HIGH SCHOOL

PRINCIPLES OF PHYSICS-HONORS

FOR THE STUDENTS OF

DR. LAURA LOWDER EDUCATIONAL CONSULTING

COURSE DESCRIPTION

This course is designed and developed to be taught at the high school honors level and is a strong introduction into **physics and chemistry phenomena**. The course spans a full academic year and equates to a physics credit with lab. Following the conclusion of these physical science units, students have an opportunity to accelerate into the chemistry honors course for opportunities to master the remaining Next Generation Science Standards (NGSS) in the physical science performance expectations made up of NGSS disciplinary core ideas (DCI) for high school. This course will prepare students for further studies in advanced physics and chemistry as well as future studies of physical sciences at the collegiate level.

Scholars will engage in four core units of study that make up the core physical science. The core curriculum has been developed by a collaboration between the CREATE for STEM Institute at Michigan State University and The Concord Consortium. Many of the performance expectations for high school physical science in the Next Generation Science Standards (NGSS) are addressed within this four unit curriculum. Students accelerating on to complete the chemistry honors portion of the course will engage in learning opportunities addressing ALL of the NGSS for high school physical science.

The pedagogical basis for the units of study is inquiry-based, with a sequence of lessons focusing on science as a process. Students engage in modeling of scientific phenomena through exploration of our world at the atomic interactions level. They explore the relationships between energy transformations and the observations that we make in our everyday world. Throughout the units of study, students synthesize and organize scientific information to build their own models, use crosscutting concepts, and develop disciplinary core ideas. The Framework of this approach to the teaching and learning of science is 3-D learning.

As an extension of the Interactions Curriculum, scholars enrolled in Dr. Lowder's physical science course will also engage in a series of Project Learning Tree service learning projects; at least two of which focuses on areas of physical science; iTree and Biotechnology.

SCOPE AND SEQUENCE

SEPTEMBER

Introduction to the Interactions Curriculum

Unit One Interactions: Why do some clothes stick together when they come out of the dryer?

Investigation One: Why do some things stick together and others don't?

Module One: What are some examples of things that stick together and things that don't?

Module Two: What are some patterns with how some things stick together or push apart?

Module Three: What effect do charged objects have on uncharged objects?

Module Four: How do I know if something is positively or negatively charged?

Module Five: How does an object's charge affect its interaction with neutral objects?

Investigation Two: What are the factors that affect how strongly objects interact with each other?

Module One: How can charged objects have an effect on each other without touching?

Module Two: How do factors like distance and amount of charge affect interactions between objects?

Module Three: How does our model of charge interactions connect with a variety of phenomena?

Investigation Three: What are all materials made of?

Module One: Can the same piece of paper be cut in half indefinitely?

Module Two: Does 5 + 5 always equal 10?

Module Three: Is the particle model always better?

Module Four: What model best supports our observations?

OCTOBER

Investigation Four: What are nature's building blocks?

Module One: What are the particles that make up all substances, and how small are they?

Module Two: If you can't see it, how do you know it's there?

Module Three: How do we know what's inside an atom?

Module Four: What are the electrons?

Investigation Five: How does an object become charged?

Module One: What is the effect of changing the composition of an atom?

Module Two: How do objects become charged?

Module Three: What causes neutral objects and charged objects to interact with each other?

Module Four: Revising our models of charge interactions

Post-Assessment

Add Unit Products to Portfolio

Project Learning Tree Service Learning Project # One: Project iTree Unit

Session One-Tree Benefits and Identification

Session Two-Tree Value

Session Three-Land Manager Role Play

Post-Assessment

Add Unit Products to Portfolio

Project Learning Tree Service Learning Project # Two: Exploring Environmental Issues-Focus on Risk Biotechnology

Session One-Biotechnology and You

Session Two-Bioremediation

Session Three-Biotechnology and Human Health

Session Four-Forest Biotechnology

Post-Assessment

Add Unit Products to Portfolio

NOVEMBER

Unit Two Interactions: How does a small spark trigger a huge explosion?

Investigation One: What is happening when a spark occurs?

Module One: Can my finger start a fire?

Module Two: What happens to energy when objects collide?

Module Three: If moving objects have kinetic energy? Do moving atoms have kinetic energy?

Module Four: If energy cannot go away, why don't things move forever?

Investigation Two: Where does the energy of a spark come from?

Module One: How does potential energy change when things are pushed or pulled?

Module Two: Where does the energy that was used to charge the Van de Graaff generator go?

Module Three: Why is lightening so much bigger than a spark from the Van de Graaff generator?

Module Four: Why do I get shocked if I am too close to the Van de Graaff generator?

Investigation Three: How can a spark start a huge explosion?

Module One: What makes material different from each other?

Module Two: What holds the atoms of a molecule together?

Module Three: When atoms get close to each other, what happens to their potential energy?

Module Four: How are bonds formed and broken?

DECEMBER

Investigation Four: Where does all the energy in an explosion come from?

Module One: What energy changes occur during an explosion?

Module Two: What happens to atoms during a chemical reaction?

Module Three: When changes in energy occur when atoms rearrange during a chemical reaction?

Module Four: How does a spark trigger an explosion?

Post Assessment

Add Unit Products to Portfolio

JANUARY

Unit Three Interactions: What powers a hurricane?

Investigation One: What makes water special?

Module One: How are water and other liquids similar and different?

Module Two: Why is water different from other liquids?

Module Three: Is oxygen really that special?

Module Four: How does electron distribution impact our observations?

Investigation Two: What happens to the energy of water molecules during hurricanes?

Module One: What does boiling do to water molecules?

Module Two: How hot can water get?

Module Three: How does energy change when evaporation is reversed?

FEBRUARY

Unit Four Interactions: Why is a temperature of 107 degree deadly?

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

Module One: Why don't oil and water mix?

Module Two: Can a substance dissolve in both a nonpolar and polar liquid?

Module Three: What are proteins and how do they fold into biologically important shapes?

MARCH

Investigation Two: Why is a body temperature of 107 degree Fahrenheit deadly?

Module One: How do polar and non polar interactions affect protein structure and properties?

Module Two: How do antibodies help protect us from diseases?

Module Three: Why is a body temperature of 107 degrees Fahrenheit deadly?

Post Assessment

Add Unit Products to Portfolio

APRIL-MAY

Accelerate to Chemistry Honors Course (Continuation of Scope and Sequence TBD w/ emphasis on the remaining high school physical science performance indicators.)

STANDARDS FOR LEARNING

INTERACTIONS UNIT ONE: WHY DO SOME CLOTHES STICK TOGETHER WHEN THEY COME OUT OF THE DRYER?

Unit 1: Why do some clothes stick together when they come out of the dryer?

Investigation 1: Why do some things stick together and other things don't?

In this investigation, students will begin to develop a conceptual model of electrostatic interactions by exploring how various charged objects (scotch tape, balloons, rods of various materials, and a Van de Graaff generator) interact with each other and with uncharged objects (paper,waterbottle,ahand).Bytheendoftheinvestigation,the studentmodelwillinclude positive and negative charges as well as patterns that can be used to explain and predict how charged objects interaction. *This investigation builds toward NGSS PE: HS-PS2-4*

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and[1] electrostatic forces between objects

Objective: Target Model

What should the student's conceptual model include?
● Objects can be positively charged, negatively charged, or uncharged (Neutral)
● Objects with the same charge repel each other, Oppositely charged objects attract each

other. Charged and uncharged objects attract each other regardless of whether the charged object has a positive or negative charge.

Investigation 2: What are factors that affect the interactions between objects?

In this investigation, students develop a model of electric fields to explain how charged objects interact. Students analyze how the charge on objects and the distance between them affects the strength of the interactions between those objects. *This investigation builds toward NGSS PEs: HS- PS2-4 and HS-PS3-5*.

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects

[1] The interactions curriculum focuses on electrostatic interactions. Throughout this document, portions of PE's are greyed if they are not addressed in the associated investigation.

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.

Objective: Target Model

What should the student's conceptual model include?

- Objects can be positively charged, negatively charged, or uncharged (neutral).
- Objects with the same charge repel each other; oppositely charged objects attract.
- The distance between charged objects affects the interactions between them. The closer they are, the stronger the interaction.

- The amount of charge on the charged objects affects the interactions between them. The greater the charge, the stronger the interaction.
- Charged objects generate an electric field in the region around them.
- It is through the electric field that charged objects interact with each other.

- **Investigation 3: What are all materials made of?**
  In this investigation, students will start by analyzing observations of matter in order to evaluate continuous and particle models of matter. Students will then use evidence from mixing water and ethanol to evaluate those models. Finally, students will apply their model to explain observations of gases. *This investigation builds towards NGSS PE: HS-PS1-3*
  HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
  Objective: Target Model
  What should the student's conceptual model include?
    - All substances are made of particles that are too small to be seen
    - There is empty space between the particles making up substances.

Investigation 4: What are nature's building blocks?

This investigation follows the historical development of models of atomic structure and provides students with the opportunity to explore simulations of some of the experiments that led to these models. In addition, through hands-on activities involving representative objects, this investigation helps students gain insight into the size of atoms as compared with other small objects. *This investigation builds toward NGSS PEs: HS-PS1-1 and HS-PS1-3*

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

Objective: Target Model

What should the student's conceptual model include?

- All materials are made of particles that are too small to be seen.
- These particles are called atoms.
- Atoms have a dense, positively charged nucleus that consists of neutrons and protons; the nucleus is surrounded by much smaller, negatively charged electrons.
- Electrons can be modeled as a "cloud" surrounding the nucleus and are best represented in terms of probability maps.

- **Investigation 5: How does an object become charged?**
  By collecting evidence as to how the composition of an atom relates to its identity, students will build upon the model of atomic structure that they developed in the previous investigation. In addition, they will explore the forces involved in maintaining an atom's structure and the effect that introduction into an electric field has on electron distribution. Students will extend their conceptual model of electrostatic interactions to include 1) electron transfer as the mechanism for how an object becomes charged and 2)

shifting electron distribution to explain how neutral objects can be attracted to both positively and negatively charged objects. Finally, students will revise their models of some phenomena developed during previous investigations. *This investigation builds toward NGSS PEs: HS-PS1-1 and HS-PS1-3* HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

Objective: Target Model

What should the student's conceptual model include? Students' models of the structure of matter should include:

- All materials are made of particles called atoms which are too small to be seen with the unaided eye.
- Atoms have a dense, positively charged nucleus that consists of neutrons and protons surrounded by much smaller, negatively charged electrons. The nucleus takes up only a small fraction of the volume of an atom.
- Every element consists of a different type of atom; the identity of an element is determined by the number of protons in the nucleus of an atom of that element.
- An atom has an electric charge when it contains an unequal number or protons and electrons. Students' models of electrostatic interactions should include:
- Opposite charges attract; like charges repel.
- The strength of the interaction between charged objects depends on the distance between them and the amount of charge on each object (qualitative understanding of Coulomb's law).
- Neutral objects are attracted to both positively and negatively charged objects.
- There is more than one way to charge an object.
    - An object can be rubbed with another material
    - Charge can be transferred to or from an object when it touches another object.
- Charge is due to electrons from atoms of one object transferring to atoms of another object.

Unit 2: How does a small spark trigger a huge explosion?

- **Investigation 1: What is happening when a spark occurs?**
  In this investigation, students begin talking about the idea of energy. Students start by defining energy and investigating differences between potential and kinetic energy. They then explore energy transfer and energy conservation. Finally, they connect energy to charges and atomic structure of matter. *This investigation builds toward NGSS PEs: MS-PS3-5, MS-PS1-4, and HS-PS3-2*.

MS-PS3-5. Construct, use and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects).

Objective Target Model:

What should the student's conceptual model include?

- Energy is useful to track changes in systems; • The model of energy should include the following:
  Energy transfer
  Energy conversion
  Conservation of energy
  The idea that energy is either associated with motion (kinetic energy) or stored (potential energy)

Investigation 2: Where does the energy of a spark come from?

In this investigation, students define potential energy and factors that impact the amount of potential energy that exists in a system. Students start by defining potential energy as energy that is stored in a system of interacting objects. Student then explore the relationship between potential energy and fields in order to explain how the objects interact without touching. Finally, students evaluate factors that affect the amount of potential energy stored in a system. *This investigation builds toward NGSS PEs: MS-PS3-2 and HS-PS3-5 and HS-PS3-4*.

MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

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-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Objective Target Model:

What should the student's conceptual model include?

- Students will use and apply a model to explain the relationship between electric force and

electric potential energy as the distance between two charged particles changes and the amount of charges changes.

- ○ When the amount of charge increases, the amount of force and electric potential energy stored in a field both increase.
- ○ For objects that are interacting through attractive forces (have opposite charges), when the distance between the objects increases, the amount of electric potential energy stored in the electric field increases.
- ○ For objects that are interacting through repulsive forces (have the same charge), when the distance between the objects increases, the amount of electric potential energy stored in the electric field decreases.
- ○ In general, if you have to apply a force to move the objects away from their natural position you have increased the amount of potential energy stored in the system.
- ○ If a system is free to move on its own, it will tend to move in a direction that will lower the potential energy stored in the system.

- **Investigation 3: How can a small spark start a huge explosion?**
  This investigation focuses on how electric forces and energy are connected to molecules. Students will explore various simulations to build their understanding of the relationships among electric forces, energy, and the relative distance of two atoms. They will also explain the energy transfers that occur when molecules form and break using the concept of conservation of energy (developed in previous investigations). *This investigation builds toward NGSS PEs: MS-PS1-1 and HS- PS1-4.*
  MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.
  HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

Objective Target Model:

What should student's target model include?

- Students will develop a model that a molecule is formed when different atoms combine because the electric field energy is lower for the molecule than for the individual atoms.
- Students will provide an explanation of a chemical bond in a molecule using attractive and repulsive interactions at the atomic level.

- **Investigation 4: Where does all the energy in an explosion come from?**
  In this investigation, students will construct a model of chemical reactions involving energy and electrostatic interactions. Students learn that a chemical reaction is a process that involves the atoms of substances rearranging to form new substances and that to start any chemical reaction, energy is needed to break bonds in the reactants. Students will compare reactions and changes in energy. Students develop several models to describe observations of reactions. *This investigation builds toward NGSS PEs: HS-PS1-4, HS-PS1-5 and HS-PS3-2*

HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects).

Objective Target Model:

What should the student's conceptual model include?
Students will construct a model to explain how energy and electrostatic forces are involved in chemical reactions. The model should include the following:

- If the properties of the substances before and after a process differ, than new substances have formed and a chemical reaction has occurred.
- Chemical reactions involve bonds breaking and forming such that the same atoms rearrange to form new molecules.
- Breaking bonds requires an input of energy. When bonds form, the potential energy decreases; the available energy is used to continue the reaction or is transferred to the surroundings, or both.
- When a chemical reaction transfers energy to the surroundings after the product molecules have formed, it is an exothermic reaction; if energy must continually be transferred in from the surroundings for the chemical reaction to continue, it is an endothermic reaction.

PROJECT LEARNING TREE SERVICE LEARNING PROJECT # ONE: ITREE

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Middle and High School

The following topics found in the Next Generation Science Standards are addressed in this Unit.

ESS: Earth and Space Sciences	Teaching with i-Tree Activity
Middle School	
ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	Activity 2–Tree Value Activity 3–Land Manager Role Play
High School	
ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.	Activity 2–Tree Value Activity 3–Land Manager Role Play
ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.	Activity 2–Tree Value Activity 3–Land Manager Role Play
ESS: Life Sciences	**Teaching with i-Tree Activity**
Middle School	
LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	Activity 2–Tree Value Activity 3–Land Manager Role Play
LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.	Activity 2–Tree Value Activity 3–Land Manager Role Play
High School	
LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.	Activity 2–Tree Value Activity 3–Land Manager Role Play
LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.	Activity 2–Tree Value Activity 3–Land Manager Role Play
ETS: Engineering, Technology, and Application of Science	**Teaching with i-Tree Activity**
Middle School	
ETS1-1. Design the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	Activity 2–Tree Value Activity 3–Land Manager Role Play
ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	Activity 2–Tree Value Activity 3–Land Manager Role Play
ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.	Activity 2–Tree Value Activity 3–Land Manager Role Play
High School	
ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	Activity 2–Tree Value Activity 3–Land Manager Role Play
ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	Activity 2–Tree Value Activity 3–Land Manager Role Play
ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.	Activity 2–Tree Value Activity 3–Land Manager Role Play
ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.	Activity 2–Tree Value Activity 3–Land Manager Role Play

For more information on the Next Generation Science Standards, visit: https://www.nextgenscience.org/

COMMON CORE ENGLISH LANGUAGE ARTS STANDARDS

Grades 6–12

The following Common Core Standards in the **Literacy in History/Social Studies, Science, and Technical Subjects** are addressed in this Unit.

Reading Standards for Literacy in Science and Technical Subjects (RST)	Teaching with i-Tree Activity
Key Ideas and Details	
RST 3. Cite specific textual evidence to support analysis of science and technical texts.	Activity 2–Tree Value Activity 3–Land Manager Role Play
Craft and Structure	
RST 4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context.	Activity 2–Tree Value Activity 3–Land Manager Role Play
Integration of Knowledge and Ideas	
RST 7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually.	Activity 2–Tree Value Activity 3–Land Manager Role Play
Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects (WHST)	**Teaching with i-Tree Activity**
Text Types and Purposes	
WHST 2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.	Activity 2–Tree Value
Production and Distribution of Writing	
WHST 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	Activity 2–Tree Value
WHST 6. Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.	Activity 2–Tree Value

For more information on the Common Core Standards, visit: http://www.corestandards.org/

PROJECT LEARNING TREE SERVICE LEARNING PROJECT # TWO17: EXPLORING ENVIRONMENTAL ISSUES

Conceptual Framework with standards links

Unit Description with Skills

- **Unit 3: What powers a hurricane**
-

Investigation 1: What makes water special?
In this investigation, students will connect observations of different substances to properties of the molecules of those substances. *This investigation builds toward NGSS PE: HS-PS1-3*.
HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
Objective Target Model:
What should the student's conceptual model include?

- Given an atom's electronegativity, students will make and support claims about the polarity of molecules.
- Predict how electron distribution within molecules affects the way molecules interact with each other.
- Predict and explain the effect that differences in polarity of molecules of a substance have on observable phenomenon.
-
- **Investigation 2: What happens to the energy of water molecules during hurricanes?**
In this investigation, students will add energy to their descriptions of how molecules interact. *This investigation builds toward NGSS PEs: HS-PS3-2 and HS-PS1-3*.

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

Objective Target Model:

What should the student's conceptual model include?

- Students will develop a model that explains how intramolecular and intermolecular interactions result in arrangements that lower potential energy.
- Intramolecular interactions (such as the formation of chemical bonds) and intermolecular interactions (such as the formation of hydrogen bonds) involve similar kinds of electrostatic interactions. However, the former involve interaction between full charges, and the latter involve interactions between partial charges. Therefore, the magnitude of each types of interaction is different; the interaction is stronger for chemical bonds and weaker for intermolecular interactions.

INTERACTIONS UNIT FOUR: WHY IS A TEMPERATURE OF 107 DEGREES DEADLY?

- **Unit 4: Why is a temperature of 107 degrees deadly?**

- **Investigation 1: How are interactions with water important for maintaining my life?**
  Students will look at how molecular interactions between the water-based environment ubiquitous to life and molecular interactions within the larger molecules themselves result in molecules with just the right shape to have a particular biological function. In the Investigation that follows students will explore why shape is important and how thermal energy levels are important to the stability of the molecular interactions. *This investigation builds toward NGSS PEs: HS-PS3-5, HS-LS1-6 and MS-PS3-2.*
  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.

MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

Objective Target Model:

What should student's conceptual model include?

- 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.

- **Investigation 2: Why is shape important to the role a molecule plays in our body?**
  Students will take the notion of stability and energy and apply this to how having a fever can disrupt the structure (and thus the function) of biologically important molecules. They start by exploring how shape affects the strength of attractions between molecules, both the amount of surface area contact and the opportunity for oppositely charged areas of molecules to come in contact with each other. Students will use simulations to see how temperature changes can affect the binding and structure of biologically important molecules. *This investigation builds toward NGSS PEs: HS-PS2-6, MS-PS1-4, MS-PS2-3 and MS-LS3-1.*
  HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
  MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
  MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
  MS-LS3-1. Develop and use a model to describe why structural changes to genes (mutations) located on

chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects [changes] to the structure and function of the organism.

- **Objective: Target Model**
  What should the student's conceptual model include?
  ● The attractive forces between polar and nonpolar molecules are of different strengths.
  ● The different attractive forces between polar and nonpolar molecules affect how one substance does or does not dissolve into another substance.
  ● Proteins are large molecules that have polar and nonpolar parts that can interact with each other and the surrounding molecules.
- The interaction between molecules and the molecules around them can cause specific structures to form.
- The resulting configurations result in lower potential energy for the entire system.
- The greater the surface contact between molecules the stronger the attraction between them.
- Molecules with specific shapes have specific functions due in large part to those shapes.
- Increasing temperature causes increased molecular motion which can overcome the interactions between molecules and different parts of the same molecule, thus affecting the shape and function of the molecule.

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PROJECT LEARNING TREE

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SIMULATIONS FROM THE INTERACTIONS CURRICULUM BY THE CONCORD CONSORTIUM

https://learn.concord.org/interactions?redirecting_after_sign_in=1

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