Unit 4: Why is a body temperature of 107 F deadly?

Investigation 1: How are interactions with water important for maintaining my life?

NGSS PEs:

HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.

Activity	What did we observe?	What did we figure out?	Model/Explanation	NGSS Dimensions
1: Why don't water and oil mix?	• Dissolving sugar candy in water at different temperature and observing how fast the dissolution process takes • Dissolving substances in polar and nonpolar liquids • Boiling eggs demo • Dissolution process simulation • Changing polarity simulation • Mixing oil and water simulation	• Polar substances tend to dissolve in polar solvents, nonpolar substances tend to dissolve in nonpolar solvents • Substances dissolve faster in warmer solvents • Polar substances have higher boiling points than nonpolar substances	Substances that are made of molecules with similar strength of electrical interactions tend to dissolve together	DCI: *Relationship Between Energy and Forces:* When two objects interacting through a field change relative position, the energy stored in the field is changed. CCC: Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller-scale mechanisms within the system. SEP: *Constructing explanations and designing solutions:* Construct and revise 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. Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

2: Can a substance dissolve in both polar and nonpolar liquid?	• Mystery substance (soap) dissolves in both polar (water) and nonpolar (cooking oil) solvents. • Sorting molecules simulation • Elements and polarity simulation • Soap self-assembly simulation • Soap in oil and water mixture simulation	Molecules that contain both polar and nonpolar regions self-assemble in a solvent such that the areas that are facing the solvent are the same polarity as that of the solvent.	Apply ideas related to polar and nonpolar interactions to explain interactions between mixtures of various solvents and molecules that have both polar and nonpolar regions.	DCI: *Relationship Between Energy and Forces:* When two objects interacting through a field change relative position, the energy stored in the field is changed. CCC: *Energy and Matter:* Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. *Patterns:* Students observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena. They recognize that classifications or explanations used at one scale may not be useful or may need revision using a different scale, thus requiring improved investigations and experiments. SEP: *Developing and using models:* • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.
3: What are proteins and how do they fold into biologically important shapes?	• Building blocks of proteins simulation • Which parts of protein are polar and which are nonpolar simulation • Protein folding simulation • Protein folding and energy change simulation • Protein representation simulation	Forming intermolecular interactions releases energy and leads to overall energy minimization in the system	The final shape of a protein molecule is a combination of interactions between different parts of the molecule and with the solvent in which the protein resides (i.e. water) which is driven by energy minimization principle.	DCI: *Organization of Matter and Energy Flow in Organisms:* The sugar molecules thus formed contain carbon, hydrogen, and oxygen; their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA) used, for example, to form new cells. *Relationship Between Energy and Forces:* When two objects interacting through a field change relative position, the energy stored in the field is changed. CCC: *Energy and Matter:* • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • Students learn that the total amount of energy and matter in closed systems is conserved. They can describe changes of energy and matter in a system in terms of

			• Polar and nonpolar molecules have different attractive forces. • The different attractive forces between polar and nonpolar molecules affect how one substance dissolves or doesn't into another substance. • Proteins are large molecules that have polar and nonpolar parts that can interact with each other and the surrounding molecules. • The interactions within molecules and/or with other the molecules around them can cause specific structures to form. • The resulting configurations result in lower potential energy for the entire system.	energy and matter flows into, out of, and within that system. They also learn that energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems. SEPs: *Developing and using models:* • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. *Analyzing and interpreting data:* • Analyze and interpret data to provide evidence for phenomena • Evaluate impact on new data on a working explanation and/or model of a proposed process or system *Constructing explanations and designing solutions:* • Construct and revise 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. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

Investigation 2: Why can't you uncook an egg?

NGSS PEs:

HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.

Activity	What did we observe?	What did we figure out?	Model/Explanation	NGSS Dimensions
1: How do polar and nonpolar interactions affect protein structure and properties?	• Pineapple and jello hands on experiment • Effect of polarity on strength of interactions simulation • Effect of polarity on potential energy of a system • Interaction between polar regions of the protein and other molecules simulation • Effect of molecular shape on interactions between molecules simulation • Effect of temperature on protein function simulation • Effect of temperature on substrate and active sire simulation	Fresh pineapple contains an enzyme that interacts with jello molecules and prevents them from interacting with each other, which in turn prevents jello from solidifying. High temperature causes the intermolecular interactions that maintain 3D shape of the enzyme to become disrupted, which leads to loss of function.	• model predicts the relative strength of attraction between the polar and nonpolar parts of a protein and the polar and nonpolar parts of another molecule based on the magnitude of charges, shape and alignment of the molecules to explain why proteins interact with molecules of specific shape and atomic composition. • model explains how temperature affects 3D structure and function proteins as related to polar and nonpolar interactions to explain why high temperature prevent proteins from forming interactions with substrates and carry out their biological function.	DCI: *Relationship Between Energy and Forces:* When two objects interacting through a field change relative position, the energy stored in the field is changed. CCC: *Cause and Effect*: Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller-scale mechanisms within the system. SEP *Developing and using models:* • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.

2: How do antibodies protect us from diseases?	• Design antibodies that target specific biological molecules simulation	If vaccines contain antibodies that are not highly specific for a given antigen (the 3D shape of the antibody is not complementary to the shape of the antigen, and the charges on the surfaces of antigen and antibody don't align in a way that the generated net force is attractive), then the antibody won't be effective in fighting against the given antigen.	Model includes how polar and nonpolar interactions between protein (antigen) and antibody (infectious agent) help protect us from diseases.	DCI: *Relationship Between Energy and Forces:* When two objects interacting through a field change relative position, the energy stored in the field is changed. CCC: *Cause and Effect* Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller-scale mechanisms within the system. SEP: *Developing and using models:* • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.
3: Why is the temperature of 107 F deadly?	Develop final model to answer the DQ	as the temperature in our body rises to 107° F the energy of the system increases. This means that atoms in the amino acids that make up proteins in our body have more kinetic energy to move around, and overcome intermolecular interactions that form 3D structure of the protein. Once the 3D structure of the protein is distorted, protein regions where various molecules can bind no longer have the same shape, and no longer are composed of the same amino acids as before. This means that the specific interactions between protein and other molecules that are based on complementarity of shape, and interaction between specific polar and nonpolar regions can no longer happen in the same fashion as at normal temperatures. This prevents proteins from interacting with other molecules and carry out their specific functions like including enzymatic, cell signaling, defense against antigens	• Polar and nonpolar molecules have different attractive forces. • The different attractive forces between polar and nonpolar molecules affect how one substance dissolves or doesn't into another substance. • Proteins are large molecules that have polar and nonpolar parts that can interact with each other and the surrounding molecules. • The interactions within molecules and/or with other the molecules around them can cause specific structures to form. • The resulting configurations result in lower potential energy for the entire system. • The resulting configuration is affected by temperature of the system: higher temperature is associated with higher kinetic energy of the protein. • Higher kinetic energy of the protein results in distorting and sometimes (if temperature is high enough) overcoming polar and nonpolar intermolecular interactions causing the 3D structure of the protein to be changed.	*DCI: Relationship Between Energy and Forces:* When two objects interacting through a field change relative position, the energy stored in the field is changed. *CCC: Cause and Effect*: Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller-scale mechanisms within the system. *SEP: Developing and using models:* • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. *Constructing explanations and designing solutions:* • Construct and revise 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. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

		etc. Once these basic biological functions are no longer fulfilled, human organism can die.	• Specific 3D structure is essential for protein to carry out its functions. If the 3D structure is changed, a protein can no longer carry out the intended function.	