Correlations to Next Generation Science Standards

Physical Science Disciplinary Core Ideas

PS-1 Matter and Its Interactions

PS1.A Structure and Properties of Matter

Each atom has a charged substructure consisting of a **nucleus** made up of protons and neutrons, **surrounded by electrons**.

> **Fascinating Chemistry Lesson 1, 2, 3, 4, 5, 6, 10, 14, 15, 16, 17, 18**
> **Fascinating Physics Lesson 8, 9, 11, 14, 15**
> **Fascinating Biology Lesson 2**

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.

> **Fascinating Chemistry Lesson 2, 3, 5, 14**

The structure and interactions of matter at the bulk scale are determined by **electrical forces within and between atoms**.

> **Fascinating Chemistry Lesson 1, 2, 3, 4, 5, 6, 7, 8, 11, 12, 14, 15, 16, 17, 18**
> **Fascinating Biology Lesson 2**

A stable **molecule has less energy than the** same set of **atoms separated**, and one must provide at least this energy in order to take the molecule apart.

> **Fascinating Chemistry Lesson 1, 2, 3, 4, 6, 14, 17**

PS1.B 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**, with consequent changes in the sum of all bond energies in the set of molecules that are matched.

> **Fascinating Chemistry Lesson 2, 3, 4, 7, 13, 17**

In many situations a dynamic and condition-dependent balance between a **reaction and** the **reverse reaction** determines the numbers of all types of molecules present.

Fascinating Chemistry Lesson 7, 13, 16, 17
Fascinating Biology Lesson 4

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.

Fascinating Chemistry Lesson 13, 15, 16, 17

PS1.C 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.

Fascinating Chemistry Lesson 18
Fascinating Physics Lesson 15

PS-2 Motion and Stability: Forces and Interactions

PS2.A Forces and Motion

Newton's Second Law accurately predicts changes in the motion of macroscopic objects.

Fascinating Physics Lesson 3, 4, 5, 11

Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.

Fascinating Physics Lesson 4, 5
Fascinating Physics Lesson 14

If a system interacts with objects outside itself, the **total momentum of the system** can change; however, any such change is balanced by changes in the momentum of objects outside the system.

Fascinating Physics Lesson 4, 5

PS2.B Types of Interactions

Newton's Law of Universal Gravitation and Coulomb's Law
provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.

Fascinating Chemistry Lesson 11
Fascinating Physics Lesson 11, 12, 15

Forces at a distance are explained by **fields** (gravitational, electrical, and magnetic) permeating space that can transfer energy through space. Magnets or electrical currents cause magnetic fields; electrical changes or changing magnetic fields cause electrical fields.

Fascinating Chemistry Lesson 11
Fascinating Physics Lesson 9, 11, 12,

Attraction and repulsion between electrical charges at the atomic level explain the structure, properties, and transformation of matter, as well as the contact forces between material objects.

Fascinating Chemistry Lesson 2, 3, 4, 5, 6, 7, 8, 11, 12, 13, 14, 15, 16, 17, 18
Fascinating Physics Lesson 11, 12, 15

PS-3 Energy

PS3.A Definitions of Energy

"**Electrical energy**" may mean energy stored in a battery or energy transmitted by electrical currents.

Fascinating Chemistry Lesson 16
Fascinating Physics Lesson 11, 12, 13, 15

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.

Fascinating Chemistry Lesson 13, 16, 18
Fascinating Physics Lesson 6, 9, 12, 13, 14, 15
Fascinating Biology Lesson 5, 6, 7, 8

At the macroscopic scale, **energy manifests itself in multiple ways**, such as in motion, sound, light, and thermal energy.

Fascinating Chemistry Lesson 6, 7, 11, 16
Fascinating Physics Lesson 4, 6, 7, 8, 9, 12, 13, 14, 15
Fascinating Biology Lesson 5, 6, 7, 8

These relationships are better understood at the microscopic scale, at which all of the different manifestations of **energy** can be modeled as a combination of energy associated with the **motion of particles and** energy associated with the **configuration** (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

Fascinating Chemistry Lesson 6, 11, 12
Fascinating Physics Lesson 4, 6, 7, 8, 9, 11, 12, 13, 14, 15
Fascinating Biology Lesson 5

PS3.B Conservation of Energy and Energy Transfer

Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.

Fascinating Chemistry Lesson 13, 16, 18
Fascinating Physics Lesson 4, 6, 12, 13
Fascinating Biology Lesson 5, 6, 7, 8

Energy cannot be created or destroyed, but it **can be transported** from one place to another and transferred between systems.

Fascinating Chemistry Lesson 1, 6, 7, 11, 13, 16, 18
Fascinating Physics Lesson 4, 6, 7, 8, 12, 13, 14, 15
Fascinating Biology Lesson 5, 6, 7, 8

Mathematical expressions, which quantify how the **stored energy in a system** depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.

Fascinating Chemistry Lesson 7, 11, 13, 16, 18
Fascinating Physics Lesson 4, 6, 7, 8, 9, 11, 12, 13

The **availability of energy** limits what can occur in any system.

Fascinating Chemistry Lesson 11, 13, 16, 18
Fascinating Physics Lesson 4, 6, 8, 13, 15
Fascinating Biology Lesson 4, 5, 6, 7, 8

Uncontrolled **systems** always **evolve toward more stable states** – that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).

Fascinating Chemistry Lesson 1, 2, 3, 4, 5, 13, 14, 15, 17, 18
Fascinating Physics Lesson 6

PS3.C Relationship Between Energy and Forces
When two objects interacting through a field change relative position, the **energy stored in the field** is changed.

Fascinating Chemistry Lesson 17
Fascinating Physics Lesson 4, 6, 11, 12, 13

PS3.D Energy in Chemical Processes and Everyday Life
Although **energy cannot be destroyed**, it can be converted to less useful forms – for example, to thermal energy in the surrounding environment.

Fascinating Chemistry Lesson 13, 16
Fascinating Physics Lesson 8, 12, 15
Fascinating Biology Lesson 5, 6, 7, 8

Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy.

Fascinating Chemistry Lesson 7, 16

PS-4 Waves and Their Applications in Technologies for Information Transfer

PS4.A Wave Properties
The **wavelength and frequency of a wave** are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.

Fascinating Chemistry Lesson 6
Fascinating Physics Lesson 7, 8, 9, 14, 15

Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.

Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other.

Fascinating Physics Lesson 7, 8, 9, 14

PS4.B Electromagnetic Radiation
Electromagnetic radiation (e.g., radio, microwaves, light) can be modified as a wave of **changing electrical and magnetic fields or** as **particles** called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.

Fascinating Chemistry Lesson 6
Fascinating Physics Lesson 7, 8, 9, 14, 15

When light or longer wavelength **electromagnetic radiation** is **absorbed in matter**, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.

Fascinating Chemistry Lesson 6, 8, 9, 15
Fascinating Biology Lesson 5, 6

Photoelectric materials emit electrons when they absorb light of a high-enough frequency.

Fascinating Physics Lesson 14

PS4.C Information Technologies and Instrumentation

Multiple technologies based on the understanding of **waves and their interactions** with matter are part of everyday experiences in the modern word (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.

Fascinating Chemistry Lesson 6
Fascinating Physics Lesson 14