungs, which stick out from the sugars, are the interesting parts. They serve as four letters of the genetic alphabet – four different kinds of molecules abbreviated A, T, G, and C for adenine, thymine, guanine, and cytosine. The four molecules are called bases (Rensberger, 1996).



Narrator*: The 1953 discovery by Dr. Francis Crick and JamesWatson of the structure of the huge DNA molecule, the molecule which we now know stores the genetic information for all life, has been cited by many scientists as the single most important development in biology of the 20th century. Watson and Dr. Francis Crick's breakthrough, and the ensuing investigations into the nature of the genetic code and its transmission of information from generation to generation, have redefined the study of genetics and virtually created the science of molecular biology. For their work James Watson and Dr. Francis Crick, along with physicist Maurice Wilkins, were awarded the 1962 Nobel Prize in Medicine. Dr. Francis Crick recalls the award with his characteristic good humor.
Dr. Francis Crick: Well, I certainly didn't think I would win the prize. It's unclear whether Jim was thinking about it. He says in his book he was, but he never in those years mentioned it to me or to any other of my colleagues that I know of. It never occurred to me that it was prize worthy until about three years later when someone mentioned it to me. And it indeed struck me this is just the sort of thing people get prizes for.



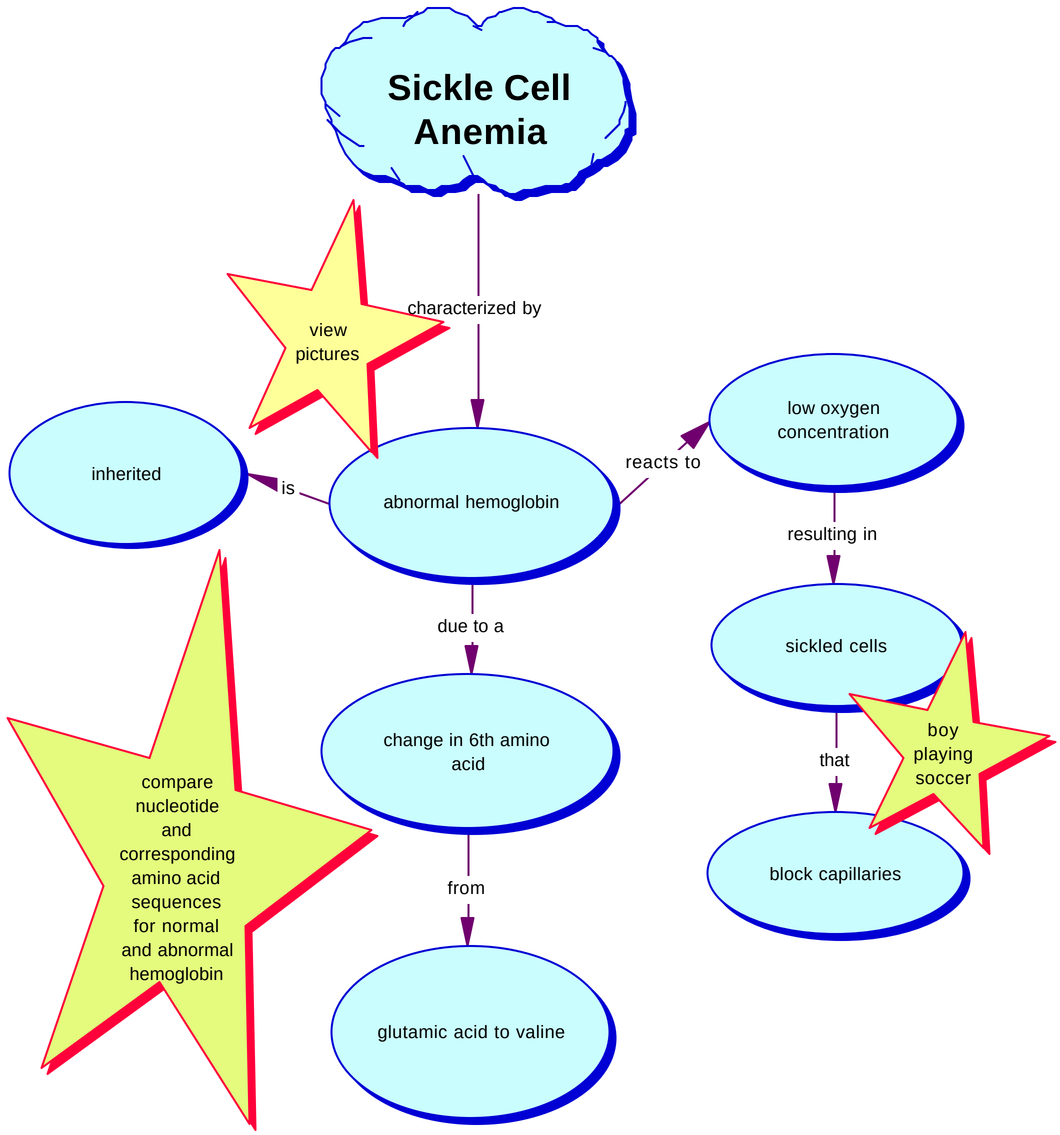
*Taken from www.accessexcellence.com

MODULE 4: ENGAGEMENT

A little boy races across a soccer field, gets to the ball, and kicks with all his might. Minutes later he is rolling on the ground in tears, his legs burning with pain. He does not know it, but he could die from what is happening inside the cells of his legs. His exercise has triggered a chain reaction of that is turning his normally life-giving red blood cells into killers. The usually doughnut-shaped oxygen-carriers are being twisted into the shapes of crescents or sickles. Like nails trying to flow throw a garden hose, they jam. In the narrow capillaries, only wide enough to let red blood cells through one at a time, the sickled cells block the flow of blood. The cells of the child's leg muscle, in need of oxygen, are the first to die. Because the blood cannot flow fast enough, the muscle cells are not getting enough oxygen. They are suffocating and they begin to die.

(Rensberger, Life Itself, 1996)

MODULE 4: EXPLORATION



Using Databases to find the normal and abnormal nucleotide and corresponding amino acid sequences for proteins.

OPTION 1

1) Go to Entrez at http://www.ncbi.nlm.nih.gov/entrez/
2) Click on "nucleotide" or "protein"(depending on the sequence you wish to find).
3) In the "search for" box type in the protein name that you wish to find.
4) Click on "Go". Various types of requested sequences will appear.
5) Choose the desired accession number to attain the required sequence.

OPTION 2 (Directions provided by Angelique Bosse, teacher at Montgomery Blair High School)

1) Go to http://workbench.sdsc.edu/
2) Enter Biology Workbench 3.2 and enter user name and password, click OK.
3) Scroll down to "Protein tools" or Nucleic tools" (depending on the sequence you wish to find).
4) Select "Ndjinn-Multiple Database Search" and click "Run".
5) In the text box type in the name of the protein you wish to find. Choose a database such as SWISSPROT by clicking in the white box.
6) Click on "Search" followed by "Show Records" to view the sequences of interest.

DNA for NORMAL Beta Chain Hemoglobin Protein

atggtgcacctgactcctgtggagaagtctgccgttactgccctgtggggcaag
gtgaacgtggatgaagttggtggtgaggccctgggcagg

ctgctggtggtctacccttggacccagaggttctttgagtcctttggggatctgtcc
actcctgatgctgttatgggcaaccctaaggtgaaggc

tcatggcaagaaagtgctcggtgcctttagtgatggcctggctcacctggacaa
cctcaagggcacctttgccacactgagtgagctgcact

gtgacaagctgcacgtggatcctgagaacttcaggctcctgggcaacgtgctg
gtctgtgtgctggcccatcactttggcaaagaattcaccc

caccagtgcaggctgcctatcagaaagtggtggctggtgtggctaatgccctg
gcccacaagtatcactag

DNA for MUTATED Beta Chain Hemoglobin Protein

atggtgcacctgactcctgaggagaagtctgccgttactgccctgtggggcaa
ggtgaacgtggatgaagttggtggtgaggccctgggcaggc

tgctggtggtctacccttggacccagaggttctttgagtcctttggggatctgtcca
ctcctgatgctgttatgggcaaccctaaggtgaaggctc

atggcaagaaagtgctcggtgcctttagtgatggcctggctcacctggacaac
ctcaagggcacctttgccacactgagtgagctgcactgtg

acaagctgcacgtggatcctgagaacttcaggctcctgggcaacgtgctggtc
tgtgtgctggcccatcactttggcaaagaattcacccca

ccagtgcaggctgcctatcagaaagtggtggctggtgtggctaatgccctggc
ccacaagtatcactag

NORMAL Amino Acid sequence for Beta Chain Protein of Hemoglobin

MVHLTPEEKSAVTALWGKVNVDEVGGEALGRLLVVYP
WTQRFFESFGDLSTPDAVMGNPKVKA

HGKKVLGAFSDGLAHLDNLKGTFATLSELHCDKLHVDP
ENFRLLGNVLVCVLAHHFGKEFTPPVQA

AYQKVVAGVANALAHKYH

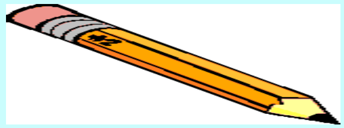
Mutated Amino Acid Sequence for Beta Chain Protein of Hemoglobin

MVHLTPVEKSAVTALWGKVNVDEVGGEALGRLLVVYP
WTQRFFESFGDLSTPDAVMGNPKVKA

HGKKVLGAFSDGLAHLDNLKGTFATLSELHCDKLHVDP
ENFRLLGNVLVCVLAHHFGKEFTPPVQA

AYQKVVAGVANALAHKYH

MODULE 4: EVALUATION



Rubric for Genetic Disorder Project

Presentation (5 minutes in class)

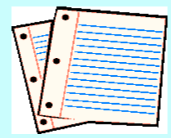
Content is presented in a clear and concise manner (concept map, graphic organizer, poster, power point, collage, etc.).

15 Points

Discuss the associations that are available to help people with genetic disorders. Were you able to telecollaborate with someone with the disease or interview a doctor who has treated patients with genetic disease? Explain.

5 Points

Report



Comparison made between the nucleotide and amino acid sequences for normal and abnormal proteins.

10 Points

Symptoms and possible treatments should be discussed adequately (some diseases will have a greater research base than ...

10 Points

Explore different parts of the world to investigate where the genetic disease is most prevalent. Propose an explanation as to why a particular genetic disease is rare in some parts of the world and rampant in others.

5 Points

Students show that research and presentation are technology enhanced. Cite use of World Wide Web, databases, electronic portfolio, inspiration software, power point, telecollaboration, etc.

5 Points