Alzheimer's & Genetic Testing Unit Plan

Major Themes for the Unit

- Scientific themes: Protein Synthesis: transcription, translation, protein folding
- Scientific practice: Computational Thinking, Modeling
- Cross-cutting Concepts: Structure and Function, Patterns, Cause and Effect
- SSI: Alzheimer's Disease and Genetic Testing

Driving Question: Should the genetic tests for determining Alzheimer's disease risk be available to the public? Should health insurance companies be allowed to require their clients to take the Alzheimer's test?

Concepts needed to explore the driving question

- Science concepts
  - Structure of DNA
  - Transcription
  - Translation
  - Protein Folding
  - Environmental Impacts
  - Genetic mutations
- What social ideas and concerns influence negotiation of the issue?
  - Insurance
  - Politics
  - Economic Status

Unit-level performance expectations

HS-LS1-1	**STANDARD / PE:** 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. **ASSESSMENT BOUNDARY:** Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.
HS-LS3-2	**STANDARD / PE:** Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. **CLARIFICATION STATEMENT:** Emphasis is on using data to support arguments for the way variation occurs. **ASSESSMENT BOUNDARY:** Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.
Social Connections	Students will analyze and interpret data and use evidence driven argumentation to describe the effects of either side of the issue of insurance and genetic testing for Alzheimer's disease.

Unit assessment(s)

- Models and algorithms
- Culminating Activity
- Content pre and post exam- multiple choice and short answer

Lesson sequence

Lesson (time)	Lesson Focus	Learner Objectives	Activity/assessment
1 (120 min)	Issue Introduction & DNA review	Students will create a model to represent the structure of DNA base-pairing.	Pre test, watch Alzheimer's video, Molecular Workbench Simulations (MWB), draw DNA model
2 (120 min)	Transcription Review and Intro to Computational Thinking (CT)	Students will construct an algorithm that explains the patterns and sequence of the process of transcription.	Play Lightbot, review transcription details with MWB, create group transcription algorithms, create a class consensus transcription algorithm
3 (180+ min)	Translation	Students will design a program to simulate the patterns associated with the translation process. Students will simulate how the system of the translation process functions.	Investigate translation with MWB, watch HHMI translation video and use it to create individual translation algorithms, body model the translation process, adjust translation algorithms, build Scratch translation program
4 (90 min)	Protein Folding	Students will simulate and develop an algorithm for how a protein folds, based on the structure of the amino acids in the chain.	Investigate protein folding with MWB, Body model protein folding, create protein folding algorithms
5 (120 min)	Mutations and their Effects; Alzheimer's Disease	Students will simulate the effects that mutations have on protein synthesis.	Student investigate mutations with MWB, determine the effects mutations have on protein structure with Scratch program and body modeling; connect to Alzheimer's: Early and late onset

6 (90 min)	Lifestyle and Diseases	Students will create an algorithm for the possible effects that the lifestyle has on diseases.	Investigate how lifestyle affects diseases, compare and contrast early and late onset Alzheimer's, create a model that predicts the possible Alzheimer's outcome
7 (90 min + homework)	Negotiating the Issue (Culminating Activity)	Students will analyze and interpret data and use evidence driven argumentation to describe the effects of either side of the issue of insurance and genetic testing for Alzheimer's disease.	Investigate genetic testing, prepare an evidence based argument in the form of a pamphlet for public distribution, post test

**The unit references a practitioner article that will be published in the American Biology Teacher journal. Contact Mandy Peel at anpn98@mail.missouri.edu for an electronic copy of the article.

Lesson 1: Issue Introduction & DNA review

Goals for the lesson/learner objectives:
Students will build a model to represent the structure of DNA base-pairing.

Lesson assessments:
Pre test, DNA model, Molecular Workbench Reports

Materials:
Video Link: http://www.cbsnews.com/news/60-minutes-alzheimers-disease-medellin-colombia-lesley-stahl/

Molecular Workbench Simulations:

- Proteins and DNA: http://mw2.concord.org/tmp.jnlp?address=http://mw2.concord.org/public/part2/pna/index.cml
- From DNA to Proteins: http://mw2.concord.org/tmp.jnlp?address=http://mw2.concord.org/public/part2/dna2prot/index.cml

Instructional sequence

Timing	Activities	Materials
30 min	Students take the pre test	Pre Test
40 min	Students watch the 60 Minutes video on Alzheimer's, and teacher pauses to discuss where appropriate Suggested discussion questions: How many of you know what Alzheimer's is? Have any of you had family members with the disease? Would you want know if you were going to get the disease? Who pays for this test to be done? (Possibly Insurance) Should insurance providers require the test? What are the insurance implications if someone is likely to get the disease? What is genetic testing?	Video
30 min	Students investigate genetic testing and learn about health insurance by exploring the following links: • https://ghr.nlm.nih.gov/primer/testing/genetictesting • http://www.medicalnewstoday.com/info/health-insurance	Computers or tablets for research
10 min	Discussion of connections between the issue and the content. Discussion prompts: • Since this issue revolves around genetic testing, what science concepts do we need to know? DNA structure, transcription, translation, mutations • Since this issue is about Alzheimer's disease, which is	

	caused by genetic mutations, we need to learn more about these mutations. How do they happen, what are their effects? • Alzheimer's disease is a result of misfolded proteins building up in the brain. What do you know about protein folding? We need to understand how and why proteins fold.	
20 min	Students work through pages 7 through 9 the "Proteins and DNA" simulation. Then they work through page one of the "From DNA to Proteins" Simulation. Student work can be evaluated if they create a report (option on the last page of each simulation), or if they take screen shots of their work and save them.	Computers, Molecular Workbench Simulations
20 min	Students work individually to draw a model of the structure of DNA	
10 min	Class discussion of models and DNA structure to review.	

Lesson 2: Transcription Review and Intro to Computational Thinking (CT)

Goals for the lesson/learner objectives:
Students will construct an algorithm that explains the patterns and sequence of the process of transcription.

Lesson assessments:
Molecular Workbench Reports, Transcription Algorithms

Materials:
Peel and Friedrichsen (2017) article. Email Mandy Peel at anpn98@mail.missouri.edu for an electronic copy of the article.

Lightbot: Download "Lightbot: Code Hour" from the app store for tablets and phones, or go to https://lightbot.com/hocflash.html for computers

Molecular Workbench Simulations:

- Proteins and DNA: http://mw2.concord.org/tmp.jnlp?address=http://mw2.concord.org/public/part2/pna/index.cml
- From DNA to Proteins: http://mw2.concord.org/tmp.jnlp?address=http://mw2.concord.org/public/part2/dna2prot/index.cml

Instructional sequence

Timing	Activities	Materials
60 min	Students play the Lightbot game and teacher introduces CT concepts as described in Peel and Friedrichsen (2017) article. The game can be played as homework.	Tablets, computers, or smart phones; Lightbot
20 min	Students review transcription by completing page 10 of the "Proteins and DNA" simulation and page 2 of the "From DNA to Proteins" Simulation.	Computers, Molecular Workbench Simulations
20 min	Students create transcription algorithms in groups, utilizing the CT concepts. See Peel and Friedrichsen (2017) article for implementation details.	White boards, dry erase markers
20 min	Come together as a class to create a consensus transcription algorithm. Students should copy their group's algorithm and the consensus algorithm into their notes.	

Lesson 3: Translation

Goals for the lesson/learner objectives:
Students will design a program to simulate the patterns associated with the translation process.
Students will simulate how the system of the translation process functions.

Lesson assessments:
Molecular Workbench Reports, translation algorithms, Scratch programs

Materials:
Molecular Workbench Simulations:

- Proteins and DNA: http://mw2.concord.org/tmp.jnlp?address=http://mw2.concord.org/public/part2/pna/index.cml
- From DNA to Proteins: http://mw2.concord.org/tmp.jnlp?address=http://mw2.concord.org/public/part2/dna2prot/index.cml

HHMI Translation video: http://www.hhmi.org/biointeractive/translation-basic-detail

Peel and Friedrichsen (2017) article.

Body Modeling Materials: Construction paper labeled with 10 different triplet codons (See table below); three chairs labeled A, P, and E; chain blocks labeled as amino acids; codon chart projected

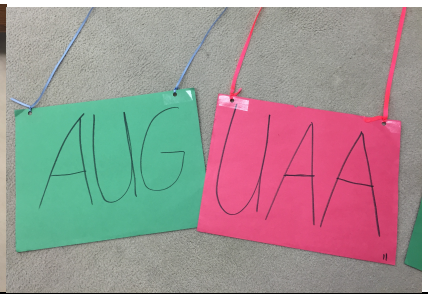
Order Number	Triplet Codon	Amino Acid
0	AUG	Start (Met)
1	GAU	Asp
2	UGG	Val
3	AGU	Trp
4	CAA	Ser
5	ACA	Gln
6	UUU	Thr
7	UGC	Phe
8	AAC	Cys
9	AAG	Asn
10	UAA	Lys

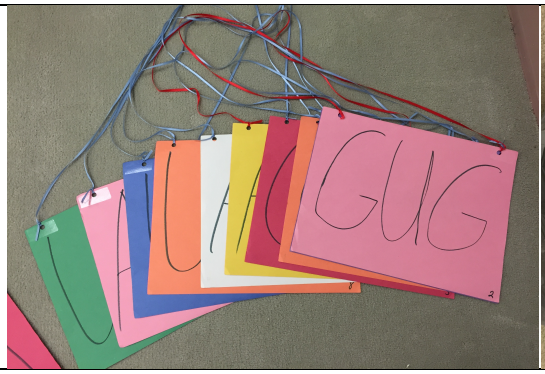
Scratch Class Account: https://scratch.mit.edu/ click "Join Scratch" to create an account

Scratch Tutorials and Guides: https://scratch.mit.edu/help/

Scratch Translation Program for Teacher Reference:
https://scratch.mit.edu/projects/100898229/#editor

Instructional sequence

Timing	Activities	Materials
15 min	Students learn translation details by completing page 11 of the "Proteins and DNA" simulation and page 3 of the "From DNA to Proteins" Simulation.	Computers, Molecular Workbench Simulations
25 min	Students watch the HHMI translation video and use it to create individual translation algorithms. See Peel and Friedrichsen (2017) article for student generated translation algorithm examples.	HHMI video
20 min	Teacher leads the class through body modeling of the translation process. Ten students wear signs that have triplet mRNA codons on them and line up to form an mRNA strand (make sure START is first and STOP is last). Three seats are set up as the ribosome and are labeled A, P, and E for the three ribosome sites. A bag with chain blocks that are labeled as the 20 amino acids is placed on the A site chair. The first person sits in the A site and reads the table for his/her codon and finds the corresponding amino acid chain block in the bag. The mRNA strand shifts, and now person 1 is in the P site with their amino acid, and person 2 is in the A site. Person 2 reads the table for his/her codon and finds the corresponding amino acid chain block in the bag and the chain shifts again. Person 1 is in the E site and hands their amino acid to person 2, who is in the P site. Person 2 connects his/her amino acid chain block to person 1's, thus beginning the polypeptide chain. Person 3 continues the process. These steps are repeated until the STOP codon is reached and the mRNA disassembles from the ribosome. During this process, 10 students are acting out the sequence and the rest of the class is helping them figure out the process and make meaning around what is happening. The teacher should facilitate and lead discussion of the steps and overall sense-making around the process.  	Body Modeling Materials

	 	
15-30 min	Teacher lectures or further explains about the details of the translation process at the teacher's discretion.	
20 min	Students compare and contrast their translation algorithms in groups, then adjust their translation algorithms individually.	
90+ min	Teacher introduces students to Scratch and runs some tutorials with the class. Next, the teacher shows them how to start building the translation program. Students work individually or in pairs to build the translation program. See the Peel and Friedrichsen (2017) article for more details on the process, and see the Scratch Translation Program for Teacher Reference.	Computers, Scratch, Scratch Translation Program for Teacher Reference

Lesson 4: Protein Folding

Goals for the lesson/learner objectives:
Students will simulate and develop an algorithm for how a protein folds, based on the structure of the amino acids in the chain.

Lesson assessments:
Molecular Workbench Reports and protein folding algorithms

Materials:
Molecular Workbench Simulation: Proteins and DNA:
http://mw2.concord.org/tmp.jnlp?address=http://mw2.concord.org/public/part2/pna/index.cml

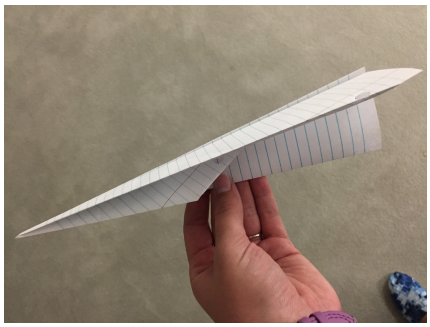
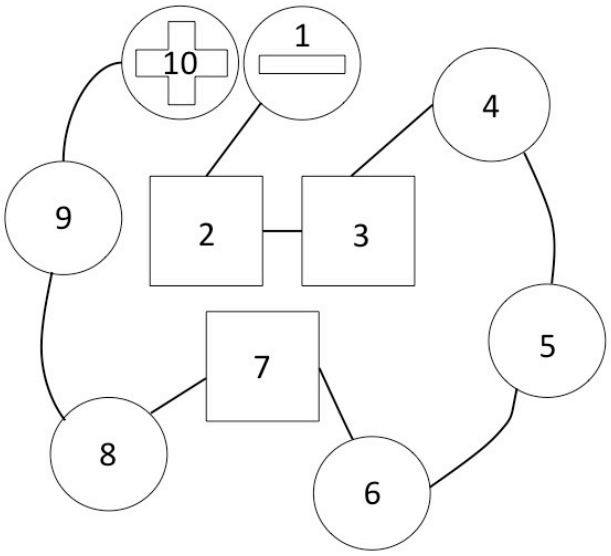
Body Modeling Materials: Construction paper labeled with 10 different amino acid properties in order- use the same amino acid sequence produced in the previous lesson, and on the backs of the signs, write the property of that amino acid (Hydrophilic/polar, hydrophobic/nonpolar, positively charged, or negatively charged); a set of Velcro "gloves" and a ball that sticks to them, a paper airplane

Order Number	Amino Acid	Property
	Start (Met)	Cleaved
1	Asp	Negatively charged
2	Val	Hydrophobic
3	Trp	Hydrophobic
4	Ser	Hydrophilic
5	Gln	Hydrophilic
6	Thr	Hydrophilic
7	Phe	Hydrophobic
8	Cys	Hydrophilic
9	Asn	Hydrophilic
10	Lys	Positively Charged

PTC paper

Instructional sequence

Timing	Activities	Materials
45 min	Students learn about and investigate protein folding by working through pages 1 through 6 of the "Proteins and DNA" simulation.	Computers, Molecular Workbench Simulation
15 min	Students body model protein folding using the same amino acid sequence produced in the previous lesson. Note that in this activity, Met is not part of the polypeptide chain because it is cleaved in eukaryotes. The students wearing Asp and Lys put on the Velcro bands around their arms (Lys left arm and Asp right arm). Have the students stand in order and hold hands, and tell them that they have to fold based on their amino acid properties	Body Modeling Materials, PTC paper

	(hydrophobic towards the center of the protein, hydrophilic on the outside of the protein, and positive and negative attract each other). When folded correctly (see picture below), the active site (two Velcro arm bands should be next to each other) should form between the positive and negatively charged amino acids (Asp and Lys). Place the ball on the Velcro bands so that it is touching both. In this scenario, the arm bands are the active site of the enzyme, the ball is the substrate, and the paper airplane is the taste signal sent to the brain. Use PTC and its taste receptor as an example. When PTC (the ball) binds to the receptor (attaches to the Velcro), the receptor sends a signal of bitter taste to the brain (throw the paper airplane to represent sending the signal). To further the experience, have students taste PTC paper to determine if they have functioning receptors or not.   Body Modeling Folded Protein Top View 	
20 min	Students then work individually to create protein folding algorithms	
10 min	Students compare, contrast, and discuss their protein folding algorithms in groups	

Lesson #5: Mutations and their Effects; Alzheimer's Disease

Goals for the lesson/learner objectives:
Students will simulate the effects that mutations have on protein synthesis.

Lesson assessments:
Molecular Workbench Reports

Materials:
Molecular Workbench Simulations: From DNA to Proteins:
http://mw2.concord.org/tmp.jnlp?address=http://mw2.concord.org/public/part2/dna2prot/index.cml

Body Modeling Materials: Construction paper labeled with 10 different amino acid properties in order- use the same amino acid sequence produced in the previous lesson, and on the backs of the signs, write the property of that amino acid (Hydrophilic/polar, hydrophobic/nonpolar, positively charged, or negatively charged); a set of Velcro "gloves" and a ball that sticks to them, a paper airplane
mRNA Sequence: AUG GAU GUG UGG AGU CAA ACA UUU UGC AAC AAG UAA
Amino Acid Sequence: Asp, Val, Trp, Ser, Gln, Thr, Phe, Cys, Asn, Lys
Mutated mRNA Sequence: AUG CAU GUG UGG AGU CAA ACA UUU UGC AAC AAG UAA
Mutated Amino Acid Sequence: His, Val, Trp, Ser, Gln, Thr, Phe, Cys, Asn, Lys

Video Link: http://www.cbsnews.com/news/60-minutes-alzheimers-disease-medellin-colombia-lesley-stahl/

Mutations Worksheet

Instructional sequence

Timing	Activities	Materials
20 min	Students learn about mutations through completing pages 5 through 7 and page 9 of the "From DNA to Proteins" simulation.	Computers, Molecular Workbench Simulations
40 min	Students determine the effects mutations have on protein structure with Scratch program and body modeling. Students enter the mRNA sequence from the body modeling exercise and determine its amino acid sequence. The teacher then tells students there was a mutation in the mRNA sequence, and they need to figure out how it will affect the enzyme. Students run the mutated mRNA sequence through their Scratch programs and determine the new amino acid sequence. The students determine the property of the new amino acid and find that the mutation causes a change from a positively charged amino acid to a negatively charged amino acids. Students then body model the correct conformation of the folded enzyme from the previous	Body Modeling Materials, Computers, Student Scratch Programs or a completed program for them to use;

	lesson. Next they change the amino acid to fold for the mutated polypeptide and see that the active site no longer forms because the two amino acids are now both positively charged and repel each other. So the substrate (ball) cannot bind to both amino acids (the two Velcro arm bands), and no signal is sent to the brain. Use PTC as an example: PTC can't bind to both amino acids in the active site, so when this person eats PTC, they don't taste the bitterness because the receptor has misfolded and no signal is sent to the brain. Students then work through different examples of mutations on the Mutations Worksheet using their Scratch programs and predict if the protein will fold correctly or incorrectly.	Mutations Worksheet
60 min	Students then connect this information to early onset Alzheimer's. Refer back to the video from lesson 1, and re-watch the section where they discuss what early onset Alzheimer's is (7:28-10:16 and 14:52-18:24). Students then research early onset and late onset Alzheimer's to determine its cause and the effect. Resources: • https://www.nia.nih.gov/alzheimers/publication/alzheimers-disease-genetics-fact-sheet • http://dmm.biologists.org/content/7/1/9 • http://onlinelibrary.wiley.com/doi/10.1111/j.1742-4658.2006.05181.x/full (Toxic amyloid formation causes many human neurodegenerative disorders Section)	Video Link, computers or iPads for research

Lesson #6: Lifestyle and Diseases

Goals for the lesson/learner objectives:
Students will create an algorithm for the possible effects that the lifestyle has on diseases.

Lesson assessments:
Predictive models

Materials:
Computers or tablets for research

Breast Cancer Algorithms 1, 2, and 3

Instructional sequence

Timing	Activities	Materials
30 min	Students investigate how lifestyle affects diseases using the following web links. • https://www.ncbi.nlm.nih.gov/books/NBK2290/ • http://www.foxnews.com/health/2015/05/25/how-diet-and-lifestyle-can-impact-your-familys-genetic-disease-risk.html • https://en.wikipedia.org/wiki/Lifestyle_disease • https://www.allianz.com.au/life-insurance/news/lifestyle-health-issues Discuss with students the variability in the resources. Do they provide scientific evidence and cite their resources? Who is in charge of the resource, and what are their motivations?	Computers or tablets for research
20 min	Students then research the connections between lifestyle and Alzheimer's with the following resources: • http://www.alz.org/research/science/alzheimers_prevention_and_risk.asp • https://www.nia.nih.gov/alzheimers/publication/preventing-alzheimers-disease/introduction • http://www.webmd.com/alzheimers/features/mind-diet-alzheimers-disease#1	Computers or tablets for research
20 min	In groups, or individually, students compare and contrast early and late onset Alzheimer's disease.	
20 min	Show students the three different Breast Cancer Algorithms as examples of what they are expected to create for Alzheimer's. All three algorithms have the same steps, but they are represented in different ways. Individually, students create an algorithm that predicts the possible Alzheimer's outcome based on various lifestyle and genetic factors. A person with the genetic mutations associated with early onset will have the outcome of getting Alzheimer's, but	Breast Cancer Algorithms 1, 2, and 3

	someone who doesn't have those mutations and eats right, exercises, and brain trains is less likely to get Alzheimer's. It is important to stress that even if someone lives a healthy lifestyle, they may still get late onset Alzheimer's and someone who lives an unhealthy lifestyle may not get Alzheimer's.	

Lesson #7: Culminating Activity: Negotiating the Issue

Goals for the lesson/learner objectives:
Students will analyze and interpret data and use evidence driven argumentation to describe the effects of either side of the issue of insurance and genetic testing for Alzheimer's disease.

Lesson assessments:
Culminating Activity Sheet and Post-test

Materials:
Computers or tablets for research
Culminating Activity Sheet
Post-test

Instructional sequence

Timing	Activities	Materials
15 min	Students review their earlier research on genetic testing and health insurance by briefly exploring the following links again: • https://ghr.nlm.nih.gov/primer/testing/genetictesting • http://www.medicalnewstoday.com/info/health-insurance	Computers or tablets for research
60+ min	Teacher introduces students to the culminating project. Students work in class and at home, if necessary, to prepare an evidence based argument in the form of a pamphlet for public distribution on whether or not insurance should require people to get genetic testing for Alzheimer's and cover the cost of the test.	Culminating Activity Sheet
~30 min	Students take the post-test to assess biological content learning, modeling skills, and CT skills.	Post-test