Unit 3
Properties of Matter

1000 B.C. | 1700 | 1800

350 B.C.
Greek philosopher Aristotle defines an element as "one of those bodies into which other bodies can decompose, and that itself is not capable of being divided into another."

1704
Isaac Newton proposes that atoms attach to each other by some type of force.

1869
Dmitri Mendeleev publishes the first version of the periodic table.

1874
G. Johnstone Stoney proposes the existence of the electron, a subatomic particle that carries a negative electric charge, after experiments in electrochemistry.

1897
J.J. Thompson demonstrates the existence of the electron, proving Stoney's claim.

1900 1950

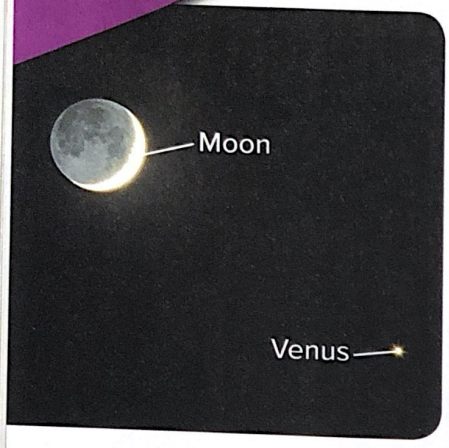
1907
Physicists Hans Geiger and Ernest Marsden, under the direction of Ernest Rutherford, conduct the famous gold foil experiment. Rutherford concludes that the atom is mostly empty space and that most of the mass is concentrated in the atomic nucleus.

1918
Ernest Rutherford reports that the hydrogen nucleus has a positive charge, and he names it the proton.

1932
James Chadwick discovers the neutron, a subatomic particle with no electric charge and a mass slightly larger than a proton.

Visit ConnectED for this unit's STEM activity.

Patterns



▲ **Figure 1** Venus is often so bright in the morning sky that it has been nicknamed the morning star.

It's a bird! It's a plane! No, it's Venus! Besides the Sun, Venus is brighter than any other star or planet in the sky. It is often seen from Earth without the aid of a telescope, as shown in **Figure 1.** At certain times of the year, Venus can be seen in the early evening. At other times of the year, Venus is best seen in the morning or even during daylight hours.

Astronomers study the patterns of each planet's orbit and rotation. A pattern is a consistent plan or model used as a guide for understanding and predicting things. Studying the orbital patterns of planets allows scientists to predict the future position of each planet. By studying the pattern of Venus's orbit, astronomers can predict when Venus will be most visible from Earth. Astronomers also can predict when Venus will travel between Earth and the Sun, and be visible from Earth, as shown in **Figure 2.** This event is so rare that it has only occurred seven or eight times since the mid-1600s. Using patterns, scientists are able to predict the date when you will be able to see this event in the future.

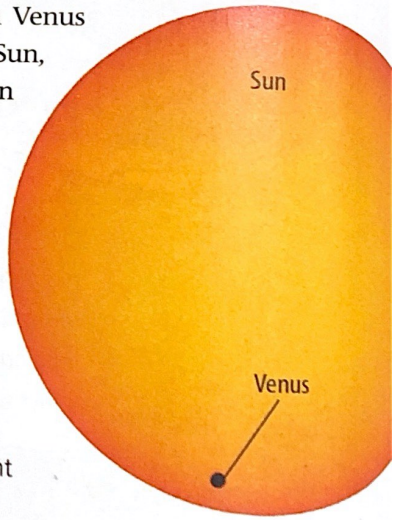


Figure 2 On June 5 and 6, 2012 observers around the world watched Venus pass in front of the Sun. This was the last time this event will take place until 2117. ►

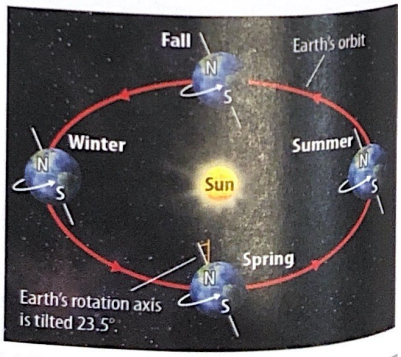
Types of Patterns

Physical Patterns

A pattern that you can see and touch is a physical pattern. The crystalline structures of minerals are examples of physical patterns. When atoms form crystals, they produce structural, or physical, patterns. The crystal structure of the Star of India sapphire creates a pattern that reflects light in a stunning star shape.

Cyclic Patterns

An event that repeats many times again in a predictable order has a cyclic pattern. Since Earth's axis is tilted, the angle of the Sun's rays on your location on Earth changes as Earth orbits the Sun. This causes the seasons—winter, spring, summer, and fall—to occur in the same pattern every year.



Patterns in Engineering

Engineers study patterns for many reasons, including to understand the physical properties of materials or to optimize the performance of their designs. Have you ever seen bricks with a pattern of holes through them? Clay bricks used in construction are fired, or baked, to make them stronger. Ceramic engineers understand that a regular pattern of holes in a brick assures that the brick is evenly fired and will not easily break.

Maybe you have seen a bridge constructed with a repeating pattern of large, steel triangles. Civil engineers, who design roads and bridges, know that the triangle is one of the strongest shapes in geometry. Engineers often use patterns of triangles in the structure of bridges to make them withstand heavy traffic and high winds.

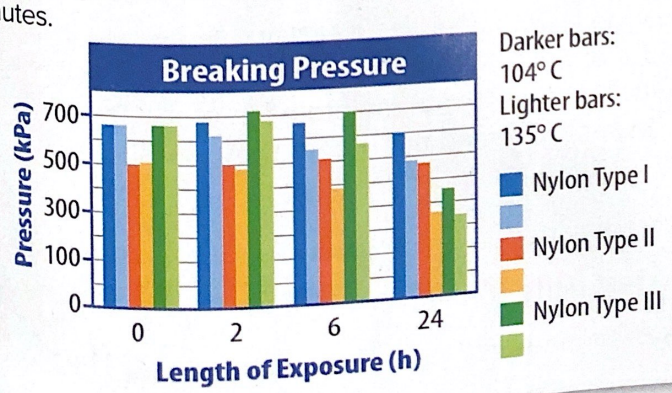
Patterns in Physical Science

Scientists use patterns to explain past events or predict future events. At one time, only a few chemical elements were known. Chemists arranged the information they knew about these elements in a pattern according to the elements' properties. Scientists predicted the atomic numbers and the properties of elements that had yet to be discovered. These predictions made the discovery of new elements easier because scientists knew what properties to look for.

Look around. There are patterns everywhere–in art and nature, in the motion of the universe, in vehicles traveling on the roads, and in the processes of plant and animal growth. Analyzing patterns helps to understand the universe.

Patterns in Graphs

Scientists often graph their data to help identify patterns. For example, scientists might plot data from experiments on parachute nylon in graphs, such as the one below. Analyzing patterns on graphs then gives engineers information about how to design the strongest parachutes.



MiniLab
15 minutes

How strong is your parachute?

Suppose you need to design a parachute. The graph to the left shows data for three types of parachute nylon. Each was tested to see how it weakens when exposed to different temperatures for different lengths of time. How would you use the patterns in the graph to design your parachute?

1. Write down the different experiments performed and how the variables changed in your Science Journal.
2. Write down all the patterns that you notice in the graph.

Analyze and Conclude

1. **Compare** Which nylon is weakest? What pattern helps you make this comparison?
2. **Identify** Which nylon is most affected by length of exposure to heat? What is its pattern on the graph?
3. **Select** Which nylon would you choose for your parachute? What pattern helped you make your decision?