Table S1: Outline of Progression and Condensed Description of Levels

Progression Level					
1	**2**	**3**	**4**	**5**	**6**
Construct A: Genetic organization					
Recognize that correlation exists, but all incorrect	2 correct	3 correct	4 correct	5 correct	All 6 correct
Construct B: Genes code for proteins					
Genes non-informational	Genes informational	Genes instruct the body at levels	Genes code for cell entities	Genes code for proteins	Genes translated into protein
Construct C1: Proteins do the work of the cell					
Cells perform functions	Proteins good for your body	Proteins do cell's work	Protein function depends on structure	Protein structure and function depends on amino acids in the protein	NA
Construct C2: Proteins connect genes and traits					
Changes to genes change traits	Changes to genes change cells	Changes to genes change proteins	Changes to genes change proteins to change traits	Changes to genes change amino acids in proteins	Changes to genes change protein functions to change traits
Construct D: Cells express different genes					
Cells different because they are in different places in the body	Cells different because they have different functions	DNA tells cells to be different	Different cells have different proteins for their functions	Somatic cells have same DNA but different proteins	Somatic cells have same DNA to express different proteins
Construct E: Genetic information is passed on to offspring					

Table S1: Outline of Progression and Condensed Description of Levels

Progression Level					
1	**2**	**3**	**4**	**5**	**6**
Organisms can only get traits of their parents	Offspring get half of DNA from each parent	Alleles are randomly assorted	Chromosomes are randomly assorted	Chromosomes can swap sections increasing genetic variation	NA
Construct F: There are patterns of correlations between genes and traits					
Organisms have different versions of traits	Traits from parents can mix or compete to give offspring traits	Organisms get one allele per parent, and traits can be predicted	Alleles differ in sequence which affects proteins to give trait variations	Level 4 + Dominant and recessive relationships can be explained by protein interactions	NA
Construct G1: DNA varies between and within species					
Organisms have different traits or functions	Organisms have different DNA	Organisms have different DNA even within a species	Organisms within species have both similar and different DNA	Organisms of different species have some similar and some different DNA	The more conserved DNA is between species, the more important the gene product
Construct G2: Changes to genetic information result in increased variation and can drive evolution					
Species look and function differently	Organisms within a species look and function differently	Changes to an organism can be beneficial or harmful	DNA changes can be beneficial, neutral, or harmful, and can change protein structure/function	DNA changes lead to increased genetic variation and evolution	NA
Construct H: The environment interacts with genetic information					

Table S1: Outline of Progression and Condensed Description of Levels

Progression Level					
1	**2**	**3**	**4**	**5**	**6**
Environment can affect organisms	Environment can affect traits or functions	Environment can affect our cells, organs, or tissues	Environment can change or mutate things inside of a cell	Environment can change type and amount of proteins that influence cell function	Environment can change genes which change proteins, or change gene expression of proteins
Construct I: Only mutations in gametes can be passed on to offspring					
A change of traits can be passed down to offspring	DNA mutations can be passed down to offspring	Only mutations in gametes can be passed down to offspring	Level 3 + mutations to somatic cells are passed on to descendent cells	NA	NA
Construct J: Gene expression can change at any point during an organism's lifespan					
Gene expression is not regulated or controlled, or does not change	Genes can be turned on during development	Genes can be turned on and/or off only during key life stages	Gene expression can change at any point during one's life	NA	NA

Table S2: Instructional Design and Activities Related to Constructs

Unit Driving Question	Instructional Time	Purpose	Description of Activities/Investigations	Constructs Addressed
Pre-Assessment (early October)				
How do cells become cancerous? [Intervention Unit]	2.5 weeks	Students explore how cells become differentiated by expressing certain proteins and how abnormal protein expression can lead to cancer.	Students examine different types of cells, describe how the structure of cells relates to function, and relate expressed proteins to different cell types. Students discover how stem cells differentiate by expressing different proteins and compare stem cells to cancer cells.	B*, C1*, C2*, D*, H*
Why are Siamese cats colored the way they are? [Intervention Unit]	2.5 weeks	Students explore protein structure and function to learn how proteins lead to observable traits.	Students examine paper and computer models of enzymes and other proteins, including molecular motors, to determine the relationship between structure and function. Students discover that under certain conditions, enzymes can denature and fail to perform their function. Students develop an explanation for how proteins in Siamese cats lead to observable traits.	C1*, C2*, H*
How can *Hyla chrysoscelis*, a native frog, tolerate being frozen?	1.5 weeks	Students examine protein expression and function in a frog species. Students relate protein function to observable and advantageous traits.	Students consider how proteins may facilitate water and nutrient transport and how transport may help protect a living organism during a freeze cycle. Students develop an explanation for how proteins in frogs lead to observable, advantageous traits.	C1*, C2, G1, G2*, H*
Midpoint-Assessment (mid November)				
How can we reduce the risk of obesity in our community?	2.5 weeks	Students investigate the structure and function of key macromolecules (protein, carbohydrates, lipids, and nucleic acids).	Students explore the structure and function of proteins, carbohydrates, lipids, and nucleic acids in food and in the human body. Students develop an explanation for how nutrients from food are used in by the human body.	A, B*, C1,

How can there be a case of disputed maternity? [Intervention Unit]	2.5 weeks	Students explore genetic inheritance and realize that connections exist between meiosis and patterns of inheritance.	Students examine DNA structure, chromosome structure, and karyotypes to determine differences and similarities between parents and offspring. Students investigate meiosis and fertilization to determine patterns of inheritance.	A, B, C1, C2, E*, F*, I
Can we genetically engineer a superhuman? [Intervention Unit]	2.5 weeks	Students examine how DNA mutations can alter protein structures and functions in both bad (genetic diseases) and good (superhuman) ways.	Students explore genetic diseases and their causes at the gene, protein, cell and trait levels. Students examine the sources and types of mutations, and how mutations to DNA can change protein structures and functions. Students also explore how observable traits can be explained by Mendelian and non-Mendelian genetics.	A, B*, C1, C2, D*, E*, F*, I
How can we diagnose and develop a treatment plan for a simulated patient with a genetic disease?	2 weeks	Students use their understanding of molecular genetics developed throughout the learning sequence to diagnose and develop a novel treatment for a simulated patient with a genetic disease.	Students receive a history and physical for a simulated patient with a genetic disease. Students investigate the symptoms, relate symptoms to specific proteins, and determine protein mutations causing the symptoms. Students propose novel treatments to reverse the effects of the protein mutation.	A, B, C1, C2, D, E, F, I
Post-Assessment (mid March)				

* Indicates a key construct for the unit
Note: Instructional period spanned ~23 calendar weeks; targeted instruction to genetics constructs (after accounting for holidays, snow days, other instruction during this time) spanned ~16 weeks.
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