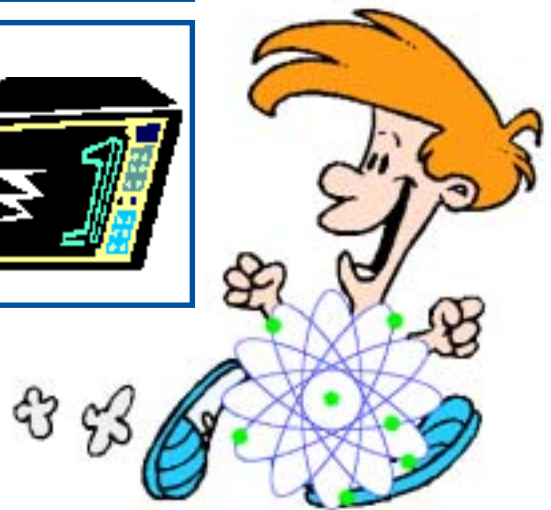
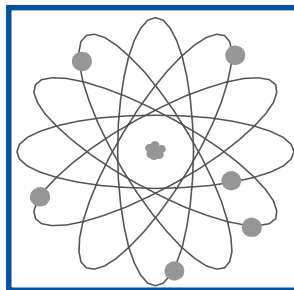


# RADIATION IN OUR WORLD



Fun Facts & Activities

# An Introduction to Radiation

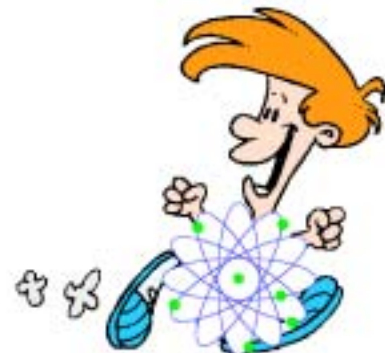
Radiation is all around us, every minute of every day. It comes from outer space, the sun, the Earth, and even from within our own bodies. Radiation is energy that comes from both natural and manmade sources that provide many of the conveniences of modern living. We use radiation in medical procedures to diagnose and treat diseases and to fuel nuclear power plants to generate electricity. Radiation is also in many electronic products and devices we use and see every day such as cell phones and other wireless communication devices, high-voltage power lines, TVs, microwave ovens, fluorescent exit signs, glow-in-the dark watches and alarm clocks. Properly managed and safely handled radiation offers us many benefits. But, there are also health and environmental risks. By understanding radiation, its uses, benefits, and exposure risks, we will be able to make informed decisions about our health and environment and the radiation risks we are and are not willing to accept.

## What is Radiation?

Matter is made up of very, very small particles called atoms. Some atoms are unstable. Radiation comes from atoms that are in the process of changing. As these atoms change to become more stable, they give off, or emit, energy in the form of particles or waves called "radiation." All radiation can be classified as either "ionizing" or "non-ionizing." Ionizing is the most energetic form of radiation. The four major types of ionizing radiation include: alpha particles, beta particles, gamma rays, and x-rays. Non-ionizing radiation comes in the form of electromagnetic waves and has enough energy to move atoms around, but not enough energy to change them chemically. This is true whether the atomic action is a naturally occurring process or a manmade process. Types of non-ionizing radiation include: ultraviolet light, visible light, infrared radiation, radio-frequency radiation, and microwaves.



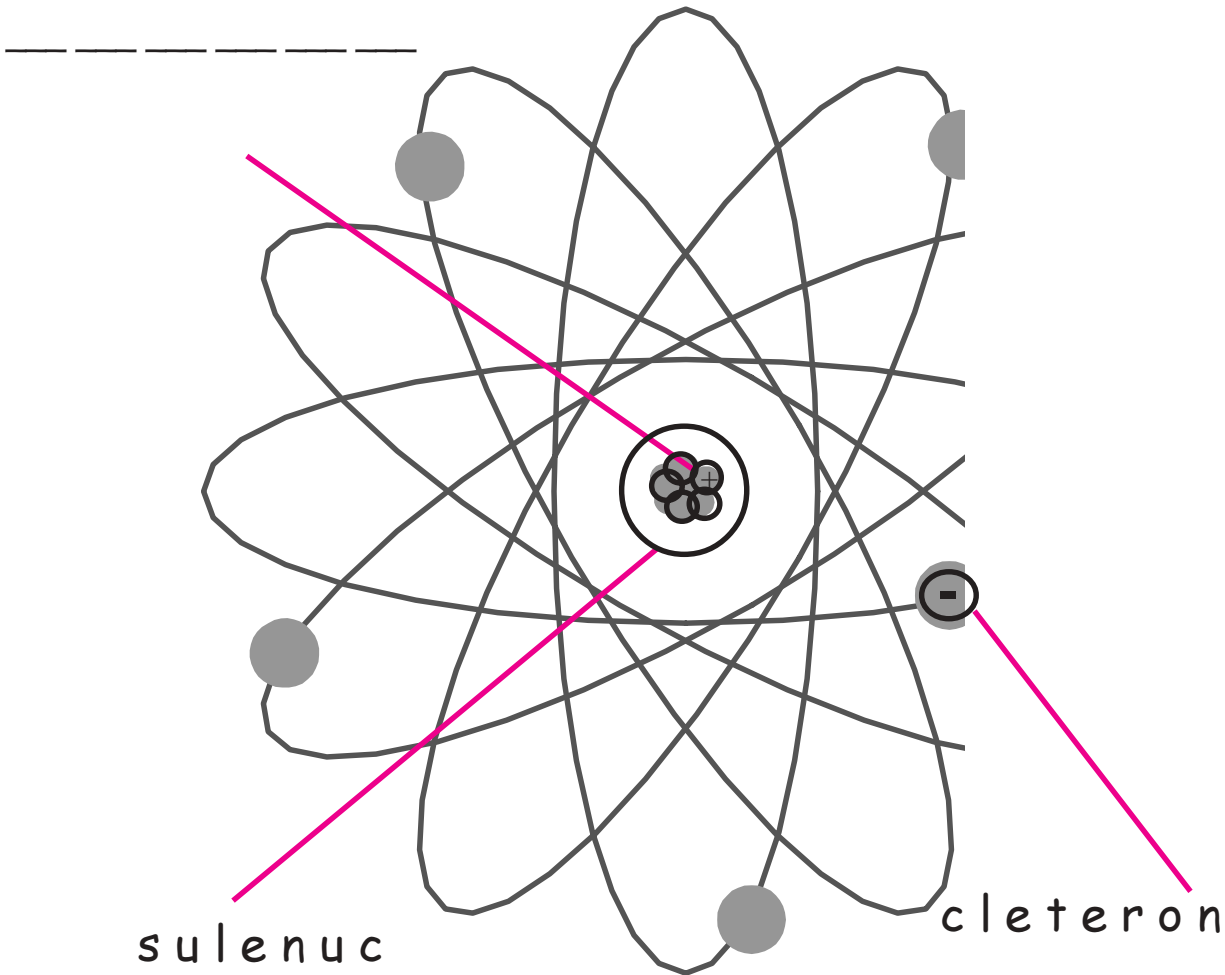
For more information on  
radiation, U.S. Environmental  
Protection Agency's Web site:  
<http://www.epa.gov/radiation>



# Name the Parts of the Atoms

Unscramble the words to name the parts of the atom below:

nrotop



The atom is the smallest unit of an element that shows the chemical behavior characteristics of an element. The structure of an atom can be compared to our solar system. At the center of every atom is the positively charged nucleus, which could be compared to the sun in our solar system. The electrons move around the nucleus as if in orbit, just like Earth orbits around the sun. Opposite electrical charges of the protons and electrons do the work of holding the nucleus and its electrons together. Neutrons have no electrical charge. They appear to be necessary to help bind together the positively charged protons, which naturally repel each other. Any change in the number, position, or energy of the nucleons can upset their balance. If this happens, the nucleus becomes unstable or radioactive.

# Secret Message

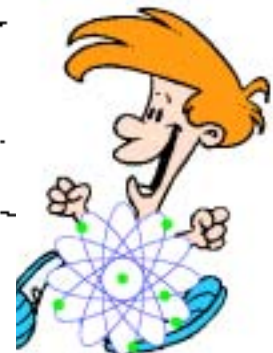
<b>CODE:</b>			
26 = A	19 = H	12 = O	5 = V
25 = B	18 = I	11 = P	4 = W
24 = C	17 = J	10 = Q	3 = X
23 = D	16 = K	9 = R	2 = Y
22 = E	15 = L	8 = S	1 = Z
21 = F	14 = M	7 = T	
20 = G	13 = N	6 = U	

9 26 23 18 26 7 18 12 13 18 8 7 19 22 11 9 12 24 22 8 8 12 21

7 9 26 13 8 14 18 7 7 18 13 20 22 13 22 9 20 2 7 19 9 12 6 20 19

8 11 26 24 22.

**Rad Fact:** Most of the ionizing radiation we are exposed to consists of natural, or background, radiation.



# Radiation Wavelengths

The higher the energy, the shorter the wavelength of the radiation. Number the wavelengths for each type from lowest energy (1) to highest energy (7).



Ultraviolet \_\_\_\_\_



Radio \_\_\_\_\_



Gamma Rays \_\_\_\_\_



X-Rays \_\_\_\_\_



Infrared \_\_\_\_\_

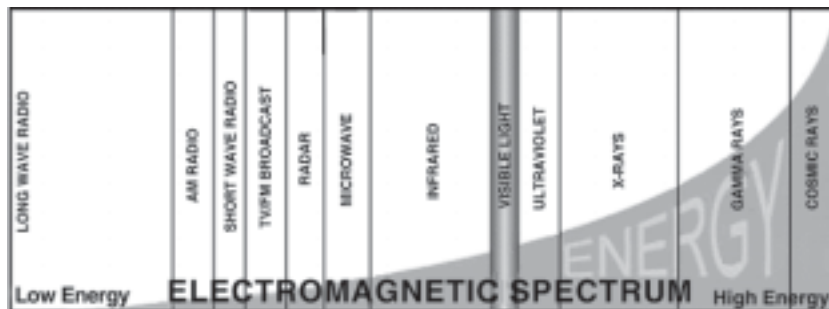


Visible Light \_\_\_\_\_



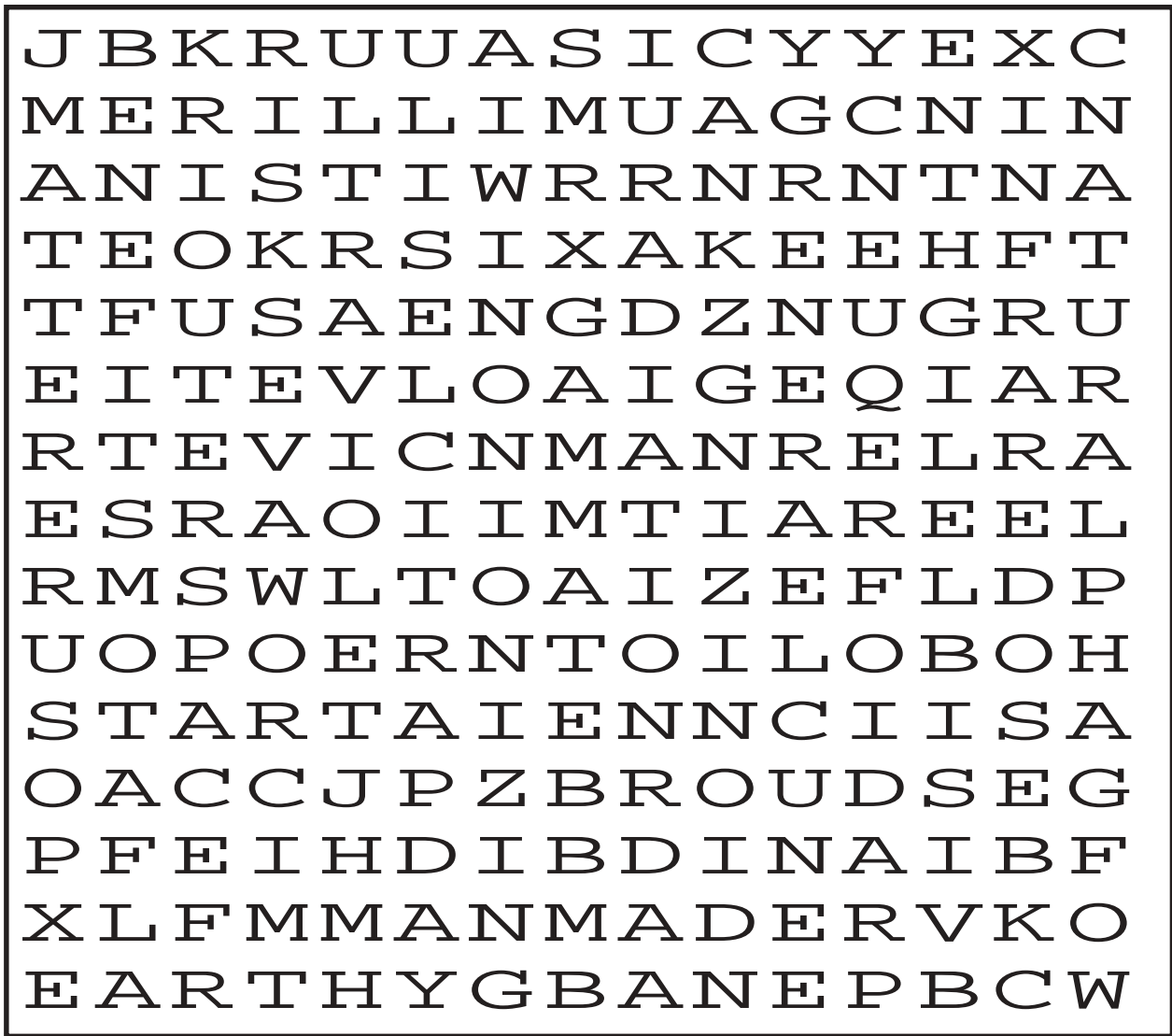
Microwave \_\_\_\_\_

The most basic distinction scientists make between types of radiation is the amount of energy involved, as shown with the electromagnetic spectrum. Radiation consists of electric and magnetic waves. It ranges from radar and radio waves with relatively long waves, and low energy, through the ultraviolet, visible, and infrared regions, to X-rays (and gamma rays) with short wave length and high energy.



Longer ← wavelenghts → Shorter

# Word Find: Radiation Terms



- |          |                 |             |                 |               |
|----------|-----------------|-------------|-----------------|---------------|
| ALPHA    | EARTH           | MANMADE     | NUCLEAR ENERGY  | SUN           |
| ATOMS    | ELECTROMAGNETIC | MATTER      | OUTER SPACE     | ULTRAVIOLET   |
| BENEFITS | EXPOSURE        | MICROWAVE   | PARTICLES       | VISIBLE LIGHT |
| BETA     | GAMMA           | MILLIREM    | RADIATION       | WAVES         |
| CURIE    | INFRARED        | NATURAL     | RADIO FREQUENCY | XRAY          |
| DOSE     | IONIZING        | NONIONIZING | RISKS           |               |

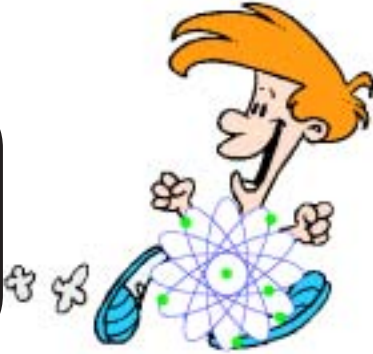
**Rad Fact:** Radiation dose is measured in units called rem. A millirem is one thousandth of a rem. In the United States a person receives an average dose of about 360 millirem per year.

# Word Find: Sources of Ionizing Radiation

SDROCDIOGNSUNLIGHTTS  
 JHILPOSKONOTKGLIGELD  
 JMEXITSIGNIHSIGNINIM  
 XOIDXISMOKEDETECTORN  
 RTYIOIENIHCAMYARXHSS  
 AASUVWOMICROWAVEWPSH  
 YGRENERAELCUNNIGELOU  
 EOLGCOMPUTERUSCHF LNM  
 RENILREWOPYESSIGDEUA  
 TIBANANALMRADONLGCUN

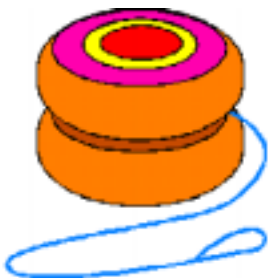
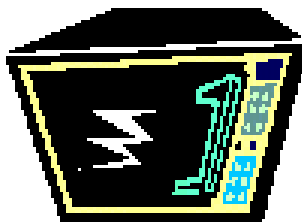
- |            |           |                |                |
|------------|-----------|----------------|----------------|
| atom       | cosmic    | mining         | smoke detector |
| banana     | exit sign | nuclear energy | sunlight       |
| cell phone | human     | powerline      | television     |
| computer   | microwave | radon          | xray machine   |

Eighty percent of human exposure to ionizing radiation comes from natural sources: radon gas, the human body, outer space, rocks and soil, and even some foods. The remaining twenty percent comes from manmade radiation sources, primarily medical x-rays. Small amounts of radiation are also given off by manmade sources and nuclear power plants.

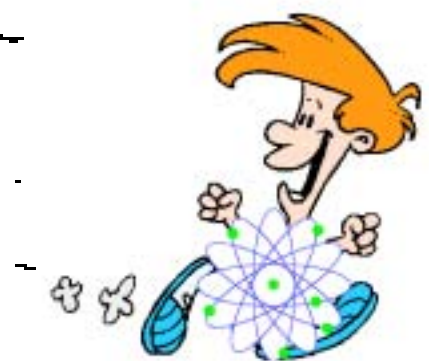


# Which Items Don't Produce Radiation?

Circle the items that don't produce radiation.



**Rad Fact:** There is an important difference between radiation and radioactivity. Radiation is energy in the form of waves or particles sent out over a distance. Radioactivity is a property of a substance which emits high-energy radiation.



# Items with Radiation

Unscramble the words to find out which items give off radiation. Look at previous pages for hints.

daori \_\_\_\_\_

nitoiveels \_\_\_\_\_

avomcriwe nevo \_\_\_\_\_

yarx hecinma \_\_\_\_\_

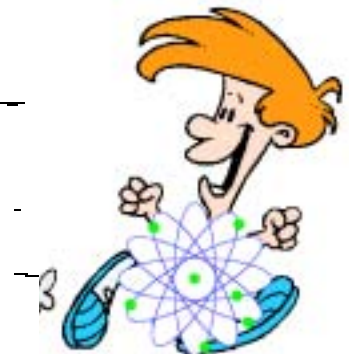
ecnarlu carerot \_\_\_\_\_

clel hnope \_\_\_\_\_

listughn \_\_\_\_\_

drona \_\_\_\_\_

**Rad Fact:** We use radiation to generate electricity, diagnose and treat medical problems, create and improve consumer products, breed more productive and disease resistant crops, and conduct a wide range of scientific research.



# Secret Message

<b>CODE:</b>			
26 = A	19 = H	12 = O	5 = V
25 = B	18 = I	11 = P	4 = W
24 = C	17 = J	10 = Q	3 = X
23 = D	16 = K	9 = R	2 = Y
22 = E	15 = L	8 = S	1 = Z
21 = F	14 = M	7 = T	
20 = G	13 = N	6 = U	

7 19 22    8 6 13    19 26 8    9 26 2 8    4 22    24 26 13 13 12 7    8 22 22

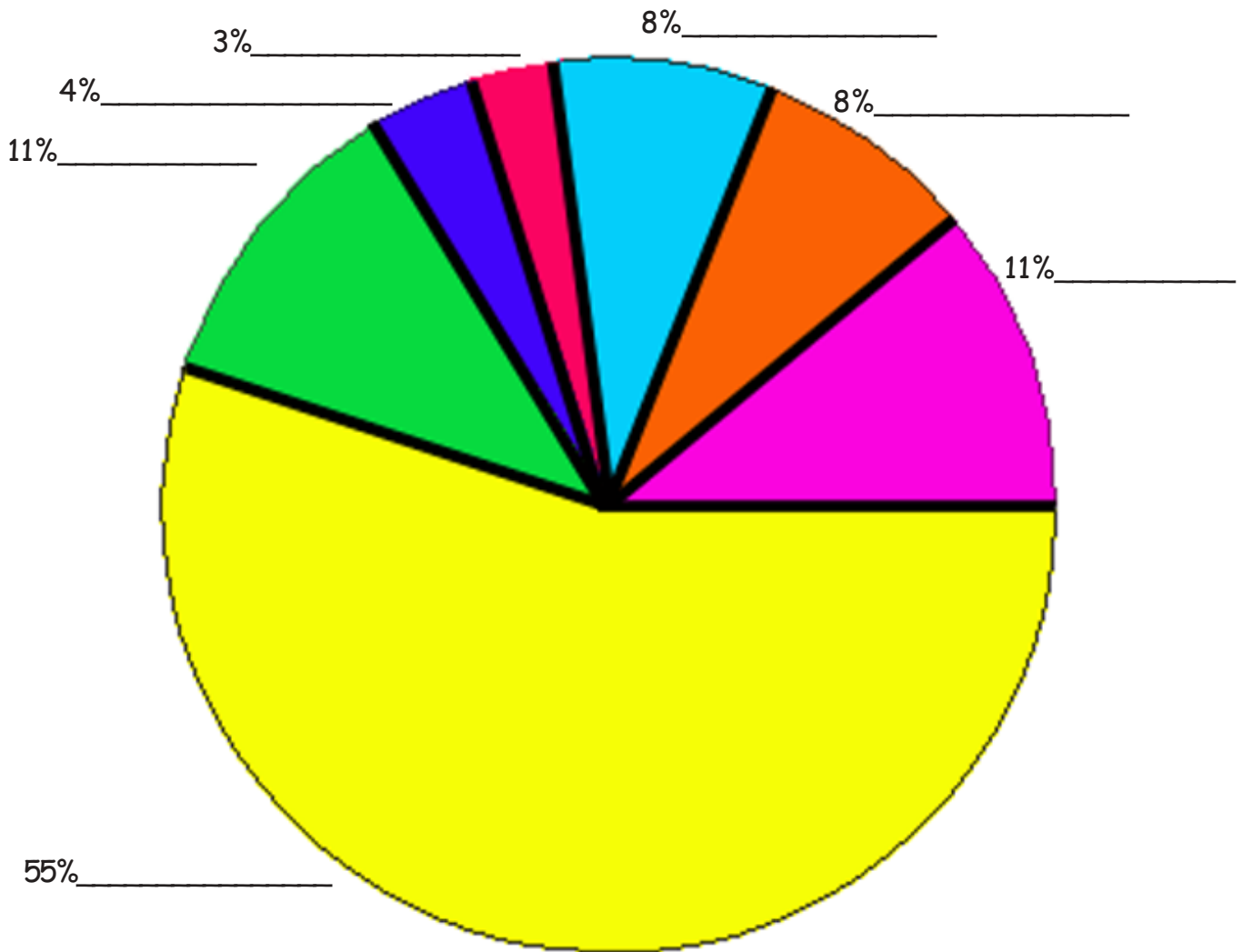
24 26 15 15 22 23    6 15    7 9 26 5 18 12 15 22 7    9 26 23 18 26 7 18 12 13.

**Rad Fact:** Ultraviolet light from the sun is one type of nonionizing radiation. Nonionizing radiation has enough energy to move atoms around, but not enough energy to change them chemically.



# Ionizing Radiation Exposure

Match the percent of exposure with the source -- they are listed below in order of the most to the least amounts. Circle those that are manmade.



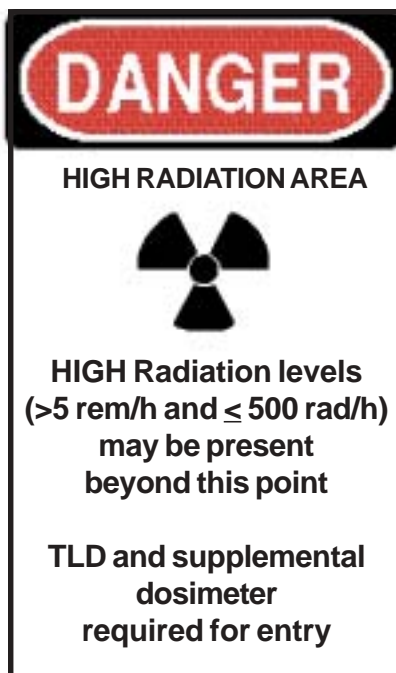
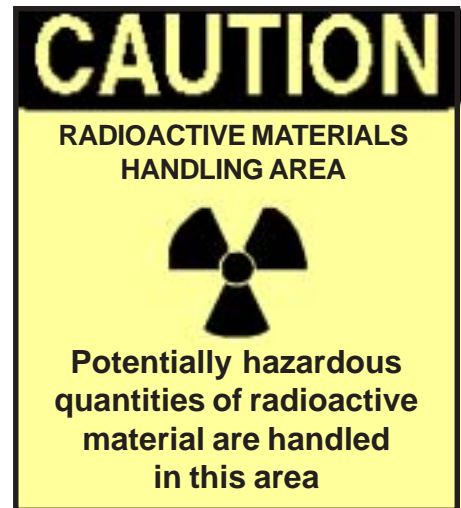
- Radon
- Internal
- Medical X-ray
- Terrestrial
- Cosmic
- Nuclear Medicine
- Consumer Products

**Rad Fact:** Ionizing radiation sources are both natural and manmade. Natural sources come from the earth (terrestrial) and from space (cosmic).

# Ionizing Radiation Symbols

Circle the symbol that is *not* a symbol for radiation.

**CAUTION  RADIATION AREA**



The tri-foil is the international symbol for radiation. The symbol can be magenta or black, on a yellow background. This sign is posted where radioactive materials are handled. This sign is used as a warning to protect people from being exposed to radioactivity. There are different versions of this symbol and they may be shown at potentially dangerous sites. For example, the signs would be posted where radioactive materials have been found and a site clean-up is happening. You might also see the symbol in a hospital where radioactive medicine is used, or in a university or research facility. There are other important symbols that also have three parts, so pay attention!

# Secret Message

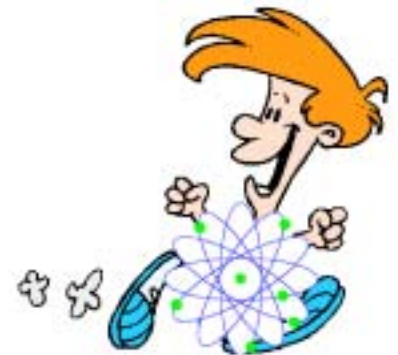
Do You Recognize This Symbol?



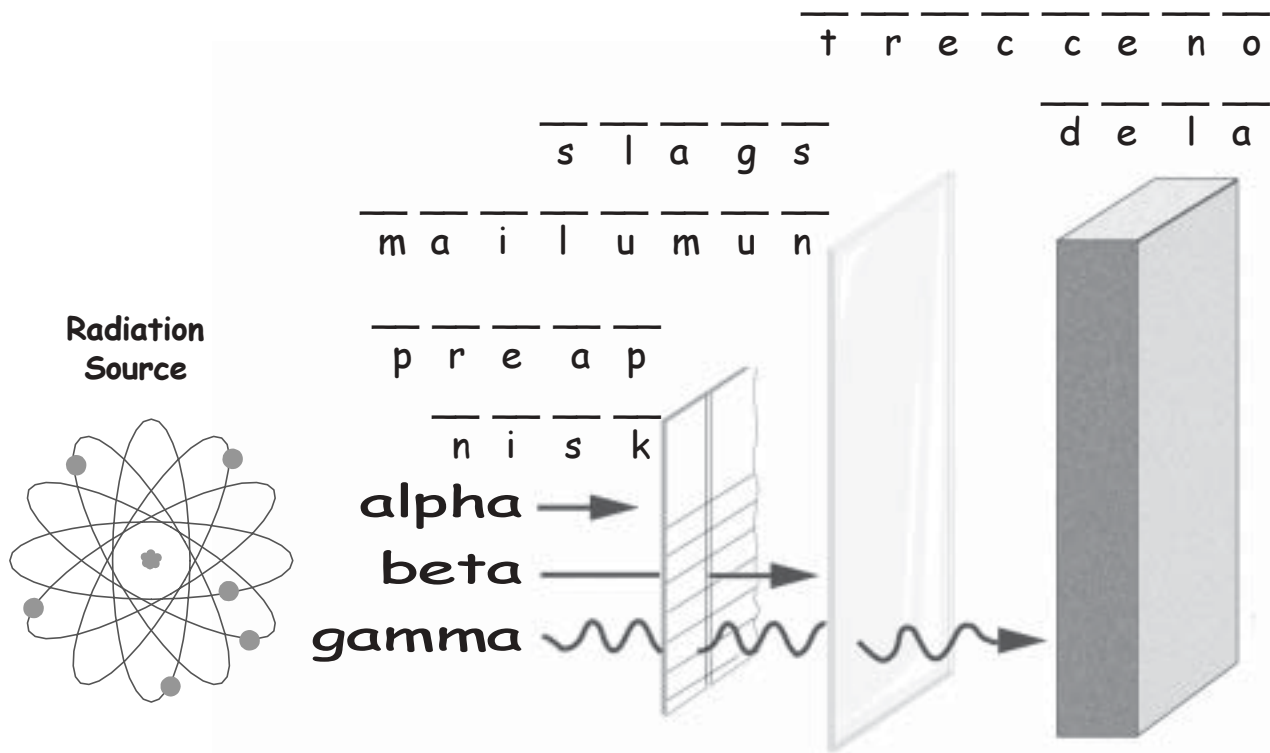
<b>CODE:</b>			
26 = A	19 = H	12 = O	5 = V
25 = B	18 = I	11 = P	4 = W
24 = C	17 = J	10 = Q	3 = X
23 = D	16 = K	9 = R	2 = Y
22 = E	15 = L	8 = S	1 = Z
21 = F	14 = M	7 = T	
20 = G	13 = N	6 = U	

7 19 22    7 9 18 - 21 12 18 15    4 26 9 13 8  
 12 21 26    9 26 23 18 26 7 18 12 13    26 9 22 26

**Rad Fact:** The international warning symbol for ionizing radiation is called the tri-foil. You should learn to recognize it and tell it from other important symbols that have three parts.



# Unscramble the Words to Find Out What Protects You From Each Type of Radiation



There are three main types of ionizing (the most energetic type) radiation: alpha, beta, and gamma. Alpha particles can be shielded by a sheet of paper or human skin. Beta particles are stopped by glass and aluminum. Gamma rays are the most penetrating and require a shield at least as thick as a concrete wall or lead. If you increase the shielding around a radiation source, it will decrease your exposure.



# Find the Hidden Message

Fill in the missing letters and place them below to find an important message.

Whi\_e some exp\_sure to su\_l\_ght \_an be enj\_ya\_le and  
 he\_lt\_y, too m\_ch is da\_gerous. Overexpo\_re  
 cont\_ibutes to immedi\_te adv\_rse he\_l\_h eff\_ts like  
 bl\_tering \_unburns, as well as l\_ng\_erm \_d\_erse  
 \_fects such as sk\_n ca\_cer, \_remature \_ging, and  
 \_ata\_acts.

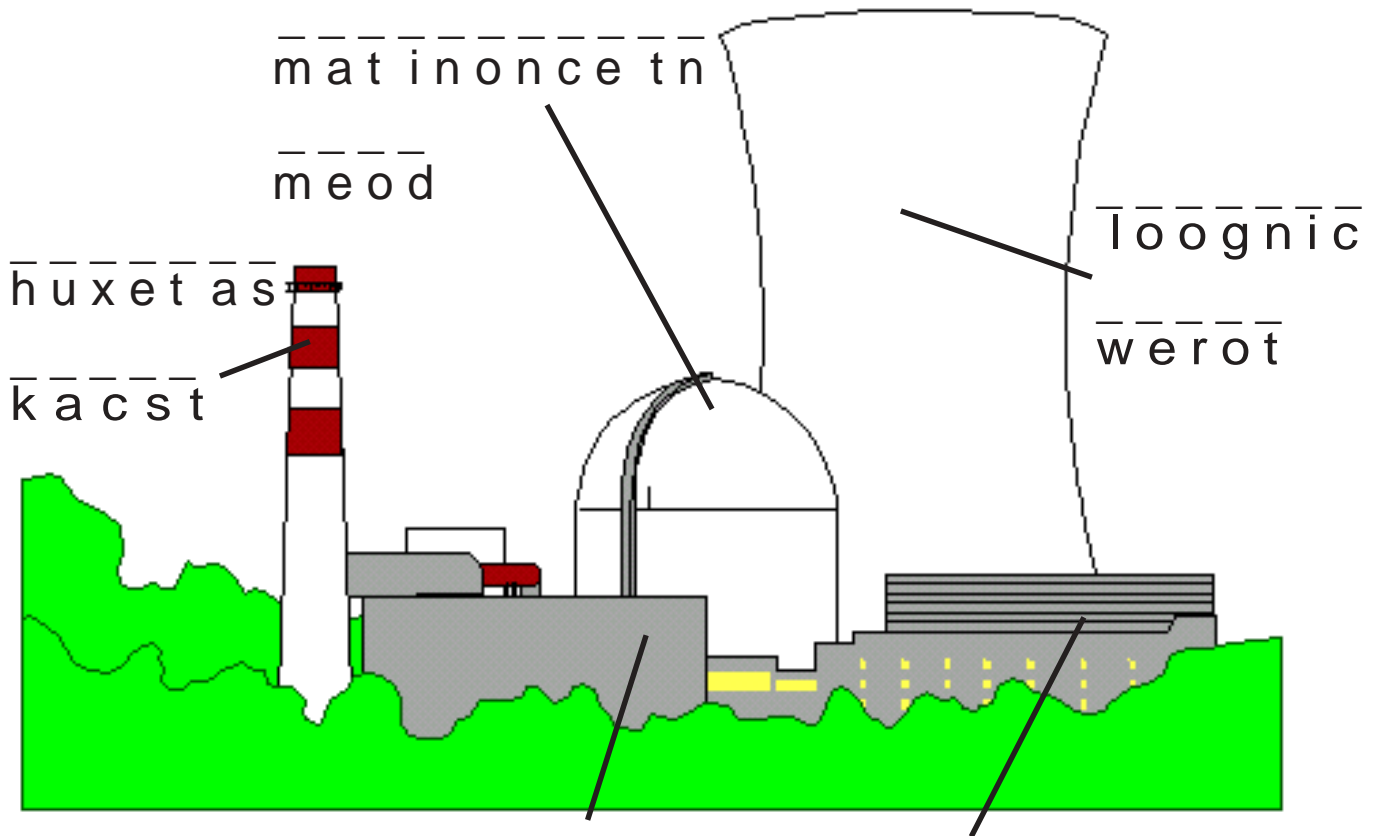
1 2 3 4 5 6 7 8 9 10 11 12  
 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35



**Rad Fact:** Ultraviolet radiation from the sun has both positive (such as sunlight for growing plants) and negative effects (such as blistering sunburns).



# Unscramble the Words to Learn Parts of a Nuclear Power Plant



grece meny iste ed

brinute dulbgini

angoterer glibudin

A nuclear power plant might look like the picture above and is an electricity generating facility using a nuclear reactor as its power (heat) source. Nuclear reactors are enclosed in massive **containment domes**. The coolant that removes heat from the reactor core is normally used to boil water. A **cooling tower** transfers exhaust heat into the air instead of into a body of water. The **exhaust stack** is for releasing tritium and other radioactive gas. In the **turbine building**, the steam produced by the boiling water drives turbines that rotate electrical generators. In the **emergency diesel generator building**, there are emergency power supplies that provide power, only when needed, to special safety electrical distribution panels. There are more than 100 nuclear power plants in the United States. People living near nuclear power plants are exposed to less than one millirem of radiation per year. The government sets strict standards governing radiation emissions and the levels near nuclear power plants are monitored 24-hours-a-day.

# People and Events

Below is a brief history of ionizing radiation, with events in the order in which they occurred. Using the clues at the bottom, fill in the blanks. For additional information, and help with the answers, go to EPA's Web site at <http://www.epa.gov/radiation>.

The ancient \_\_\_\_\_ first believed that all matter in the universe is made of tiny building blocks, or atoms. In 1869, Russian chemist \_\_\_\_\_ Mendeleev proposed a chart of elements called the periodic table. In \_\_\_\_\_, German scientist Wilhelm Conrad Roetgen announced the discovery of x-rays, which can penetrate sheets of lead. In 1896, French physicist Antoine Henri Becquerel found that certain substances, such as uranium salts, give off penetrating \_\_\_\_\_ of mysterious origin. Marie and Pierre \_\_\_\_\_ coined the word radioactivity in 1898. In 1905, Albert \_\_\_\_\_ developed his mass-energy equation,  $E=mc^2$ , as part of his special theory of relativity. The British Roentgen Society adopted a resolution in 1915 to protect people from overexposure to \_\_\_\_\_. In 1942, the Manhattan Project is formed to secretly build the atomic \_\_\_\_\_ before the Germans. Also in 1942, Italian-born American physicist \_\_\_\_\_ Fermi succeeded in producing the first nuclear chain reaction. In 1944, The first large-scale nuclear reactor was built at Hanford, Washington, for the production of nuclear \_\_\_\_\_ materials. In 1946, the Atomic \_\_\_\_\_ Act was passed, establishing the Atomic Energy Commission. In 1951, the first \_\_\_\_\_ was generated by atomic power in Idaho Falls. The Atomic Energy Act of 1954 is passed to promote the peaceful uses of nuclear energy through private enterprises and to implement President Eisenhower's Atoms for \_\_\_\_\_ Program. In 1954, the first nuclear submarine, U.S.S. \_\_\_\_\_, is launched. In 1955, Arco, Idaho, becomes the first U.S. town to be powered by \_\_\_\_\_ energy. In 1979, \_\_\_\_\_ Island's nuclear power plant suffers hydrogen explosions and a partial core meltdown. In 1986, \_\_\_\_\_ Nuclear Reactor meltdown and fire occur in the Soviet Union releasing much radioactive material. In 1996, the United Nations approves the Comprehensive Test Ban \_\_\_\_\_ which bans nuclear test explosions. In \_\_\_\_\_, an accident at the uranium processing plant at Tokaimura, Japan, exposed fifty-five workers to radiation, and one worker later dies.

Enrico  
Nautilus  
Treaty  
nuclear

X-rays  
Energy  
1895  
rays

Peace  
1999  
Einstein  
Greeks

Curie  
Chernobyl  
electricity  
weapons

Dmitry  
bomb  
Three Mile

# Careers Using Ionizing Radiation

Match the radiation professional's title with their correct job description.

There are many professions involved in the safe and beneficial use of radiation, including doctors, engineers, researchers, and emergency response personnel. A \_\_\_\_\_ works in a specialized branch of biology that studies the effects of ionizing radiation on cells and organisms. They help us understand how radiation can cause cancer and genetic effects. A \_\_\_\_\_ uses a combination of standard chemistry techniques and advanced radiation measurement techniques to determine the presence of individual radionuclides at extremely low levels. Someone who specializes in the procurement, compounding, quality control testing, dispensing, distribution, and monitoring of radiopharmaceuticals is called a \_\_\_\_\_. There are many \_\_\_\_\_ who are specifically trained and prepared to respond to radiological emergencies. A \_\_\_\_\_ is someone who helps determine how radioactive material is transported through the physical environment and through ecosystems. The information they provide can be critical in setting safe clean-up levels at contaminated sites. A \_\_\_\_\_, which is a term that originated with the Manhattan Project, provides the practical means for protecting workers, the general public, and the environment from harmful radiation exposures. They can be found in nuclear power plants, nuclear submarines, hospitals, and other places. A person who assists with patient diagnoses and treatment, when the use of radiological examination and treatment are appropriate, is called a \_\_\_\_\_. A physician, or \_\_\_\_\_, specializes in the use of radiant energy for diagnostic and therapeutic purposes. \_\_\_\_\_ work to ensure that the reactor core is configured and assembled correctly to use the nuclear fuel most efficiently and safely while producing energy.

radioecologist  
radiologist  
nuclear engineers

emergency response professionals  
nuclear medicine physician  
health physicist

radiobiologist  
nuclear pharmacist  
radiochemist

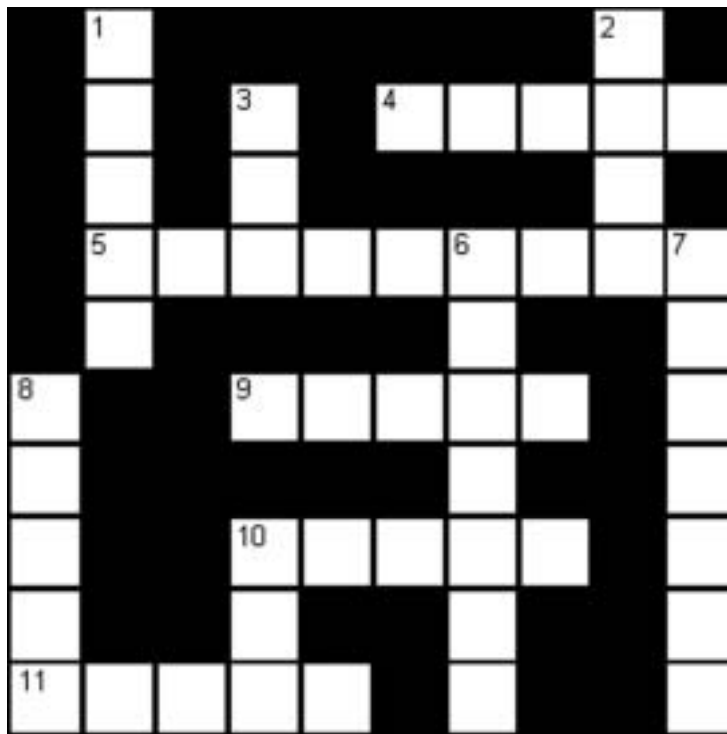
# Radiation Crossword Puzzle

**Across**

- 4. Nuclear reactors are enclosed in massive containment \_\_\_\_\_
- 5. In 1942 the \_\_\_\_\_ project was formed to build the atomic bomb
- 9. Marie and Pierre \_\_\_\_\_ coined the word radioactivity in 1898.
- 10. 55% of our radiation exposure comes from \_\_\_\_\_
- 11. Matter is made up of very, very small particles called \_\_\_\_\_

**Down**

- 1. \_\_\_\_\_ rays are the most penetrating and requires a shield of concrete or lead
- 2. \_\_\_\_\_ particles can be stopped by glass or aluminum
- 3. Ultraviolet light from the \_\_\_\_\_ is one type of nonionizing radiation
- 6. The international warning symbol for radiation is called the \_\_\_\_\_
- 7. At the center of every atom is the \_\_\_\_\_
- 8. \_\_\_\_\_ particles can be stopped by a sheet of paper or human skin
- 10. Radiation dose is measured in units called \_\_\_\_\_



**Rad Fact:** *Ionizing radiation comes from atoms that are in the process of changing. As these atoms change to become more stable, they give off or emit energy in the form of particles or waves called radiation.*

For more information on Radiation, visit

- ❖ U.S. Environmental Protection Agency's Web site:  
<http://www.epa.gov/radiation>

For the answers to these games, visit

- ❖ National Safety Council's Web site:   
<http://www.nsc.org/ehc/kidscorn.htm>

National Safety Council  
1025 Connecticut Avenue, N.W., Suite 1200  
Washington, DC 20036  
(202) 293-2270  
[www.nsc.org](http://www.nsc.org)



*Your Safety & Health Leader for 90 Years*