Fairfield Public Schools
Science Curriculum

The Chemistry of Medicines

The Chemistry of Medicines: Description

The Chemistry of Medicines is a one semester course using applications of chemistry. In the medicinal chemistry performance expectations at the high school level, there is a focus on several scientific concepts. These include understanding of covalent bonding, molecular shapes and polarity and how this effects intermolecular interaction; the basis of disease pathways and how pharmaceuticals are developed: and how energy is used in diagnostic imaging to diagnose disease.

Standards for this course are taken from the *Next Generation Science Standards* and are of three types:

Disciplinary Core Ideas (DCIs): Shown as content objectives, these standards define what students should know about the most essential ideas in the major science disciplines. The focus is on a limited number of core ideas in science and engineering both within and across the disciplines to avoid the shallow coverage of a large number of topics and to allow more time for teachers and students to explore each idea in greater depth. Reduction of the sheer sum of details to be mastered is intended to give time for students to engage in scientific investigations and argumentation and to achieve depth of understanding of the core ideas presented.

Science and Engineering Practices (SEP): These standards enable students to apply the content in the DCI's and the skills of practicing scientists and engineers to explain phenomena and solve real world problems. Engaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world. Engaging in the practices of engineering likewise helps students understand the work of engineers, as well as the links between engineering and science.

Crosscutting Concepts: These standards provide students with connections and intellectual tools that are related across the differing areas of disciplinary content and can enrich their application of practices and their understanding of core ideas. These broad concepts tie together the influence of engineering, technology, and science on society and the natural world.

http://www.nextgenscience.org/next-generation-science-standards

The Chemistry of Medicines: Overview

Enduring Understandings

Course Essential Questions

- How does molecular structure affect how pharmaceuticals interact in the body?
- How is energy used to diagnosis disease?

Course: Semester-at-a Glance

Unit	Title	Unit Essential Questions
1	Molecular Structure	**HS-PS1-1:** How can the periodic table be used as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms? **HS-PS 1-2:** How can the outcome of simple chemical reactions be explained based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties? **HS-PS 2-6**: How do scientists communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials?
2	Disease Pathways	**HS-LS1-3:** How can investigations be planned and conducted to provide evidence that feedback mechanisms maintain homeostasis? **HS-PS1-5**: How are scientific principles and evidence applied 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-LS3-2:** How do scientists make and defend a claims 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?
3	Applications for Medical Diagnoses	**HS-PS3-1:** How are computational model created to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known? **HS-PS3-5:** How can scientists 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-PS1-8.** How can models be used to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

Unit 1: Molecular Structure

Overview

In structure and properties of matter, students are expected to develop understanding of how atoms bond in molecules, intermolecular forces, and to provide an understanding of the mechanisms of pharmaceuticals. Further explore the role of electromagnetic radiation in medicinal diagnosis of disease.

Performance Expectations

At the conclusion of this unit, students will be able to:

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-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Unit Essential Question

- How does structure of molecules affect their function?

Crosscutting Concepts

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HSPS1-5)

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. (HS-PS2-6)

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

Structure and Properties of Matter

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)
- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)

Chemical Reactions

- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7)

Types of Interactions

- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (secondary to HS-PS1-1),(secondary to HS-PS1-3)

Structure and Properties of Matter

- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (secondary to HS-PS2-6)

Types of Interactions

- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS2-6),(secondary to HS-PS1-1),(secondary to HS-PS1-3)

SCIENCE AND ENGINEERING PRACTICES (SEP):

Developing and Using Models

- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

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. (HS-PS1-2)

Obtaining, Evaluating, and Communicating Information

- Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple format (including orally, graphically, textually, and mathematically). (HS-PS2-6)

Corresponding CT Core Standards:

ELA/Literacy – RST.9-10.7, WHST.9-12.2, WHST.9-12.5, HSN-Q.A.1, HSN-Q.A.3

Mathematics – HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3,

Unit 2: Disease Pathways

Overview

Students are able to understand basics of disease pathways, historically how diseases were targeted, and modern medicinal design.

Performance Expectations

At the conclusion of this unit, students will be able to:
HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
HS-LS3-2. 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.
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.

Unit Essential Questions

- How has modern science advanced our understanding of medicine?

Crosscutting Concepts

Stability and Change
- Feedback (negative or positive) can stabilize or destabilize a system. (HSLS1-3)

Cause and Effect
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS3-1),(HS-LS3-2)

Patterns
- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HSPS1-5)

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

Structure and Function

- Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HS-LS1-3)

Variation of Traits

- In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3-2)
- Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. (HS-LS3-2),(HS-LS3-3)

Chemical Reactions

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HSPS1-4),(HS-PS1-5)

SCIENCE AND ENGINEERING PRACTICES (SEP):

Planning and Carrying Out Investigations

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-LS1-3)

Engaging in Argument from Evidence

- Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence. (HS-LS3-2)

Constructing Explanations and Designing Solutions

- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)

Corresponding CT Core Standards:

ELA/Literacy – RST.11-12.1; WHST.9-12.5; WHST.9-12.7, WHST.11-12.8,

Mathematics – MP.2, HSN-Q.A.1, HSN-Q.A.3

Unit 3: Applications for Medical Diagnoses

Overview

Students will be able to understand how electromagnetic radiation and nuclear medicine is used to diagnose diseases.

Performance Expectations

At the conclusion of this unit, students will be able to:

HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

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.

Unit Essential Questions

- How is energy used to understand the status of the human body?

Crosscutting Concepts

Energy and Matter

- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8)

Cause and Effect

- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions
- and approximations inherent in models. (HSPS3-1)
- 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. (HS-PS3-5)

NGSS Unit Standards

DISCIPLINARY CORE IDEAS (DCI):

Nuclear Processes

- Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HSPS1-8)

Definitions of Energy

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HSPS3-1),(HS-PS3-2)

Relationship Between Energy and Forces

- When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)

SCIENCE AND ENGINEERING PRACTICES (SEP):

Developing and Using Models

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4),(HS-PS1-8)

Using Mathematics and Computational Thinking

- Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)

Developing and Using Models

- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2),(HSPS3-5)

Corresponding CT Core Standards:

ELA/Literacy – RST.9-10.7; WHST.11-12.8; HSN-Q.A.2

Mathematics – MP.4, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3