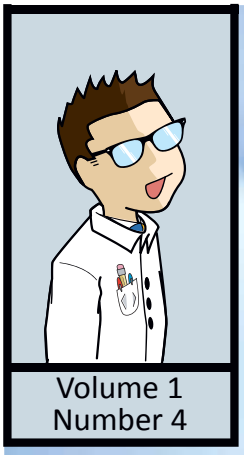
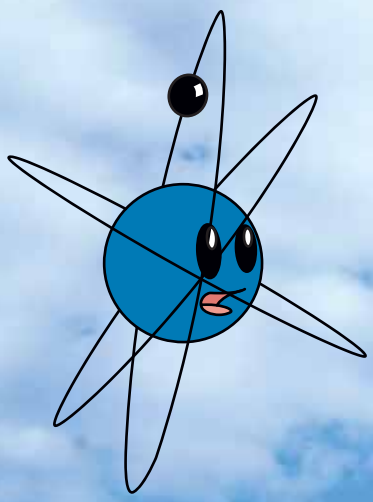


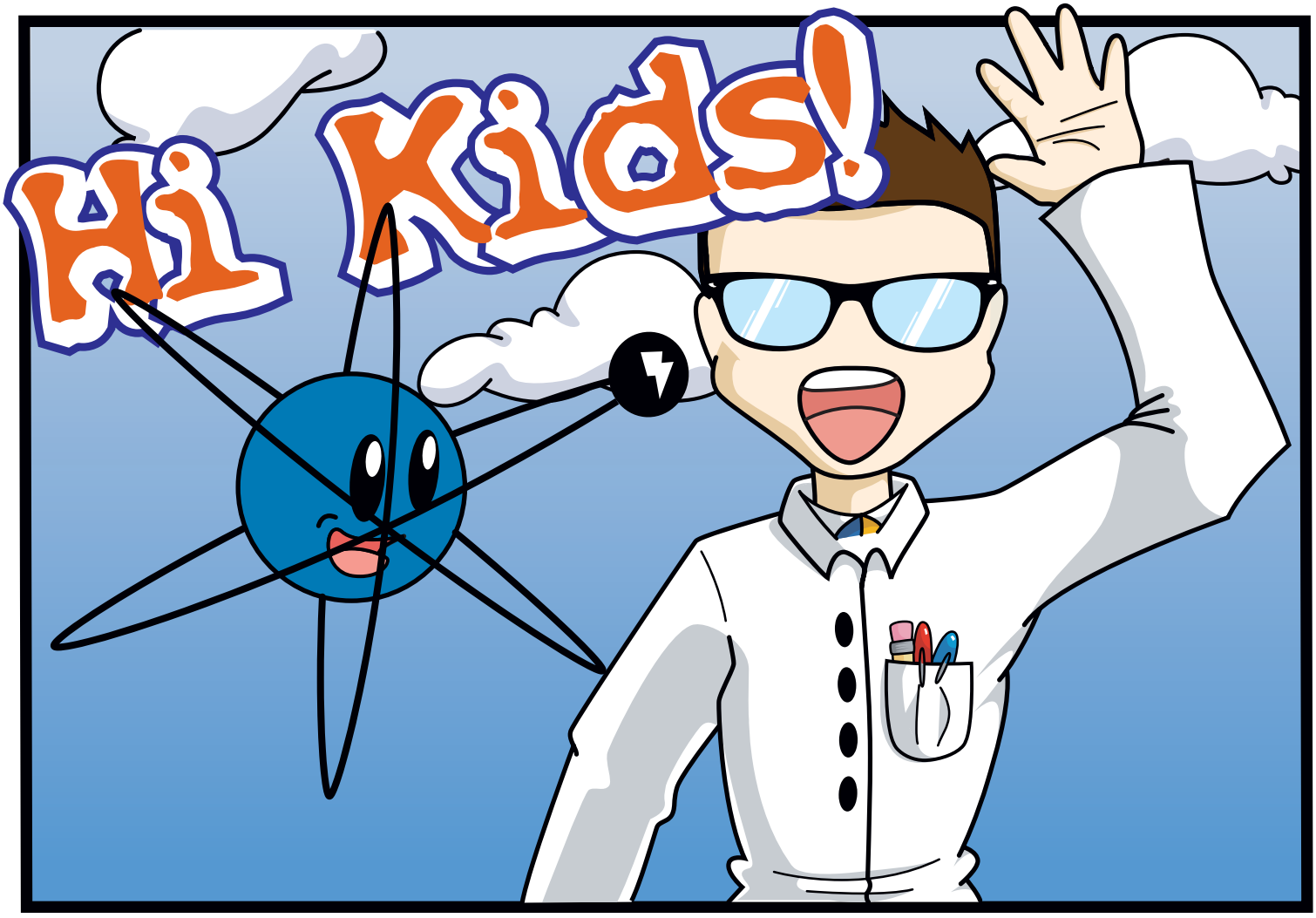
Volume 1
Number 4

OPERATION

CLEAN DESERT



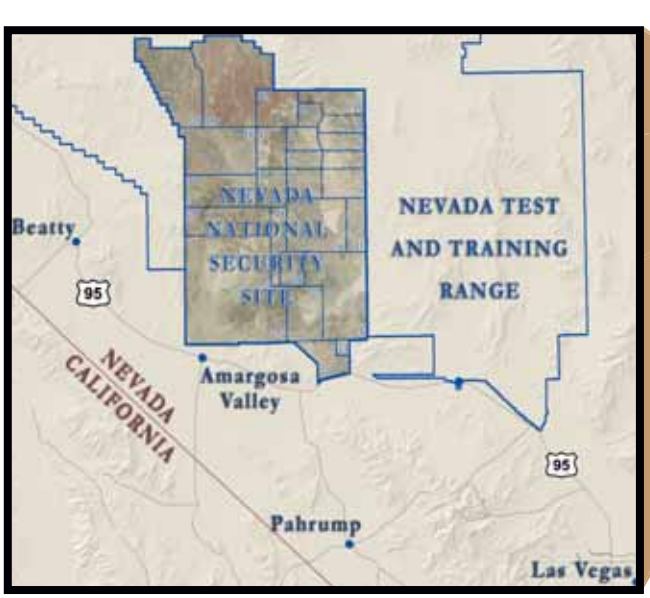
ACTIVITY BOOK

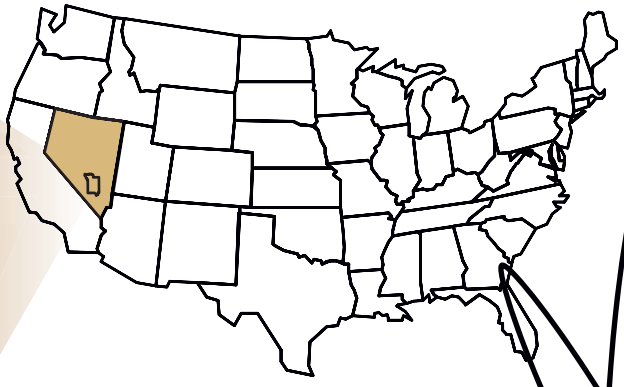


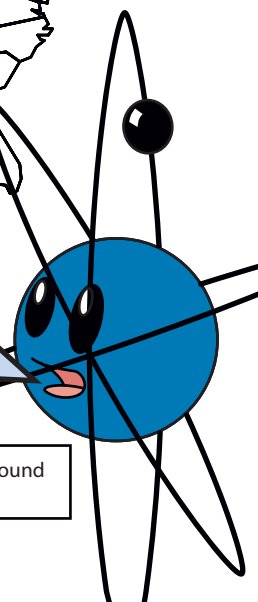
Welcome to Operation Clean Desert!

Grab your hiking boots and tie them tight, because you're about to go on a journey to the Nevada National Security Site!

Along the way, Dr. Proton, Adam the Atom, and their friends will share with you tons of interesting facts about the site, including its unique and important history and environmental cleanup activities.



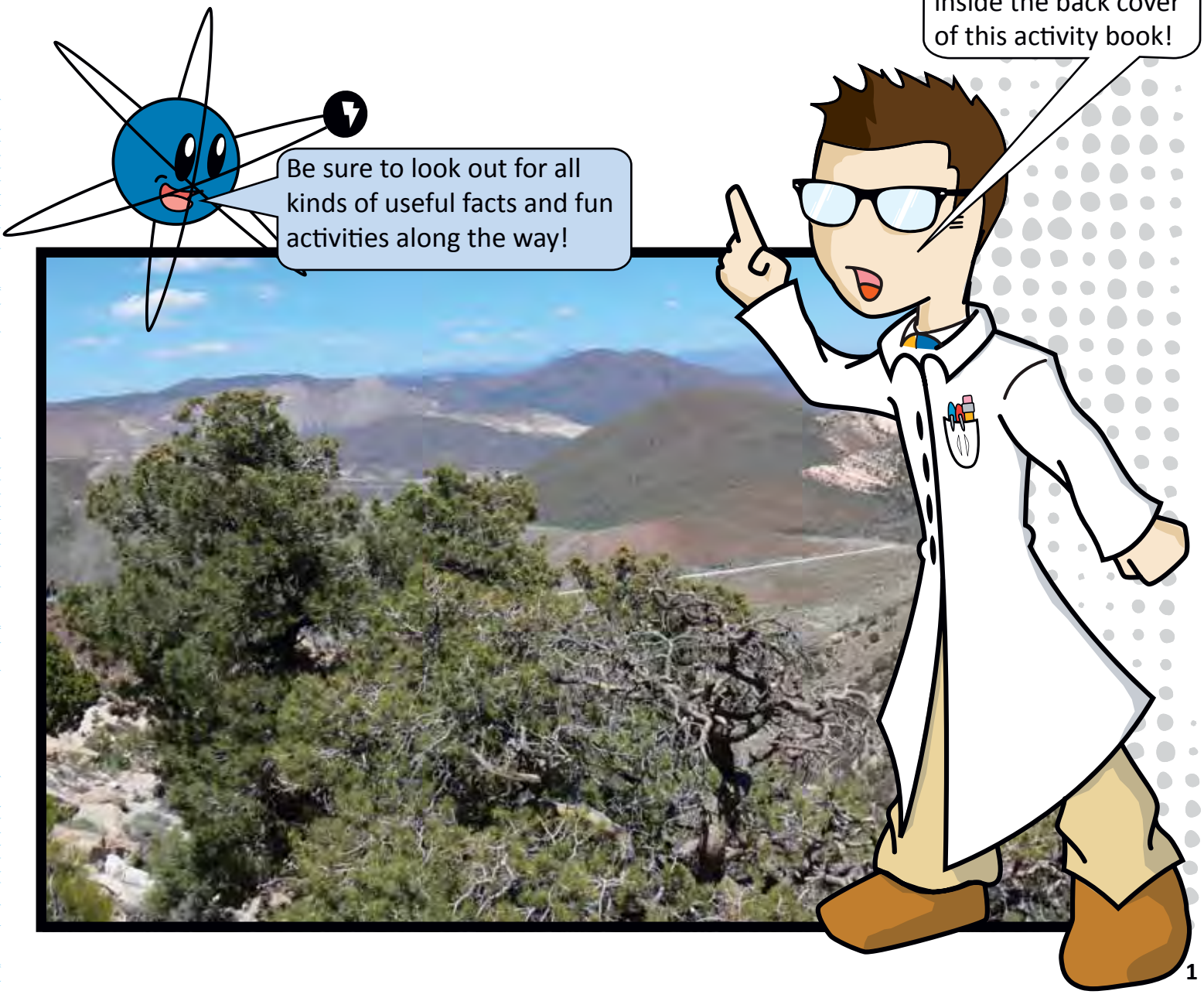




About the cover: Unused metal borehole casings remaining at the Nevada National Security Site are retrieved for transport to a historic underground nuclear site. The casings were repurposed to cover contaminated piping and then filled with concrete to protect the surrounding environment.

First let's meet the leaders of your tour:

Dr. Proton is the coolest genius you'll ever meet. His trusty sidekick, **Adam the Atom**, is part particle and part whiz kid. Their job: teach people about the Nevada National Security Site. And they can't wait to get started…so have fun and enjoy the tour.



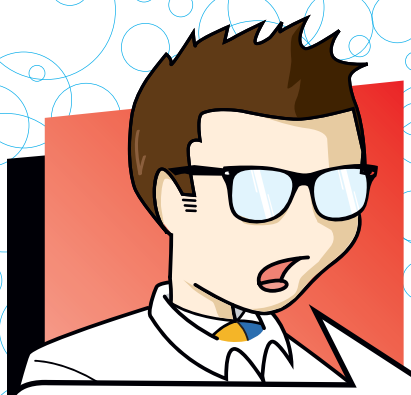
Between 1951 and 1992, scientists conducted 100 aboveground and 828 underground nuclear tests at the NNSS.

Back in 1951, scientists began testing nuclear bombs in a remote area previously used as an Army gunnery range in southern Nevada. This area, located 65 miles northwest of Las Vegas, is what we now call the Nevada National Security Site.

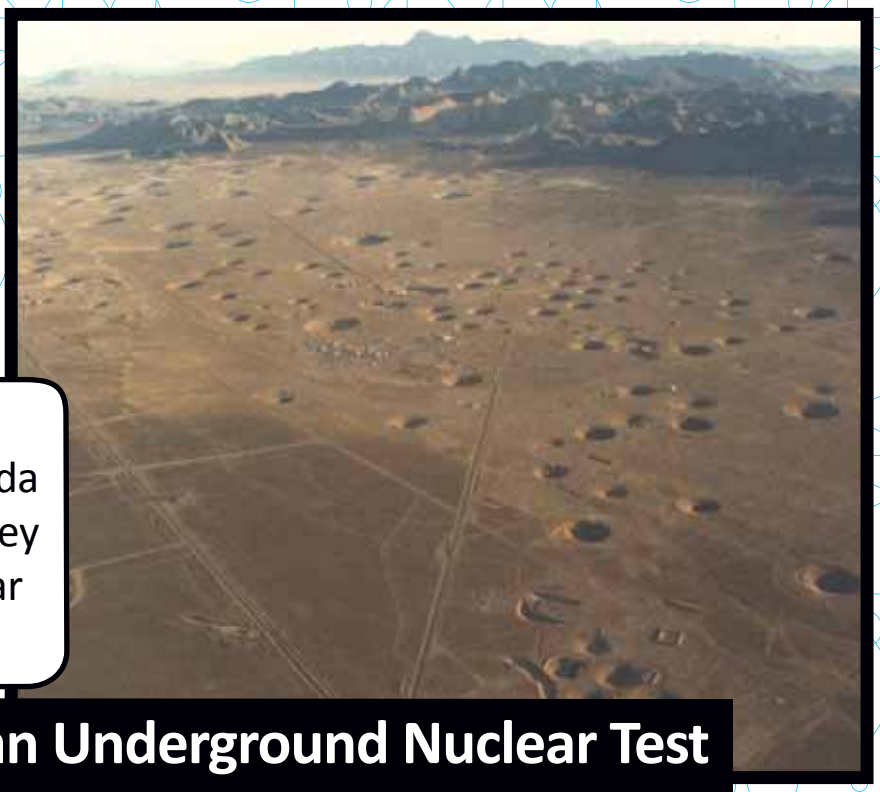
The goal was to learn everything about the power of nuclear bombs and how the government could use them to protect Americans from foreign threats. And so, full-scale **nuclear testing** began.

Did You Know...

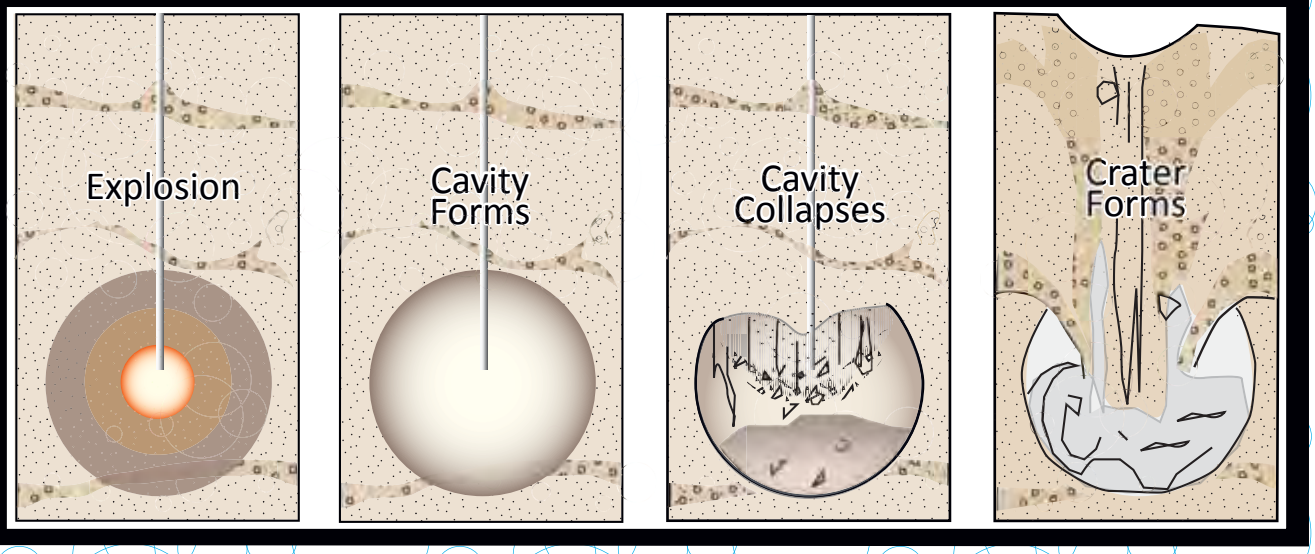
In December 1961, the first of the Plowshare Program nuclear tests was conducted in New Mexico. Plowshare Program tests were designed to explore the technical and economic feasibility of using nuclear explosives for industrial applications such as excavation and natural gas stimulation. Learn more about the Plowshare Program at www.nv.energy.gov/library/factsheets/DOENV_766.pdf.



It may look like the moon, but these craters are actually part of the Nevada National Security Site landscape. They were formed by underground nuclear testing.



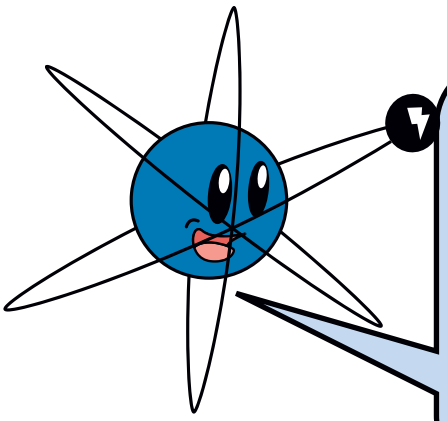
Stages of an Underground Nuclear Test



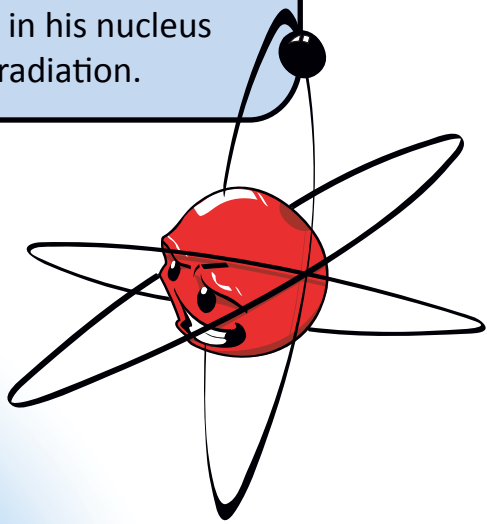
First there is an underground explosion, and then the surrounding rock is vaporized; next, as the rock cools and settles to the bottom of the cavity, the roof collapses into the cavity forming a depression on the surface, or a subsidence crater.

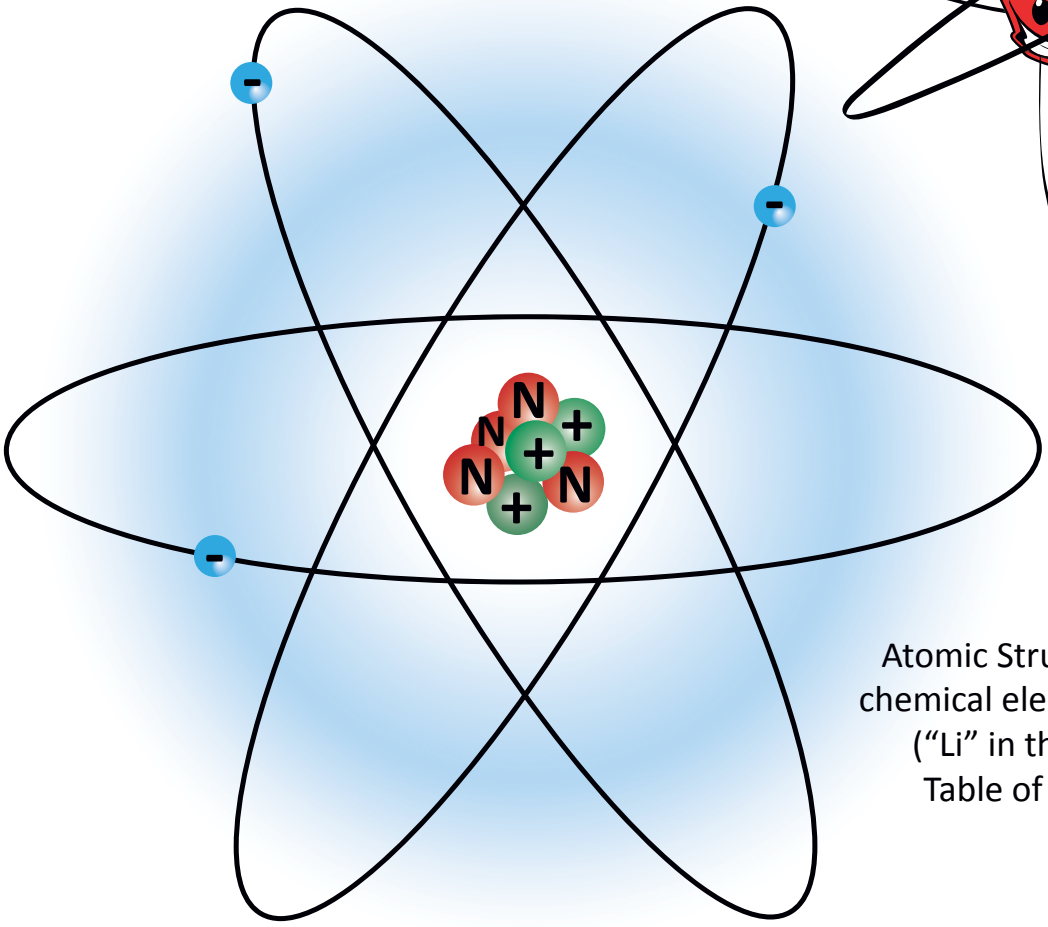
Nuclear research, development and testing caused radioactive contamination of soil, water, buildings and equipment at the Nevada National Security Site and some portions of the surrounding Nevada Test and Training Range. Contamination occurs when something harmful or unsafe is in an area where it is not wanted.

This is where the U. S. Department of Energy's Operation Clean Desert begins…



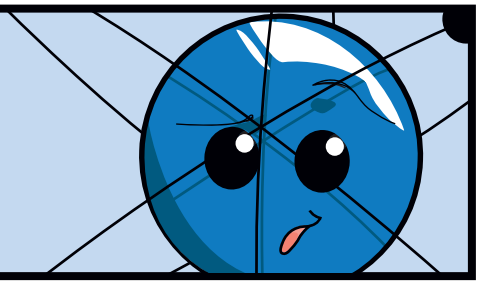
Radioactive contamination occurs when radioactive atoms come in contact with things like air, soil, water, and equipment. Radioactive atoms, or **isotopes**, are unstable like my brother **Axel**. Axel is an isotope of a **hydrogen atom**. Hydrogen atoms have one **proton** (**positive charge**) in the nucleus and one orbiting **electron** (**negative charge**). Axel has too many **neutrons** (no charge) in his nucleus which causes him to emit energy called radiation.

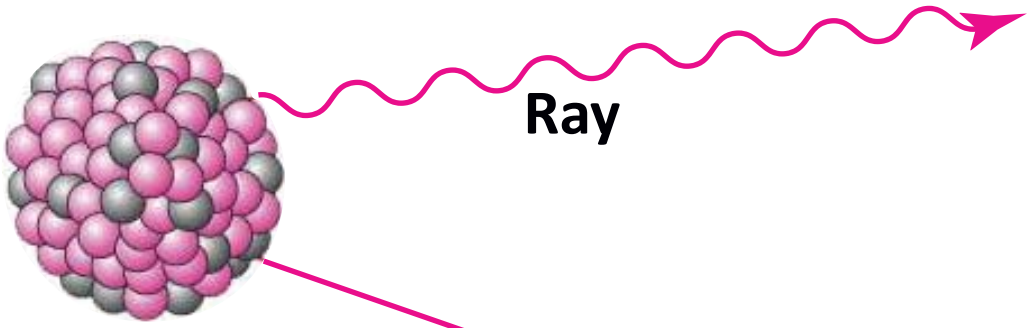


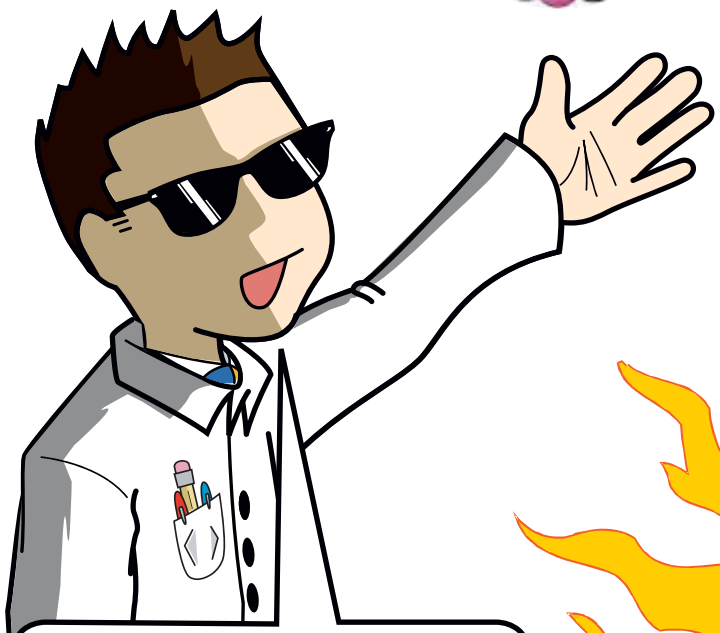


Atomic Structure of the chemical element, Lithium ("Li" in the Periodic Table of Elements)

In order to understand **radioactive contamination**, you'll need the following quick lesson in radioactive atoms!

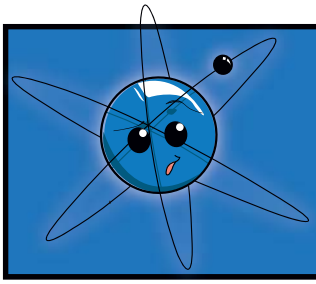






The radiation, or energy, emitted by radioactive atoms in the form of particles (protons, neutrons or electrons) or rays reduces over time as unstable (aka radioactive) atoms **decay**. Decay is the process of an unstable atom trying to become stable.

Small amounts of radiation found naturally in our environment (such as in rocks and the sun's rays) are considered safe, but large amounts can be harmful to people and the environment.

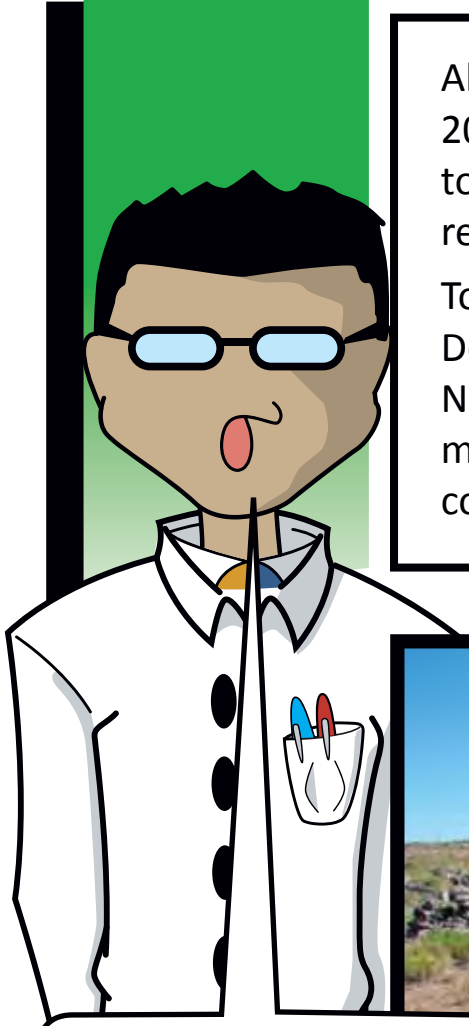


DID YOU KNOW...

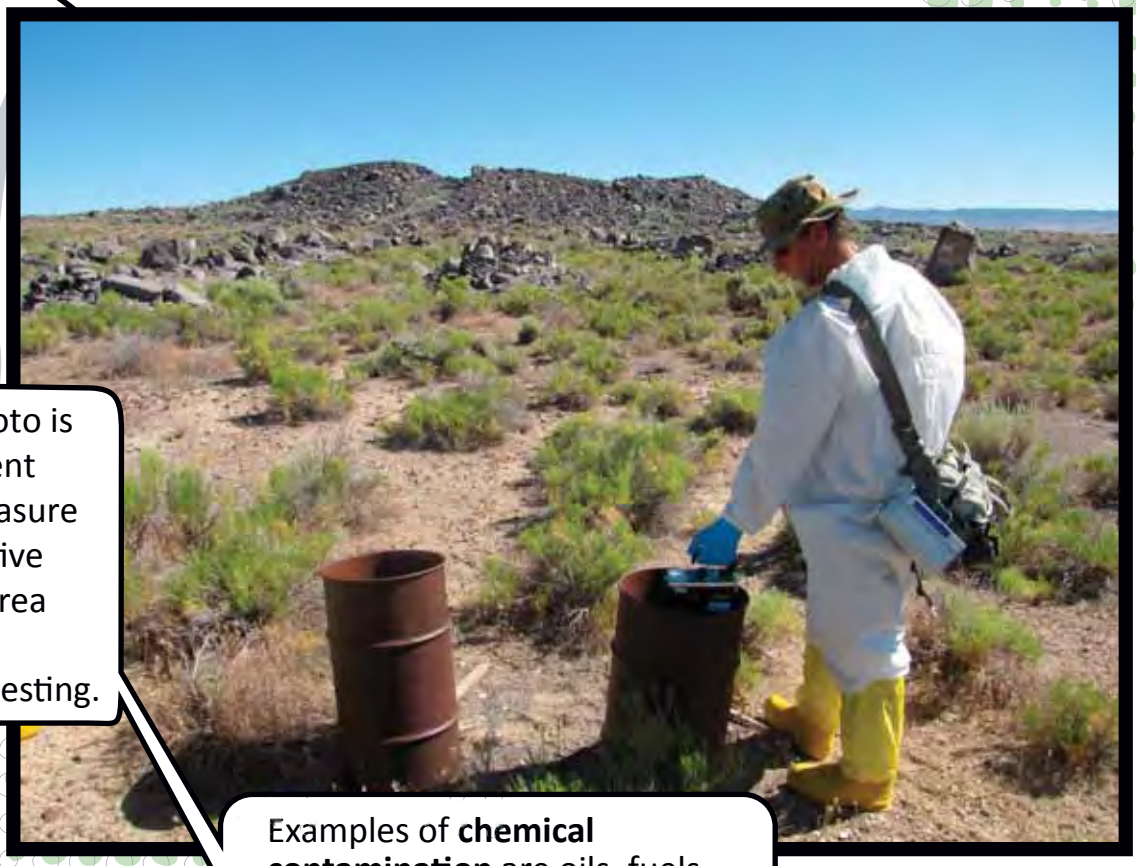
How fast a radioactive atom decays is measured by its "**half-life**," which is the time it takes for it to lose half of its radioactivity. This decay happens at a predictable and very specific rate, and each isotope has a unique half-life used to measure how much **radiation** is present.

Although nuclear testing activities were conducted between 20 and 60 years ago, the environmental laws we follow today require that we address any potential contamination remaining from these historical activities.

To responsibly address remaining contamination, the U.S. Department of Energy has set out to clean up the Nevada National Security Site. Scientists are accomplishing this mission by focusing primarily on two types of contamination - chemical and radioactive.

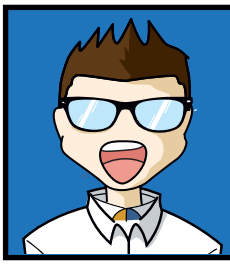


The worker in this photo is using special equipment to investigate and measure any potential radioactive contamination in an area used during historic atmospheric nuclear testing.



Examples of **chemical contamination** are oils, fuels, metals and paint.

Did You Know...



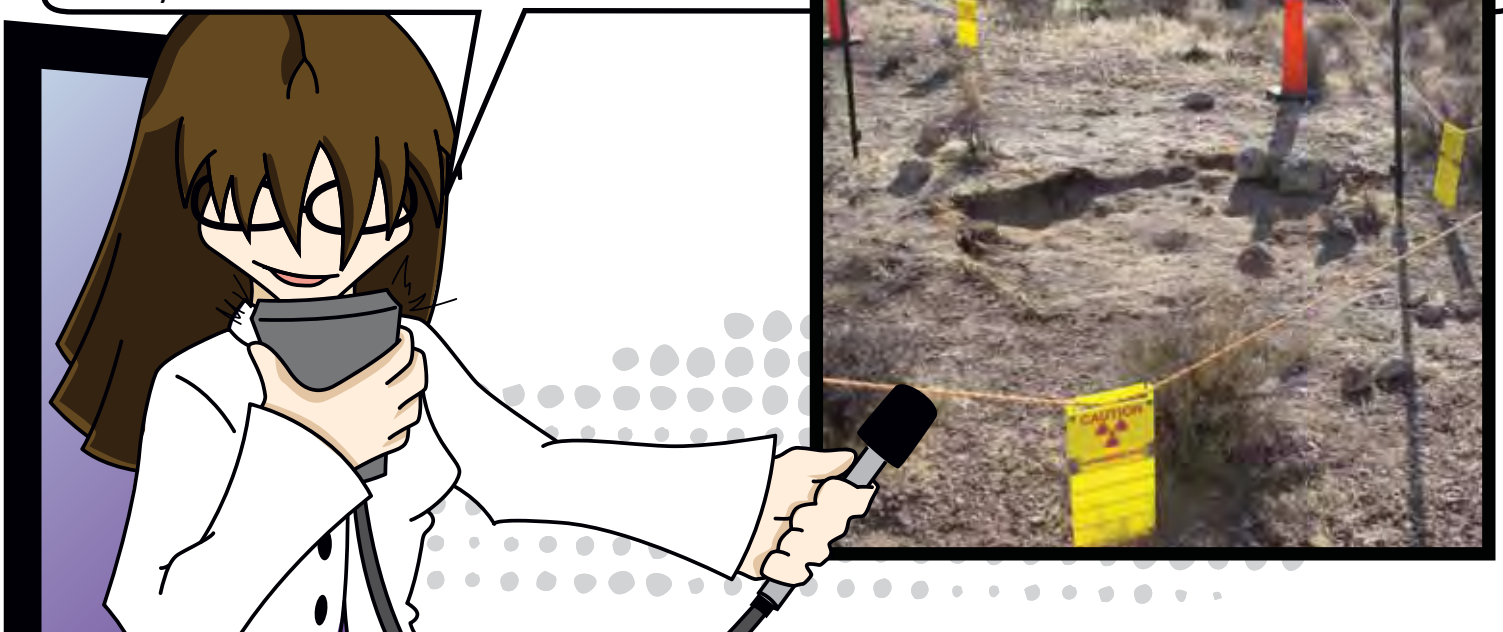
You cannot see, taste or smell radiation. Special equipment is used to detect radiation.

Let's take a closer look at some radioactive contamination...

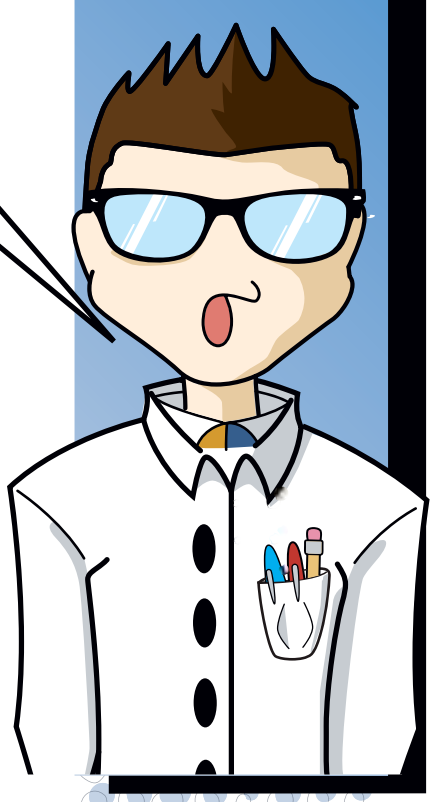
This soil was contaminated by depleted uranium ammunition that penetrated the ground.

Yes, and the contaminated soil (oxidized uranium residue is visible) was safely excavated and disposed at a special facility located within the Nevada National Security Site.

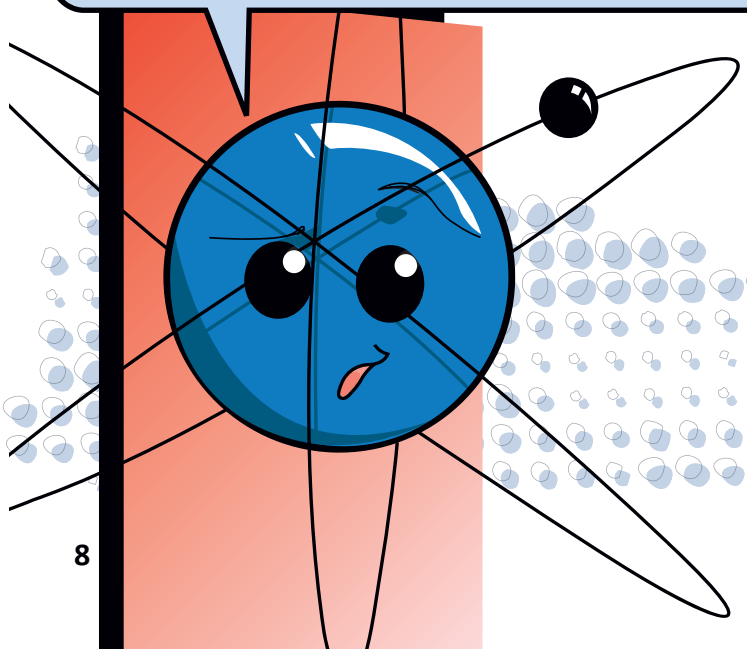
Sometimes there are visual indicators that help environmental workers find where radioactive contamination is present. However, you must remember that special instruments are needed to identify and measure radiation since it's invisible.

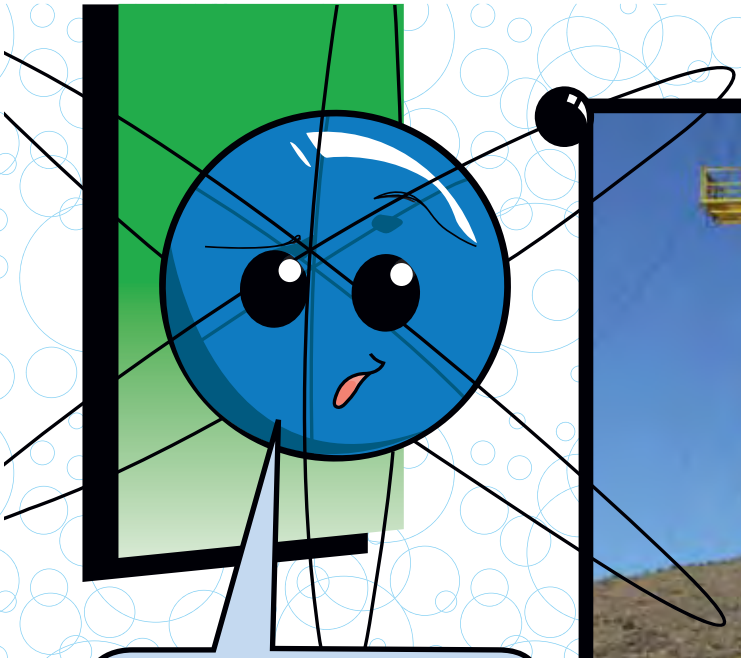


The job of Operation Clean Desert is to determine what type, how much, and where contamination is present; whether it can be **remediated** (cleaned, removed and/ or isolated) safely; and the best approach to implement any needed remediation.



Operation Clean Desert is a huge effort that takes a lot of smart and dedicated people to get it done responsibly. Our team includes scientists studying the groundwater.

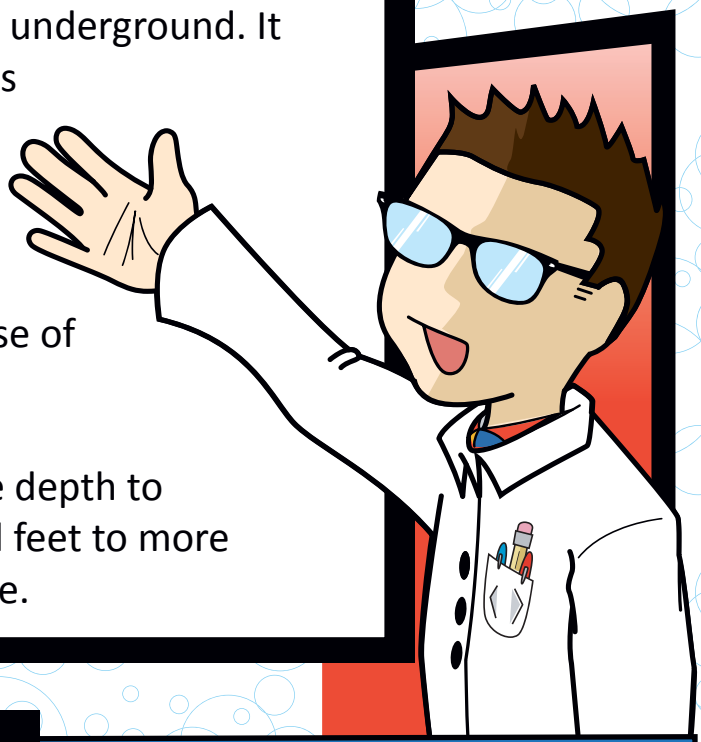


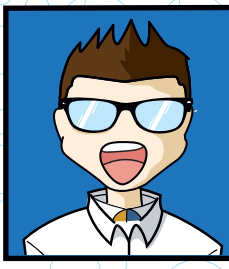


Scientists drill **wells** to gather valuable information, including rock and water samples, so they can track contaminated groundwater to make sure it cannot be accessed by the public!

Groundwater is water that has collected underground. It moves through pore spaces and fractures in **geologic** layers, like volcanic rock and soil, beneath the earth's surface. These different types of geologic layers cause groundwater to move at different speeds and in different directions because of differing pressures.

At the Nevada National Security Site, the depth to groundwater ranges from a few hundred feet to more than 4,000 feet below the ground surface.

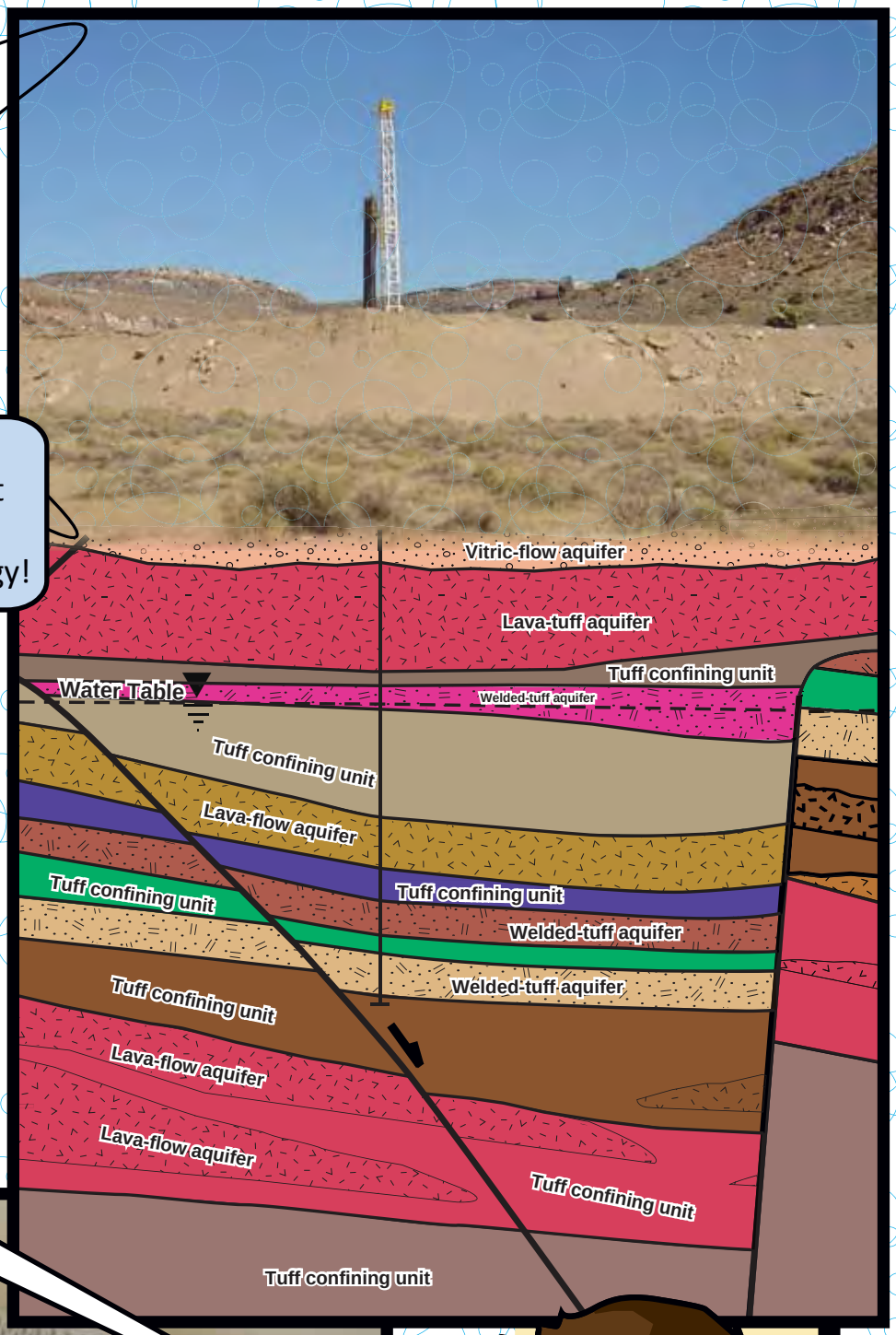




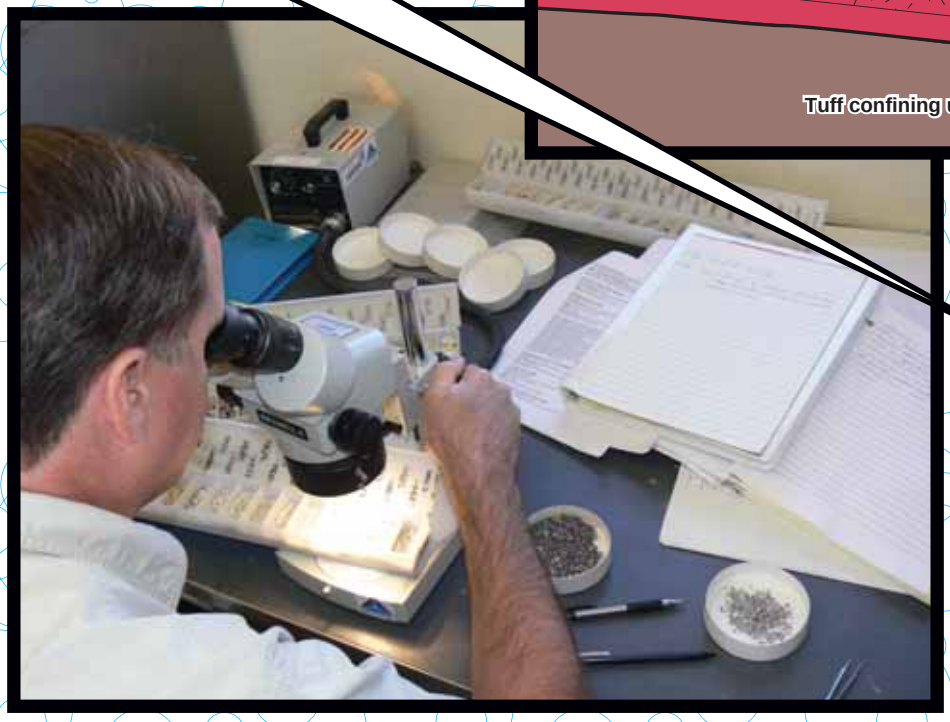
Did You Know...

The water table is the underground surface beneath which geologic layers are wholly saturated with water. It is found at the top level of an aquifer, a geologic formation of permeable rock, gravel or sand that contains or conducts the movement of groundwater. Aquifers may or may not have water, depending on where the water table is located.

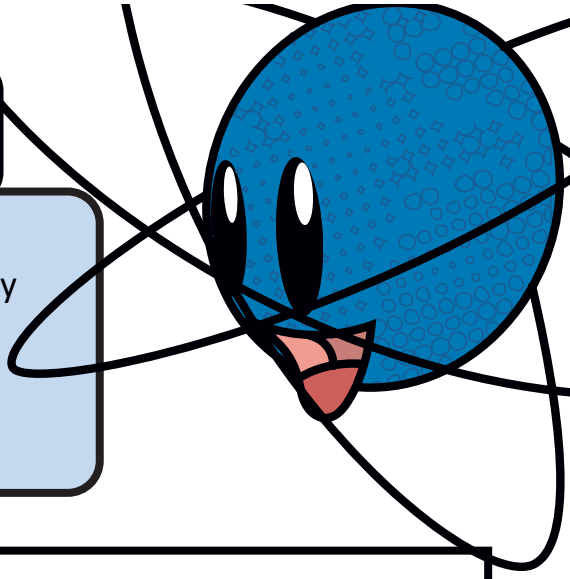
Our wells have been drilled up to 5,000 feet deep. That's going through a lot of geology!



If it sounds complicated…it is. Crews today use large **drill rigs** to dig wells deep into the earth to gather water and rock samples which help to reveal how groundwater moves. Using these samples and computers, scientists create **models** (mathematical representations of the geology and hydrology beneath the earth's surface) which **forecast** how the groundwater moves.



Adam Activity!



One-third of the U.S. public water supply comes from under the ground*. This groundwater is found in aquifers and is accessed by drilling wells or locating natural springs which bring water to the surface.

Now, let's see you build your own aquifer!

Aquifer in a Cup

Objective:
Groundwater is water that is found underground in the spaces and cracks between soil, sand and gravel. Often hidden from view, in this activity you will "see" what groundwater looks like and learn some basic groundwater vocabulary.

Materials Needed:
2 clear 16-ounce cups
Sand, gravel and aquarium rock
Pitcher of water

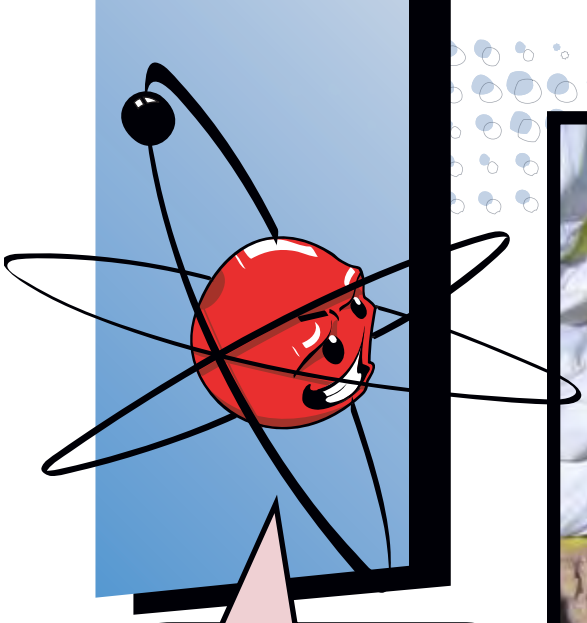
Procedure:
Fill 2 cups with various layers of sand and gravel about 3/4 full. Remember that in nature, aquifers consist of layers of sand, gravel and rock. In one of the cups, pour water slowly into it. Watch how the water fills the spaces between the particles of sand and gravel. Does the water appear to move faster through the sand or faster through the gravel? Why?

Now continue to fill this cup with water to the top (above the top of the sand and gravel). Water that is located above ground, like rivers and lakes, is called surface water. Water below the ground's surface is called groundwater. In the second cup, slowly pour water into the cup until the water line is about one inch below the top of the sand/gravel. Look closely at this line created by the water. This line is called the water table. Water below the water table is called the saturation zone. Now pretend that your pitcher of water is a large rain cloud and pour some more water into your second aquifer until the water table is about 1/2 inch below the surface of the gravel. Your groundwater supply has just been recharged. This is what happens when it rains or snows and water infiltrates (or sinks) into the ground.

Optional Extensions:
Use liquid food coloring or powdered drink mix to represent a source of groundwater contamination. Sprinkle or pour the contamination on the surface of the gravel. Sprinkle water (to represent rain) on top of the gravel and contaminant. Observe and discuss what happens.

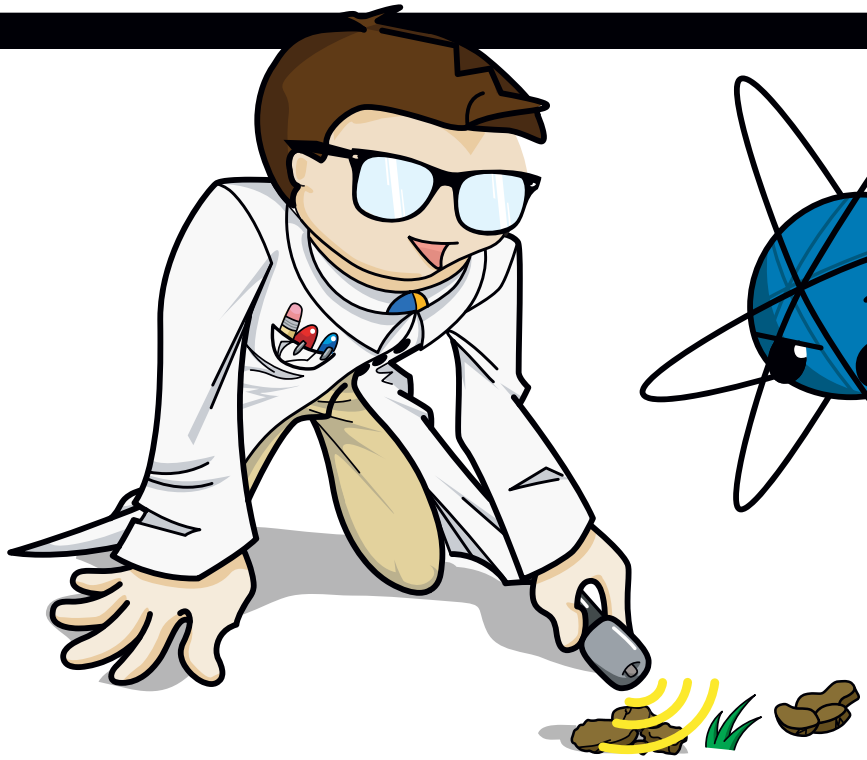
Conclusion:
We have learned that groundwater is water that is found underground in the cracks and spaces in sand, gravel and rock. We have learned that groundwater is stored in and moves through the layers of sand, gravel and rock. This geologic formation of sand and gravel which stores groundwater is called an aquifer. Aquifers get more water when they are recharged by rain and snow.

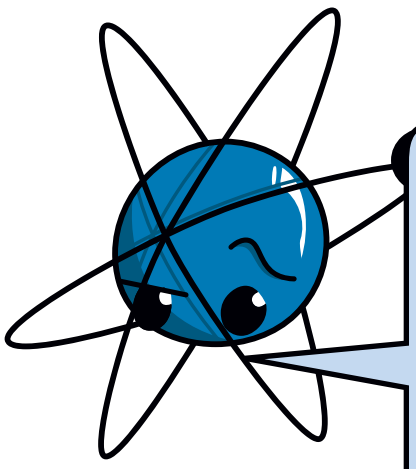
*Source: U.S. Geological Survey "Estimated Use of Water in the United States in 2005"
http://pubs.usgs.gov/circ/1344/pdf/c1344.pdf



Scientists are also studying to what extent historic nuclear research, development and testing contaminated the surface soil.

Workers today are checking the soil for radioactive contamination by using sophisticated hand-held instruments to conduct **radiation surveys** of the soil and by digging up, bottling and sending soil **samples** to special laboratories, where scientists then analyze the soil for various contaminants.



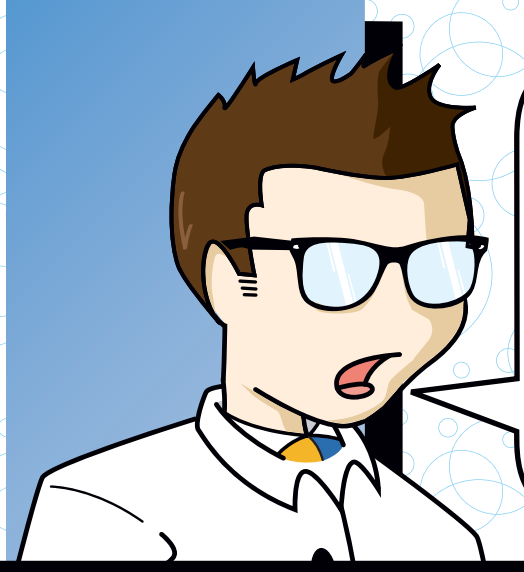


Areas on the Nevada National Security Site which have been identified as having potential soil contamination must be thoroughly analyzed and, if needed, remediated.

Operation Clean Desert crews are also busy at work removing contaminated industrial material like tools, protective clothing and, in some cases, entire buildings. These activities make waste.

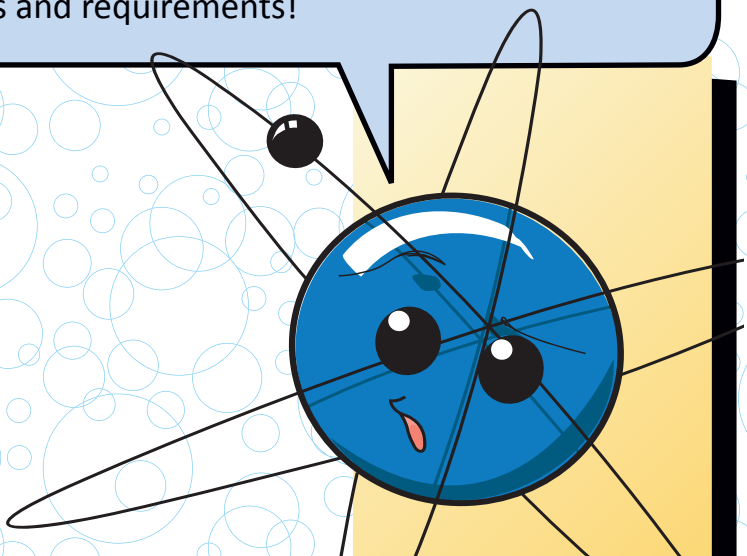
Workers use specialized equipment and methods to demolish large buildings so that radioactively contaminated debris can be packaged for **disposal**.

This waste, known as **low-level radioactive waste**, is placed into large drums, boxes, or cargo containers and taken to designated areas for safe and permanent burial.

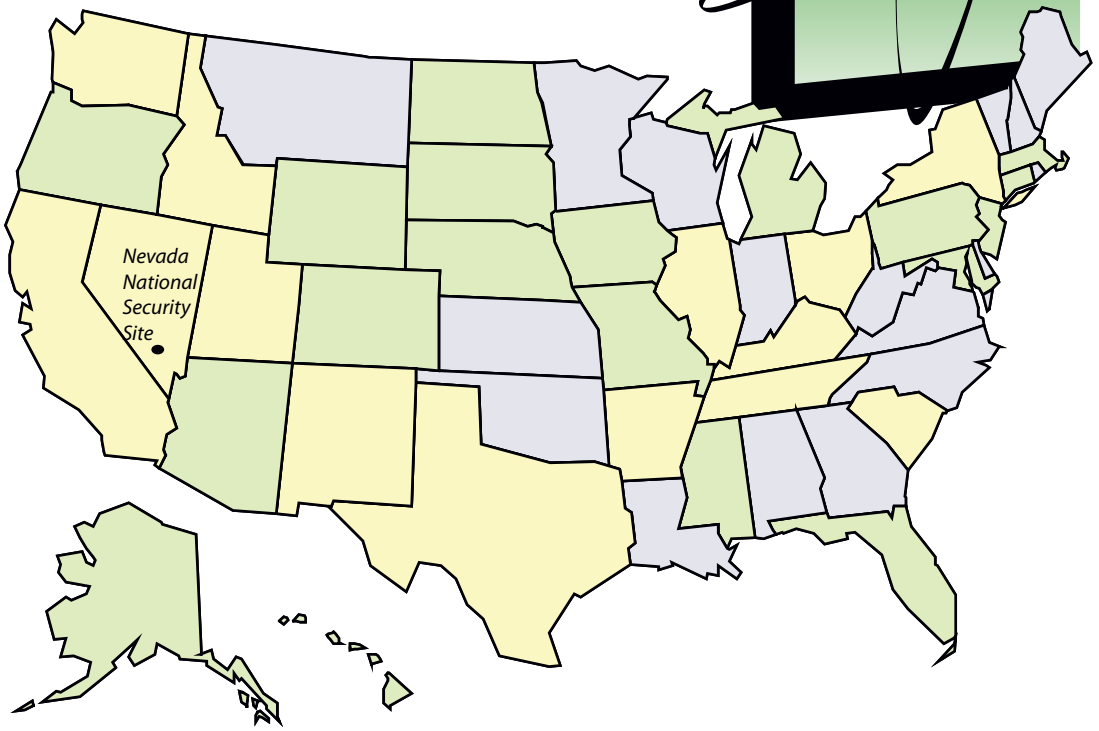


At the Nevada National Security Site, low-level and mixed low-level radioactive waste is disposed at the **Area 5 Radioactive Waste Management Site** in accordance with all applicable federal and state regulations. This facility (shown below) is located in the southeastern portion of the Nevada National Security Site.

Before any waste is accepted for disposal, it must be certified to comply with all technical and safety processes and requirements!



Some of the low-level and mixed low-level radioactive waste disposed at the Nevada National Security Site comes from the clean up of other sites within "the nuclear weapons complex," a vast research, production, and testing network that supported the United States in the nuclear arms race. You can learn more about the origins of the U.S. Department of Energy Environmental Management Program by visiting www.em.doe.gov/Pages/History.aspx.

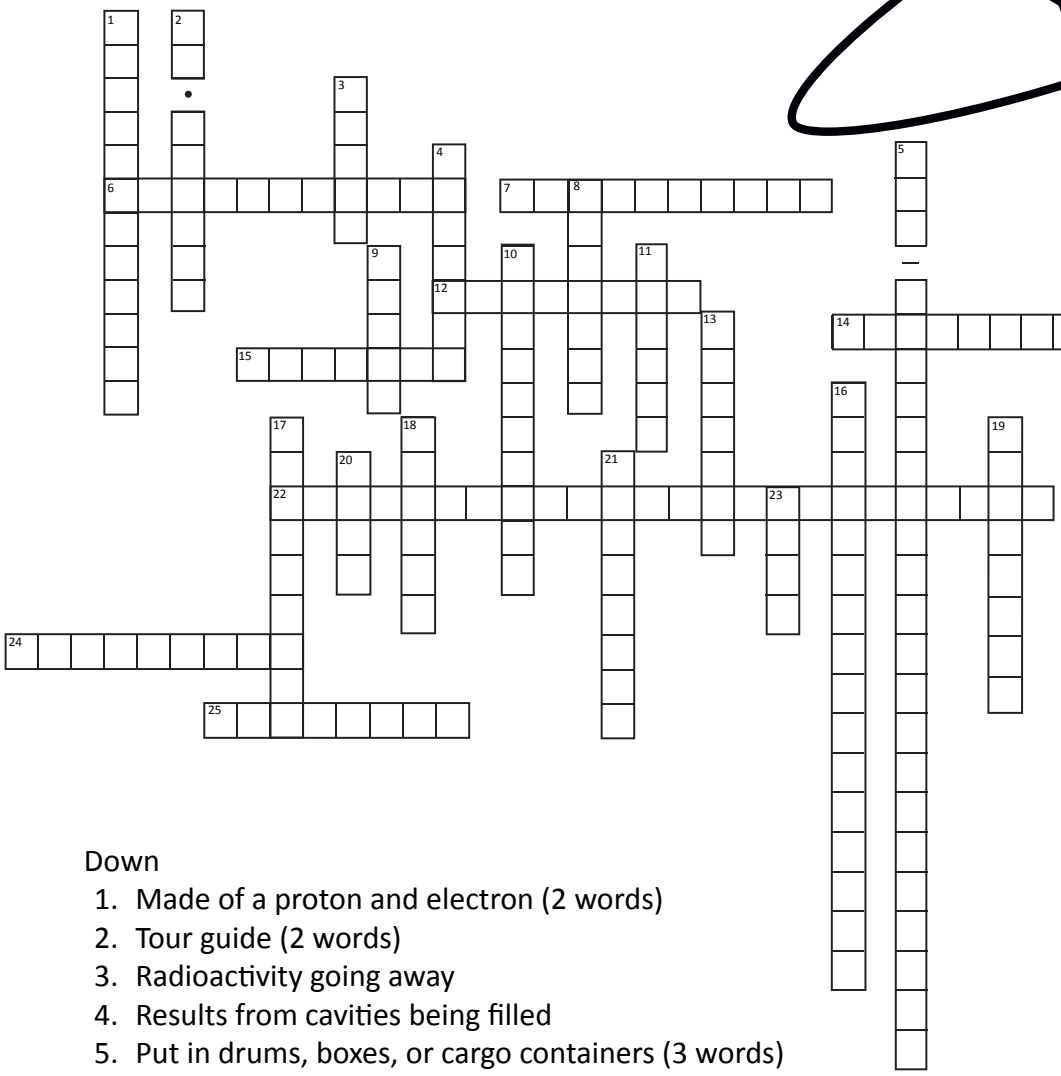


The yellow states have "active," ongoing cleanup project sites, the green states have no "active" sites, and the gray states have no cleanup sites. You can learn more about these sites at www.em.doe.gov/Pages/siteslocations.aspx

This worker is verifying documentation on a nuclear-powered generator disposed at Nevada National Security Site.

Adam Challenge!

Use the clues and solve the puzzle!



Down

1. Made of a proton and electron (2 words)
2. Tour guide (2 words)
3. Radioactivity going away
4. Results from cavities being filled
5. Put in drums, boxes, or cargo containers (3 words)
8. Axel is one
9. ___ are drilled to access groundwater
10. Cleaned, removed and/or isolated
11. Mathematical representations of the geology beneath the Earth's surface
13. Way to study nuclear bombs
16. Workers conduct ___ of soil (2 words)
17. Predictions of how groundwater will move
18. Positively charged particle
19. The layers of the Earth through which groundwater moves at different speeds and directions
20. Dr. Proton's sidekick
21. Particles with no charge
23. He has too many neutrons

Across

6. Water collected underground
7. Trackers of contaminated groundwater
12. Negatively charged particle
14. Metals, fuels, oils or paint where it is unwanted (2 words)
15. Sent to special labs
22. Radioactive atoms in an unwanted location (2 words)
24. Equipment used to dig wells (2 words)
25. Contaminated items packaged and placed for permanent burial

Operation Clean Desert isn't the only activity at the Nevada National Security Site. There are all kinds of interesting things happening every day, from studying and protecting animals, to national security training, to developing new technologies that protects Americans!

The Desert Tortoise is one of the more than 1,500 different animal species found at the site. An environmental report is published annually to report information collected on these animals (www.nv.energy.gov/library/publications/aser.aspx). Eddie the Engineer, Cathy the Chemist, and Ziggy the Zoologist have information on other Nevada National Security Site activities.

It's interesting to see a Weapons of Mass Destruction/ Counterterrorism training exercise in action!

Homeland Security sensor testing to detect the transport of radioactive materials is one of many important activities that have occurred at the site.

The important work conducted at the Nevada National Security Site is accomplished by highly educated women and men. The following list is just a few of the college degrees (Bachelors, Masters, and PhDs) possessed by various members of our Operation Clean Desert/Nevada National Security Site team:

Biology
Chemistry
Communications
Earth Science
Education
Engineering
Environmental Studies
Forensic Science
Geology
Petroleum Engineering
Soil Science
Zoology

These biologists are attaching a tracking device onto a sedated 5-6 year-old male puma (mountain lion) captured in the west-central portion of the Nevada National Security Site. This activity is part of a multi-year study on pumas living on and around the Nevada National Security Site.

The extensive and diverse education base of our team is just the beginning. Even with degrees and years of experience, everyone on our team takes time to prepare for each activity which sometimes means studying, practicing and learning new skills. Safety is paramount and Operation Clean Desert takes the time to make sure all of our workers are qualified and properly trained!

Do you know what you want to be when you get older?

Talk to your teachers and counselors about it today!

Adam Challenge!

We've given you a lot of information, now let's see if you can figure out Operation Clean Desert's main mission!

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
				25								26			15										

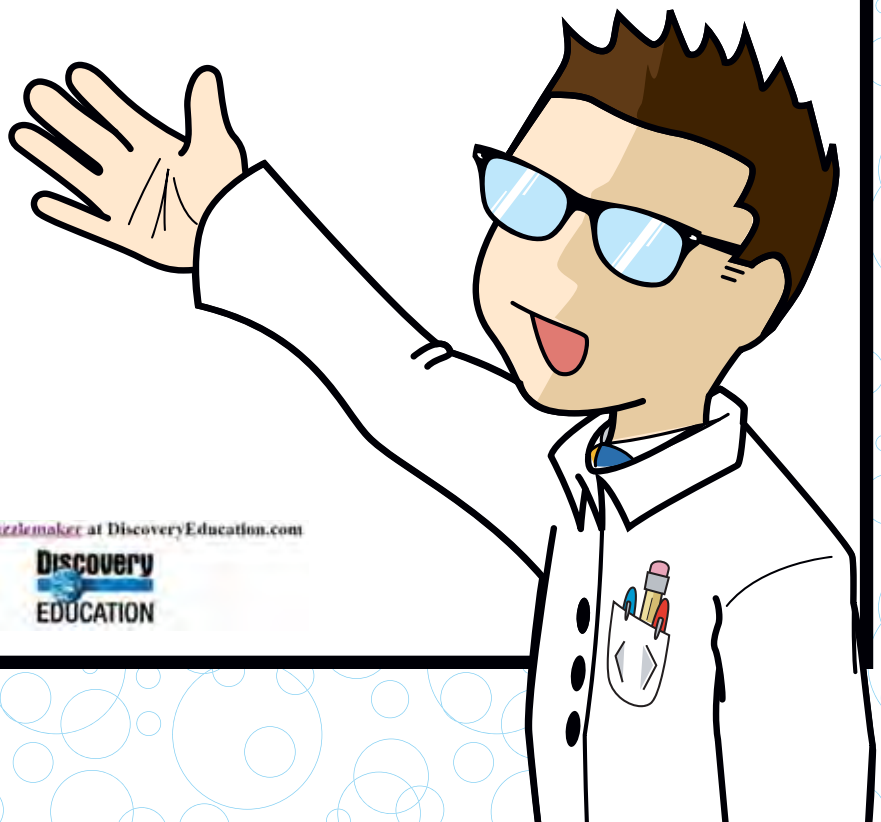
P				E					E	E								M	E			!
15	11	14	8	25	1	8		8	22	25		25	23	7	2	11	14	23	26	25	23	8

Figure out the letters and solve the cryptogram!

Remember, each letter is represented by a number. Figure them out by looking for common patterns, word endings and common short words.

Hint: The most commonly used letters in the alphabet are R, S, T, L, N and E.

Good luck!



Created by Puzzlemaker at DiscoveryEducation.com

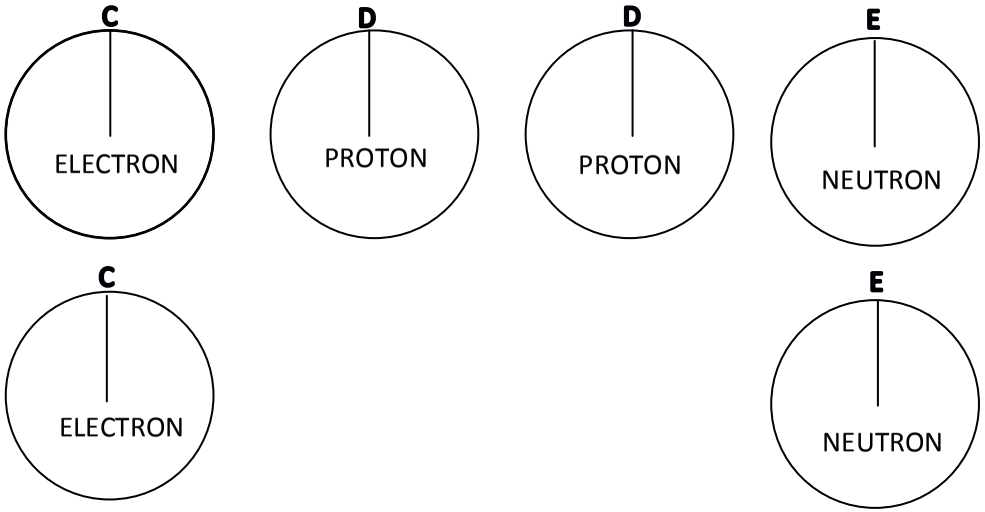
Discovery EDUCATION

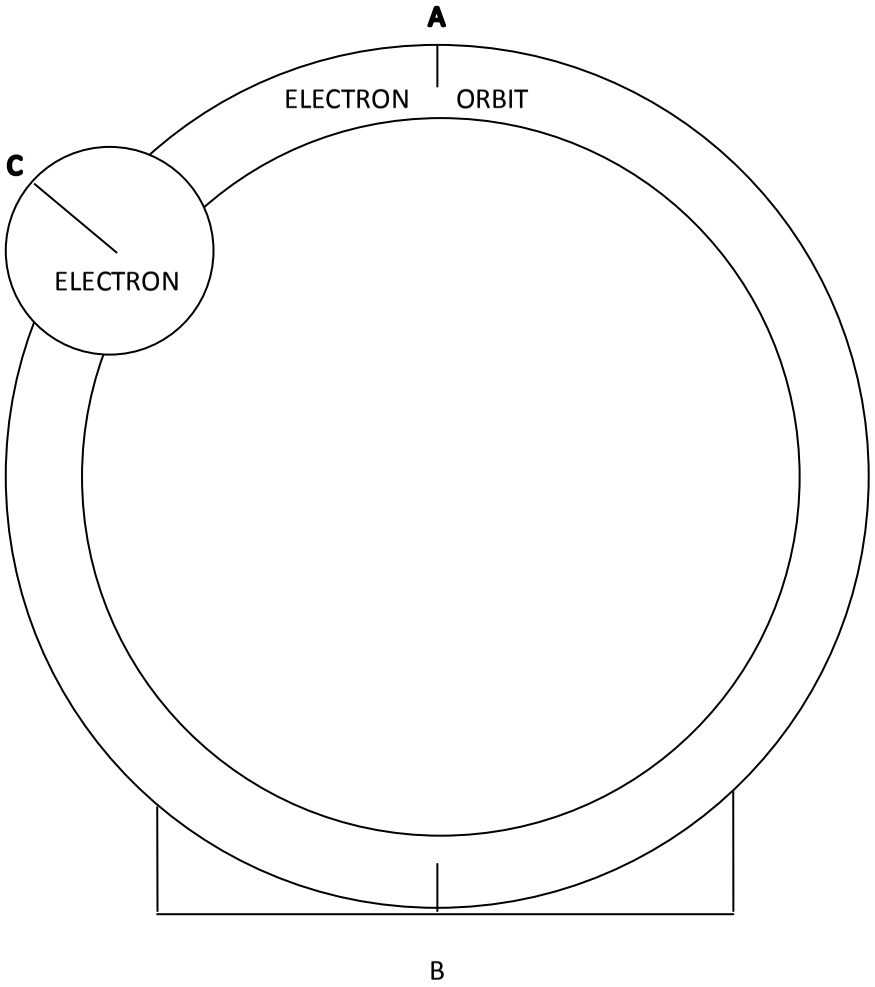
THE ANATOMY OF AN ATOM

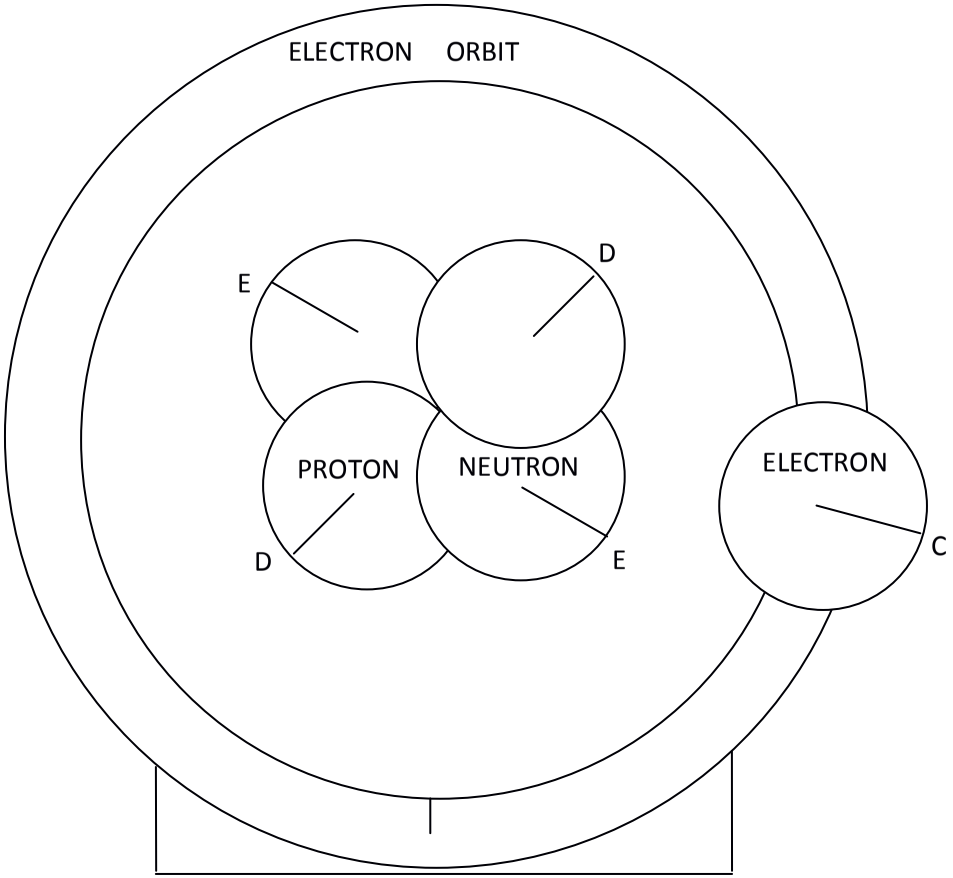
Instructions: Color each subatomic particle a different color. Cut out all atom parts. Connect orbit pieces, using slots A & B. Matching colors, letters, and slots, slip electron, proton, and neutron pieces on electron orbits and nucleus parts.

Place a knot in one end of a three inch piece of string and slide the knot into the small hole in nucleus. Wrap the other end of the string around the top of electron orbit (slot A) so that the nucleus is suspended in the center of the orbits.

You have made a model of a helium atom!







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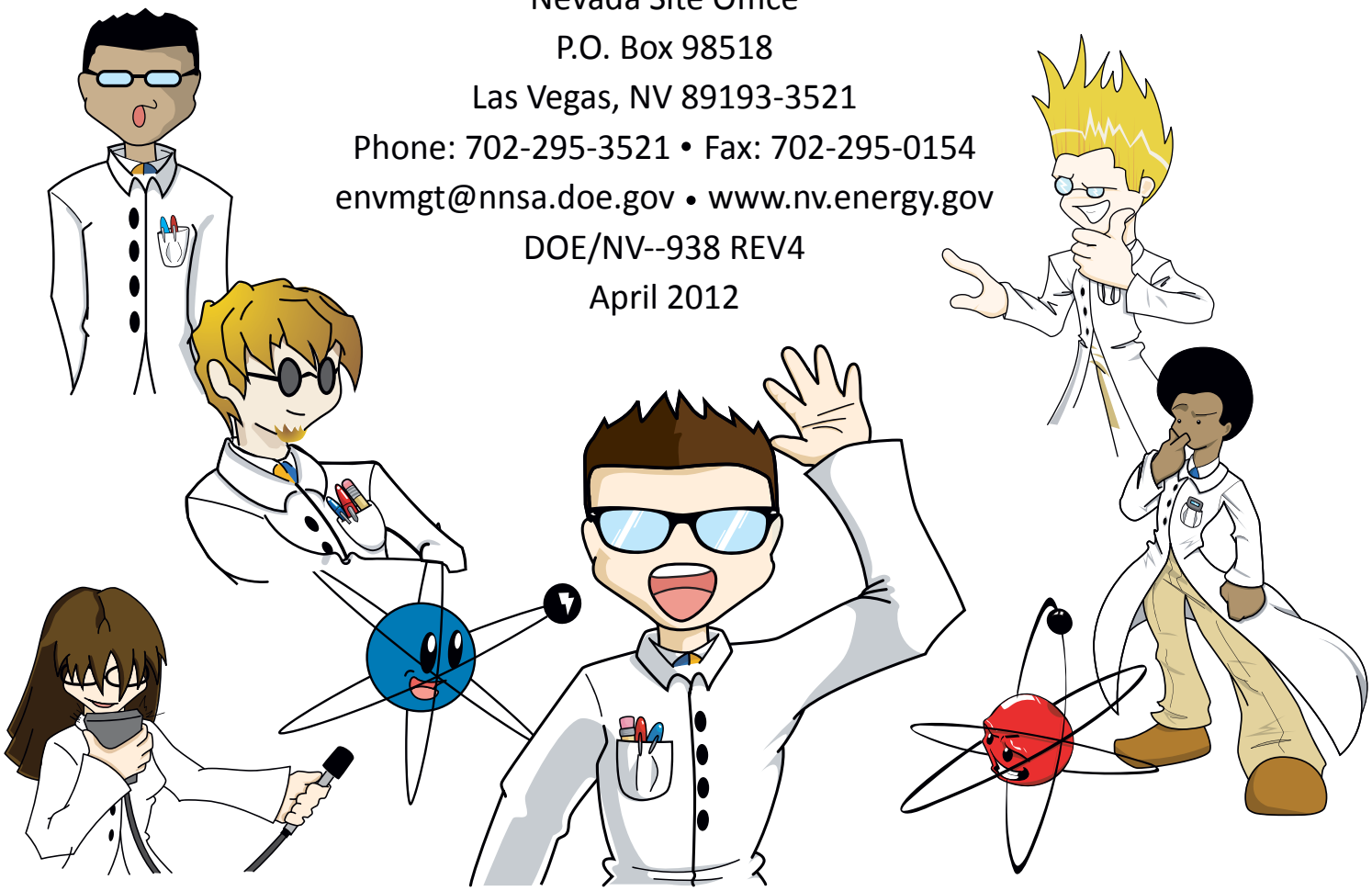

Let's all do our part to help the environment!

This book was brought to you by your friends at the Nevada National Security Site

Page 16: Down Answers: 1. Hydrogen Atom 2. Dr. Proton 3. Decay 4. Craters 5. Low-level Radioactive Waste 8. Isotope 9. Wells 10. Remediated 11. Models 13. Testing 16. Radiation Surveys 17. Forecasts 18. Proton 19. Geologic 20. Adam 21. Neutrons 23. Axel

Across Answers: 6. Groundwater 7. Scientists 12. Electron 14. Chemical Contamination 15. Samples 22. Radioactive Contamination 24. Drill Rigs 25. Disposal

Page 20: Protect the Environment