HASPI Medical Biology Lab 02
Genes, Proteins, and Disease
NGSS HS-LS1-1
Teacher Information

Description

a. Genes, Proteins, and Disease

Students will use normal and mutated DNA sequences to simulate/model transcription, translation, and resulting protein structure and function. Students tape together mRNA nucleotides transcribed from a DNA strip, then match tRNA templates to codons and determine the amino acid sequence represented by different colored beads. The beads are ordered on pipe cleaners and then folded into a functional protein. Students test the functionality of the normal and mutated proteins.

Next Generation Science/Common Core Standards

Students who demonstrate understanding can:

HS-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

a. ***Medical Application**: Comparison of normal and abnormal DNA of the CFTR gene that results in cystic fibrosis. Simulate/model DNA → mRNA → amino acids → protein structure and function of the normal and abnormal proteins.*

HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

a. ***Medical Application**: Passing of the normal or abnormal CFTR DNA/gene from parent to offspring to produce normal or abnormal proteins, which may result in cystic fibrosis.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **Asking Questions and Defining Problems** • Ask questions that arise from examining models or a theory to clarify relationships.	**LS1.A: Structure and Function** • Systems of specialized cells within organisms help them perform the essential functions of life. • All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells (linked to HS-LS3-1.) **LS3.A: Inheritance of Traits** • Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes are used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.	**Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-band: **HS.LS3.A**

Articulation to DCIs across grade-levels: ***MS.LS1.A, MS.LS3.A, MS.LS3.B***

Common Core State Standards Connections:

ELA/Literacy –

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to Important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

Essential Question

By the end of this activity students will be able to:

- explain how the structure of DNA determines the structure of proteins.
- model protein carrying out essential functions within cells.
- clarify the relationship between DNA and chromosomes coding for characteristic traits.
- model the difference between normal and mutated DNA in the proteins produced.
- Describe the impact of cystic fibrosis on individuals who inherit a mutated CFTR gene.

Time

This is an extensive activity summarizing the central dogma (DNA → RNA → protein.) If you are planning on having the students cut out the nucleotides and templates in class, plan on at least four 55-60 minute class periods. You could have the students cut out the templates at home to save some time. The thorough coverage and opportunity for students to model this complex process will be worth the time spent.

Estimated Time	***Actual Time*** *(please make note below)*
Part A: Set-Up 30-45 minutes	
Part B: Transcription 55-60 minutes	
Part C: Translation 55-60 minutes	
Part D & E: Protein Folding & Function 45-55 minutes	

***Note**: Share the actual time on the forum (**www.haspi.org**) or at HASPI curriculum conference*

Materials

HASPI is a grant-funded project and on occasion we are able to provide supplies to participating sites. Provided supplies are for 10 lab groups or 40 students. If we are unable to provide supplies, the company, item number, and approximate cost have been included.

Supply	Provided (P) or Needed (N)	Quantity	Company/ Item #	Estimated Cost
Normal DNA template	P	10	HASPI	cost of copies
Abnormal DNA template	P	10	HASPI	cost of copies
mRNA Nucleotides template	P	10	HASPI	cost of copies
tRNA Template	P	10	HASPI	cost of copies
"The Amino Acids" chart	P	10	HASPI	cost of copies
RNA Polymerase template	P	20	HASPI	cost of copies
Ribosome template	P	20	HASPI	cost of copies
Cell Membrane template	P	1	HASPI	cost of copies
Masking tape	P	1 roll	any office store	$1.99
Large marble	P	1	LandofMarbles/ chin103	$0.29
Glue dots ½"	P	120	ConsumerCrafts/ TW3783	$3.77
Pipe cleaners	P	22	ConsumerCrafts/ 10166-10	$1.97
25 mm Starflake bead - clear	P	22	ConsumerCrafts/ 06120-3-T1	$2.97

Pony beads – pink opaque	P	50	PonyBeadStore/SP64304	$0.99
Pony beads – hot pink	P	50	PonyBeadStore/SP64305	$0.99
Pony beads - red	P	50	PonyBeadStore/SP64301	$0.99
Pony beads – jade pearl	P	50	PonyBeadStore/SP64434	$0.99
Pony beads – kiwi marbled	P	50	PonyBeadStore/SP64407	$0.99
Pony beads – navy blue	P	50	PonyBeadStore/SP64315	$0.99
Pony beads – burgundy	P	50	PonyBeadStore/SP64393	$0.99
Pony beads – coral	P	50	PonyBeadStore/SP64382	$0.99
Pony beads – orange opaque	P	50	PonyBeadStore/SP64308	$0.99
Pony beads – yellow opaque	P	50	PonyBeadStore/SP64310	$0.99
Pony beads – sage	P	50	PonyBeadStore/SP64400	$0.99
Pony beads – light blue	P	50	PonyBeadStore/SP64313	$0.99
Pony beads – dark teal	P	50	PonyBeadStore/SP64435	$0.99
Pony beads – lilac	P	50	PonyBeadStore/SP64414	$0.99
Pony beads – plum	P	50	PonyBeadStore/SP64370	$0.99
Pony beads – white	P	50	PonyBeadStore/SP64319	$0.99
Pony beads – clear	P	100	PonyBeadStore/SP64340	$0.99
Pony beads – gray	P	50	PonyBeadStore/SP64320	$0.99
Pony beads – black	P	50	PonyBeadStore/SP64318	$0.99
Scissors	N	20	-	-

Company Contact Information:			
HASPI www.haspi.com Download free online	Consumer Crafts www.consumercrafts.com 888-552-7238	Pony Bead Store www.ponybeadstore.com	Land of Marbles www.landofmarbles.com 718-352-9010

Common Student Misconceptions

The following is a list of possible misconceptions that students experience. Please feel free to add any additional misconceptions students experienced during this activity to be better prepared for the future use of this lab/activity.

- The link between transcription, translation, and protein function is often difficult for students. Reinforcing the link between each of these processes throughout this activity is crucial to understanding.
- Students may be confused on DNA vs. RNA structure (why is thymine in DNA and uracil in RNA?).
- Proteins and protein function can cause confusion. Make sure every student has the opportunity to observe the function of the normal simulated protein compared to the mutated simulated protein.

Additional Misconception Notes:

Guiding Questions

These questions are meant to support discussion of the concept/standard.

- Why is it important that DNA is copied or transcribed correctly?
- Why is mRNA used for translation rather than just translating straight from DNA?
- How does the structure of DNA determine the structure of a protein?
- What are some of the essential functions of proteins within the body?
- How could a change in the structure of a protein impact its function?
- If an individual inherits a single mutated CFTR gene from a parent, what are the chances they will have cystic fibrosis? Explain your answer.

The Task/Response System

Through multiple discussions and suggestions HASPI has decided to use the task/response system for lab procedures and directions. The response column can be utilized to:

- provide space for answers to questions provided in the task column.
- provide space for data/observation records.
- provide images to help relay a step.
- support reinforcement of the standards/concepts immediately during the lab investigations.
- any other way you see fit to use it!

Additional Information

Information	Page #	Location
Lab 02: Genes, Proteins, and Disease		
The background includes information to help students understand the activity and would be best used as a pre-lab assignment. Students should already have a decent grasp of DNA structure and function before completing this activity.	Pages 89-92	Background
This is a simulation and not the actual sequence for the CFTR gene. In actuality there are more than 1500 possible mutations that cause varying severities of CF.	Page 93	Background
This activity is setup for groups of 4 with a pair of students following the lab with the normal gene and the other pair following the lab with the mutated gene. Both pairs will have the same experience creating the gene and will compare their end products at the conclusion.	Page 94	Part A
You will need to glue or tape the marble onto "The Cell Membrane" sheet, and tape that up on the wall or board somewhere in the classroom. Students will be testing their proteins to see if they are able to hold onto the marble and attach to the cell membrane.	Page 100	Part E
The connections and applications are meant to reinforce the concept(s) within the NGSS/CCSS practices and connections. Each question is extensive and requires either research, critical thinking, or graphing. Feel free to assign or allow students to choose any or all, but realize each is a lengthy assignment in itself.	Page 102-103	Connections & Applications

Expected Results

Normal mRNA and Amino Acid Sequence of CFTR Gene:

Methionine AUG TAC	Alanine GCG CGC	Proline CCU GGA	Lysine AAG TTC	Glycine GGU CCA	Serine UCC AGG	Arginine AGG TCC	Asparagine AAC TTG
Isoleucine AUC TAG	Histidine CAC GTG	Glycine GGA CCT	Proline CCU GGA	Valine GUC CAG	Phenylalanine UUU AAA	Glycine GGC CCG	Threonine ACA TGT
Arginine AGG TCC	Asparagine AAU TTA	Isoleucine AUC TAG	Leucine UUG AAC	Glycine GGG CCC	Glutamate GAA CTT	Glutamine CAA GTT	Aspartate GAC CTG
Glycine GGC CCG	Lysine AAG TTC	Arginine AGA TCT	Asparagine AAU TTA	Isoleucine AUU TAA	Cysteine UGU ACA	Glycine GGC CCG	STOP UGA ACT

Cystic Fibrosis mRNA and Amino Acid Sequence of CFTR Gene:

Methionine AUG TAC	Alanine GCG CGC	Proline CCU GGA	Lysine AAC TTG	Glycine GGU CCA	Serine UCC AGG	Arginine AGG TCC	Threonine ACA TGT
Serine UCC AGG	Threonine ACG TGC	Aspartate GAC CTG	Leucine CUG GAC	Serine UCU AGA	Leucine UUG AAC	Alanine GCA CGT	Glutamine CAA GTT
Glycine GGA CCT	Isoleucine AUA TAT	Serine UCU AGA	Tryptophan UGG ACC	Glycine GGG CCC	Asparagine AAC TTG	Lysine AAG TTC	Threonine ACG TGC
Alanine GCA CGT	Lysine AAA TTT	Glutamate GAA CTT	Isoleucine AUA TAT	Phenylalanine UUU AAA	Valine GUG CAC	Alanine GCU CGA	- GA CT

Resources and References

- *NIH. 2013. How Genes Work. NIH, National Institute of Health, National Institute of General Medical Sciences – Basic Discoveries for Better Health; http://www.nigms.nih.gov/.*
- *Bartoshesky, L.E. 2010. When There Are Problems With Genes. www.kidshealth.org.*

Images (in order of appearance)

- http://www.abdn.ac.uk/news/images/Krista-cow_rdax_400x600.jpg
- http://publications.nigms.nih.gov/insidelifescience/images/dna-structure.jpg
- http://commons.wikimedia.org/wiki/File:Cariotipo_del_paquetismo.gif
- http://s2.hubimg.com/u/6092429_f520.jpg
- http://www.interactive-biology.com/wp-content/uploads/2012/05/Human-Insulin-Protein-Structure-917x1024.jpg
- http://academic.pgcc.edu/~kroberts/Lecture/Chapter%207/07-21_PointMutations_L.jpg
- http://www.personal.psu.edu/users/j/n/jnb5091/Images/CFTR%20Protein.jpg
- http://mssdbio.weebly.com/uploads/1/3/7/6/1376185/9730254_orig.jpg
- http://learn.genetics.utah.edu/content/disorders/whataregd/cf/images/cfchannel.jpg
- http://www.piercenet.com/media/ProStructureFig1.gif
- http://www.tritechresearch.com/shop//images/