Science 8
Technical Reading

Doin' the Wave

EQ: What is in the air that I cannot see?

Targeted Skills
- Communication
  - Determine purpose
    - gather information
- Information Literacy
  - Organize and manipulate information
    - diagrams
- Technology
  - Select and Manipulate Technology Tools
    - graphic organizers

Enduring Understandings
The transfer of matter and energy within the atmosphere produces global patterns.

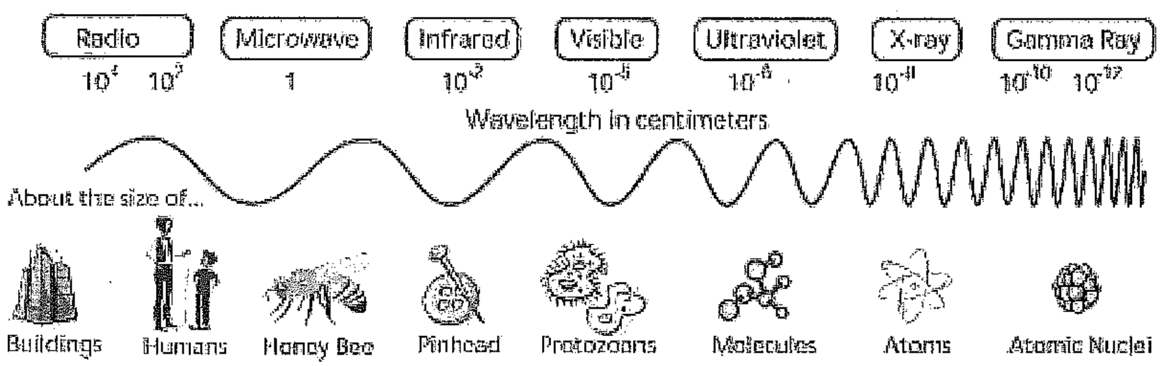
Concepts Important to Know and Understand
waves, energy transfer, global patterns

Broad Brush Knowledge
global currents, particle movement

Core Objectives
7. Analyze and interpret the interaction of waves with different media.
9. Illustrate interactions between matter and energy in various systems.

Purpose Gather information, develop technical reading skills, and demonstrate understanding by creating a concept map.

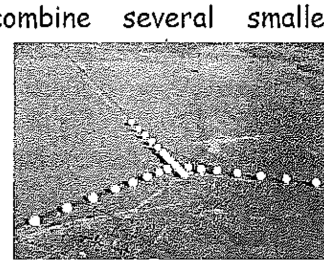
Electromagnetic waves are a special type of transverse waves that result from electricity and a magnetic field changing or moving together.



These waves do not require matter to travel through, so they move through empty space. They are arranged according to wavelength on a diagram called the **electromagnetic spectrum**. Different kinds of waves in the electromagnetic spectrum have different wavelengths, but they all travel at the same speed. They vary in size from very long radio waves the size of buildings, to very short gamma rays smaller than the size of the nucleus of an atom.

Radio waves have the longest wavelengths in the electromagnetic spectrum. These waves can be longer than a football field or as short as a football. Radio waves do more than just bring music to radios. They also carry signals for televisions and cellular phones. The antenna on a television set receives a signal, in the form of electromagnetic waves, which is broadcasted from the television station and then displayed on the television screen. Radio waves with shorter wavelengths transmit information to cell phones.

Objects in space, such as planets and comets, giant clouds of gas and dust, stars, and galaxies, emit light at many different wavelengths. Since radio waves are very large, telescopes that receive radio waves must also be very large. Radio telescopes are dishes made out of metal that reflects radio waves to a focus point. In order to make better and clearer radio images, astronomers often combine several smaller telescopes into an array. Together, the dishes act as one large telescope whose size equals the total area occupied by the array.



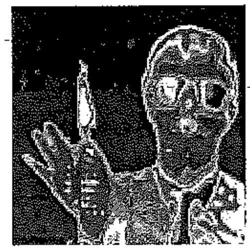
By studying radio waves, astronomers can determine the composition, structure, and motion of objects that emit radio waves. Since these waves penetrate the atmosphere, radio telescopes "see" as well on Earth as in space.

Microwave wavelengths are measured in centimeters. These waves are used for transmitting information from one place to another here on Earth because microwave energy can penetrate haze, light rain, snow, clouds, and smoke. Microwaves are used in remote sensing devices such as the Doppler radar used in weather forecasts. Microwave towers transmit information like telephone calls and computer data from one city to another. Radars transmit bursts of microwaves. The strength and origin of the echoes received from objects that were hit by the microwaves reveal their position and direction of movement. Radars analyze weather events and since microwaves can penetrate cloud cover, these waves are used for viewing Earth from space.

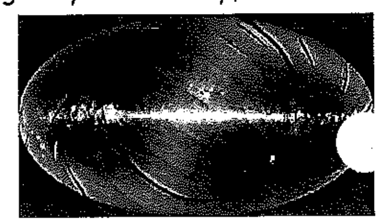
In the 1960's, a pair of scientists at Bell Laboratories detected background noise using a special low noise antenna. The strange thing about the noise was that it was coming from every direction and did not vary in intensity. If this static were from something on Earth, like radio transmissions from a nearby airport control tower, it would only come from one direction. The scientists soon realized they had discovered

cosmic microwave background radiation. This radiation, which fills the entire Universe, is believed to be a clue to its beginning, something known as the **Big Bang**. This is an image of the cosmic microwave background; the colors show the tiny fluctuations in the signals.

Infrared light lies between the visible and microwave portions of the electromagnetic spectrum. Longer infrared waves are thermal. In other words, the heat from sunlight, a fire, a radiator or a warm sidewalk are infrared rays. Shorter infrared waves are not hot and are used in remote controls. Any warm object, including a person, radiates infrared waves. Even objects that we think of as being very cold, such as an ice cube, emit infrared. When an object is not quite hot enough to radiate visible light, it will emit most of its energy in the infrared. For example, hot charcoal may not give off light but it does emit infrared radiation, which we feel as he The warmer the object, the more infrarea radiation it emits. This image shows a man holding up a lighted match. To make infrared pictures, special cameras and film that

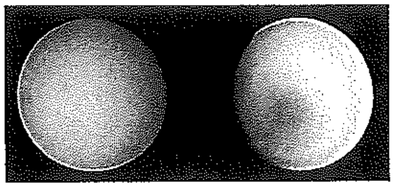


detects differences in temperature are used. Colors are then assigned to each temperature range. This provides a picture that our eyes can interpret. Many objects in space such as Earth, the Sun, stars and galaxies emit infrared light. Infrared film 'sees' the object because a star or other light source shines infrared light on it and it is reflected or absorbed by the object. An infrared satellite took this image showing the center region of our galaxy. The hazy, horizontal



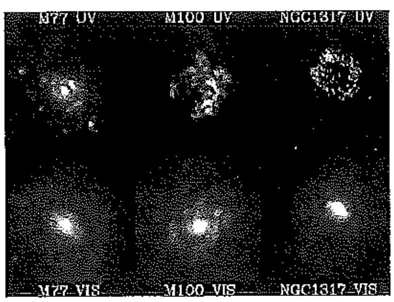
S-shaped feature that crosses the image is faint heat emitted by dust in the plane of the Solar System.

Visible light waves are the only electromagnetic waves we can see. Each color has a different wavelength. When all the waves are seen together, they make white light. When white light shines through a prism or through water vapor, the white light is broken apart into the colors of the visible light spectrum. When we look at an object, cones in our eyes receive the visible light waves. The Sun is a natural source of visible light waves and our eyes see the reflection of this sunlight off the objects around us. The color of an object that we see is the wavelength of light reflected. All other wavelengths of visible light are absorbed. Many instruments that detect visible light can see farther and more clearly than our eyes could alone. We not only look at the Earth from space but we can also look at other planets from space. Both of these images are of the planet Uranus. The one on the left is exac how the image appears using visible light. The image on the right is enhanced. The colors were



chosen to exaggerate the subtle details of the polar region of the planet.

Ultraviolet (UV) light has shorter wavelengths than visible light. Satellites equipped with ultraviolet telescopes analyze light from stars and galaxies. The Sun emits light at all the different wavelengths in the electromagnetic spectrum, but ultraviolet waves are responsible for causing sunburns. Though some ultraviolet waves from the Sun penetrate Earth's atmosphere, most of them are blocked from entering by various gases like Ozone. Some days, more ultraviolet waves get through our atmosphere. Scientists have developed a UV index to help people protect themselves from these harmful ultraviolet waves. This image shows three different galaxies taken in visible light (bottom three images) and ultraviolet light (top row.) The difference in how the galaxies appear is due to which type of stars shine brightest in the visible and ultraviolet wavelengths. Pictures of galaxies like these show mainly clouds of gas containing newly formed stars many times more massive than the sun, which glow strongly in ultraviolet light. In contrast, visible light pictures of galaxies show mostly the yellow and red light of older stars. By comparing these types of data, astronomers learn about the structure and evolution of galaxies.

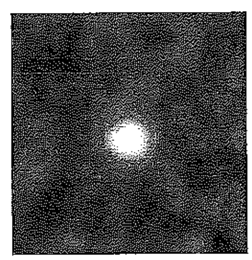


X-rays have smaller wavelengths and therefore higher energy than ultraviolet waves. These waves were first observed and documented in 1895 by Wilhelm Roentgen, a German scientist who accidentally found them when experimenting with vacuum tubes. Roentgen called it "X" to indicate it was an unknown type of radiation. The Earth's atmosphere is thick enough that virtually no X-rays are able to penetrate from outer space all the way to the Earth's surface. While the atmosphere protects us from the harmful effects of X-rays, this means that X-ray telescopes only work in space.

If we could see X-rays, we could see things that either emit X-rays or halt their transmission. Satellites with X-ray detectors record emissions by black holes, neutron stars, binary star systems, supernova remnants, stars, the Sun, and even some comets. The amount and speed of X-rays provide astronomers valuable information about the structure and function of these objects.

Gamma-rays have the smallest wavelengths and the most energy of all the waves in the electromagnetic spectrum. These waves are generated by radioactive atoms and in nuclear explosions. Naturally occurring gamma-rays are absorbed by Earth's atmosphere, but they can also be created in medical labs. Since these waves kill living cells, they are used as a treatment for cancer.

Instruments aboard high-altitude balloons and satellites provide our only view of gamma-rays in the universe. They are produced in the hottest regions of space by events such as supernova explosions, neutron stars, pulsars, and black holes. By studying gamma waves, scientists can search for new objects, test theories and perform experiments that are not possible on Earth. Perhaps the most spectacular discovery in gamma-ray astronomy came in the late 1960s and early 1970s. Detectors on board satellites began to record bursts of gamma-rays from deep space. Today, these gamma-ray bursts, which happen at least once a day, last for fractions of a second to minutes, popping off like cosmic flashbulbs from unexpected directions. Gamma-ray bursts can release more energy in 10 seconds than the Sun will emit in its entire 10 billion-year lifetime! By solving the mystery of gamma-ray bursts, scientists hope to gain further knowledge of the origins of the Universe, the rate at which the Universe is expanding, and the size of the Universe.



-adapted from http://imagers.gsfc.nasa.gov/ems