Volume 1
Number 4

OPERATION CLEAN DESERT

U.S. Department of Energy,
National Nuclear Security Administration
Nevada Field Office

Teacher's Guide

ACTIVITY BOOK

Developed in cooperation with Patricia MacLeod, 8th Grade Science Teacher
Updated March 2013

Table of Contents

Preface

There are ongoing Environmental Management activities at the Nevada National Security Site (formerly known as the Nevada Test Site), which is located 65 miles northwest of Las Vegas, Nevada, addressing impacts from historic atmospheric and underground nuclear testing that spanned from 1951 to 1992. Many scientific experts are working together to develop and implement effective strategies to characterize more than 3,000 contaminated soil, industrial facilities, and groundwater sites at the Nevada National Security Site. Once characterized, contaminated sites are remediated and then closed in accordance with the Federal Facility Agreement and Consent Order (www.nv.energy.gov/library/factsheets/DOENV_964.pdf).

In addition to the above remediation activities, low-level and mixed low-level radioactive waste disposal at the Nevada National Security Site has been ongoing since 1961. Originally, this waste was generated by historic on-site nuclear weapons testing. More recently, the low-level and mixed low-level radioactive waste is generated during environmental cleanup and operational activities at the Nevada National Security Site and other U.S. Department of Energy sites across the United States. This waste is permanently disposed in excavated cells located at the Area 5 Radioactive Waste Management Site, a 740 acre facility at the Nevada National Security Site. Located in a remote, arid environment with very deep groundwater (approximately 800 feet below the surface), Area 5 Radioactive Waste Management Site activities are conducted in accordance with applicable federal, state, and local regulations (www.nv.energy.gov/library/factsheets/DOENV_631.pdf).

References

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office on-line resources:

www.nv.energy.gov/emprograms/default.aspx (Environmental Management Activities)
www.facebook.com/NNSANevada
www.youtube.com/user/NNSANevada
http://twitter.com/#!/NNSANevada
www.flickr.com/photos/NNSANevadaSiteOffice
envmgt@nnsa.doe.gov

Science Objectives

National Science Standards: Grades 6-8

N.8.A STUDENTS UNDERSTAND THAT SCIENTIFIC KNOWLEDGE REQUIRES CRITICAL CONSIDERATION OF VERIFIABLE EVIDENCE OBTAINED FROM INQUIRY AND APPROPRIATE INVESTIGATIONS.

- N.8.A.1 STUDENTS KNOW HOW TO IDENTIFY AND CRITICALLY EVALUATE INFORMATION IN DATA, TABLES, AND GRAPHS. E/S
- N.8.A.2 STUDENTS KNOW HOW TO CRITICALLY EVALUATE INFORMATION TO DISTINGUISH BETWEEN FACT AND OPINION. E/S
- N.8.A.4 STUDENTS KNOW HOW TO DESIGN AND CONDUCT A CONTROLLED EXPERIMENT. E/L
- N.8.A.5 STUDENTS KNOW HOW TO USE APPROPRIATE TECHNOLOGY AND LABORATORY PROCEDURES SAFELY FOR OBSERVING, MEASURING, RECORDING, AND ANALYZING DATA. E/L
- N.8.A.5 STUDENTS KNOW SCIENTIFIC INQUIRY INCLUDES EVALUATING RESULTS OF SCIENTIFIC INVESTIGATIONS, EXPERIMENTS, OBSERVATIONS, THEORETICAL AND MATHEMATICAL MODELS, AND EXPLANATIONS PROPOSED BY OTHER SCIENTISTS. E/S

N.8.B STUDENTS UNDERSTAND THE INTERACTIONS OF SCIENCE AND SOCIETY IN AN EVER CHANGING WORLD.

- N.8.B.1 STUDENTS UNDERSTAND THAT CONSEQUENCES OF TECHNOLOGIES CAN CAUSE RESOURCE DEPLETION AND ENVIRONMENTAL DEGRADATION, BUT TECHNOLOGY CAN ALSO INCREASE RESOURCE AVAILABILITY, MITIGATE ENVIRONMENTAL DEGRADATION, AND MAKE NEW RESOURCES ECONOMICAL.

Nevada and Clark County School District Science Standards: Grade 6

1.15 THE STUDENT WILL DISCUSS CAREERS RELATED TO LIFE SCIENCE.

L.8.C.3 STUDENTS WILL EVALUATE HOW CHANGES IN ENVIRONMENTS CAN BE BENEFICIAL OR HARMFUL. E/S

8.9 THE STUDENT WILL DISCUSS THE COSTS AND BENEFITS OF HUMAN-CAUSED CHANGES IN THE ENVIRONMENT.

E.8.C.7 STUDENTS KNOW THE CHARACTERISTICS, ABUNDANCE, AND LOCATION OF RENEWABLE AND NONRENEWABLE RESOURCES FOUND IN NEVADA. E/S

8.10 THE STUDENT WILL COMPARE AND CONTRAST RENEWABLE AND NONRENEWABLE RESOURCES.

Nevada and Clark County School District Science Standards: Grade 7

1.16 THE STUDENT WILL DISCUSS CAREERS RELATED TO EARTH SCIENCE.

E.8.C.7 STUDENTS KNOW THE CHARACTERISTICS, ABUNDANCE, AND LOCATION OF RENEWABLE AND NONRENEWABLE RESOURCES FOUND IN NEVADA. E/S

5.5 THE STUDENT WILL DISTINGUISH BETWEEN RENEWABLE AND NONRENEWABLE RESOURCES FOUND IN NEVADA.

E.8.A.2 STUDENTS KNOW HOW THE PROCESSES INVOLVED IN THE WATER CYCLE AFFECT CLIMATIC PATTERNS

7.2 THE STUDENT WILL EXPLAIN THAT THE WATER CYCLE IS A PROCESS IN WHICH ENERGY, PROVIDED BY THE SUN, CONTINUOUSLY CYCLES WATER THROUGH EARTH'S SYSTEMS.

E.8.C.4 STUDENTS KNOW THE VERY SLOW MOVEMENT OF LARGE CRUSTAL PLATES RESULT IN GEOLOGICAL EVENTS. E/S

3.1 THE STUDENT WILL DESCRIBE THE CHARACTERISTICS OF THE LAYERS OF THE OF THE EARTH.

Nevada and Clark County School District Science Standards: Grade 8

1.1 THE STUDENT WILL DISCUSS CAREERS RELATED TO PHYSICAL SCIENCE.

P.8.A.2 STUDENTS KNOW ELEMENTS CAN BE ARRANGED IN THE PERIODIC TABLE WHICH SHOWS REPEATING PATTERNS THAT GROUP ELEMENTS WITH SIMILAR PROPERTIES. E/S

5.6 THE STUDENT WILL RECOGNIZE THAT WITHIN A PERIOD ON THE PERIODIC TABLE, THE ATOMIC NUMBER OF ELEMENTS INCREASE BY ONE PROTON GOING FROM LEFT TO RIGHT.

5.7 THE STUDENT WILL RECOGNIZE THAT GROUPS ON THE PERIODIC TABLE CONTAIN ELEMENTS WITH SIMILAR PROPERTIES.

P.8.A.6 STUDENTS KNOW MATTER IS MADE UP OF TINY PARTICLES CALLED ATOMS. E/S

5.3 THE STUDENT WILL DEVELOP AN OPERATIONAL DESCRIPTION OF THE ATOMIC THEORY.

5.2 THE STUDENT WILL DESCRIBE CHARACTERISTICS OF PROTONS, NEUTRONS, AND ELECTRONS BASED ON THEIR RELATIVE MASS, CHARGE, AND LOCATION IN THE ATOM.

P.8.C.3 STUDENTS KNOW PHYSICAL, CHEMICAL, AND NUCLEAR CHANGES INVOLVE A TRANSFER OF ENERGY. E/S

7.1 THE STUDENT WILL USE AN OPERATIONAL DEFINITION OF ENERGY.

7.4 THE STUDENT WILL DESCRIBE DIFFERENT FORMS OF ENERGY (HEAT, CHEMICAL, LIGHT, ELECTRICITY, MECHANICAL MOTION, SOUND, AND NUCLEAR).

7.20 THE STUDENT WILL EXPLAIN THAT IN NUCLEAR REACTIONS, MASSIVE AMOUNTS OF ENERGY IN THE FORM OF HEAT IS GENERATED.

7.22 THE STUDENT WILL EXPLAIN THE DIFFERENCE BETWEEN FUSION AND FISSION, BASED ON THE ENERGY CHANGES.

P.8.C.4 STUDENTS KNOW ENERGY CANNOT BE CREATED OR DESTROYED, IN A CHEMICAL OR PHYSICAL REACTION, BUT ONLY CHANGED TO FROM ONE FORM TO ANOTHER. E/S

7.13 THE STUDENT WILL IDENTIFY TYPES AND SOURCES OF ENERGY.

7.14 THE STUDENT WILL DISTINGUISH BETWEEN RENEWABLE AND NONRENEWABLE SOURCES OF ENERGY.

Introduction

This science module is an activity book that uses characters, Dr. Proton and Adam the Atom, to take students through the process of Operation Clean Desert. The focus is on the environmental cleanup of contamination caused by historic nuclear testing conducted from 1951 to 1992 at what is now known as the Nevada National Security Site.

Students will use the scientific processes, protocols, and tools, including inquiry, to build understanding of structures, patterns, and relationships explained through the Operation Clean Desert Activity Book. Critical thinking, collaboration, accuracy, and communication skills will be emphasized as students refine their scientific literacy.

A focus on contamination, studying and monitoring groundwater, and low-level radioactive waste disposal will help students navigate the process and responsibility of addressing the environmental impacts from historic nuclear testing. Furthermore, students understand the complex interaction of geology with hydrology by creating an "Aquifer in a Cup."

The Hook

Initiate student interest in this unit by playing ***PIRDy224-OperationDoorstep.mpg*** (1 minute, 3 seconds). This video shows Federal Civil Defense Administration film footage of the March 17, 1953, 16-kiloton ANNIE test and the May 5, 1955, 29-kiloton APPLE-2 test. Both tests were conducted at the Nevada National Security Site under the Civil Defense Program names Operation Doorstep and Operation Cue. (Additional information on this video is available on YouTube at www.youtube.com/watch?v=8QYcUj_pL1c).

Discuss the history of U.S. nuclear testing. Read ***EM History*** (following page). Then, working in groups of two or three, have students prepare responses to these questions:

- ***What is the Manhattan Project?***
- ***How would you describe the Government's past and present approach to the environmental legacy of the Manhattan Project?***
- ***Why did the Government create an Environmental Management program?***

Each group selects a spokesperson to share the group's responses.

Discussion Topic: History of the U.S. Department of Energy Environmental Management Program

The Manhattan Project

The quest for nuclear explosives, driven by the fear that Hitler's Germany might invent them first, was an epic, top-secret engineering and industrial venture in the United States during World War II. The term "Manhattan Project" has become a byword for an enormous breakneck effort involving vast resources and the best scientific minds in the world. The workers on the Manhattan Project took on a nearly impossible challenge to address a grave threat to the national security.

From its beginning with Enrico Fermi's graphite-pile reactor under the bleachers of Stagg Field at the University of Chicago to the fiery explosion of the first atomic bomb near Alamogordo, New Mexico, the Manhattan Project took a little less than 3 years to create a working atomic bomb. During that time, the U.S. Army Corps of Engineers managed the construction of monumental plants to enrich uranium, three production reactors to make plutonium, and two reprocessing plants to extract plutonium from the reactor fuel. ***In 1939, Nobel Prize-winning physicist Niels Bohr had argued that building an atomic bomb "can never be done unless you turn the United States into one huge factory."*** Years later, he told his colleague Edward Teller, "I told you it couldn't be done without turning the whole country into a factory. You have done just that."

The Cold War and the Nuclear Weapons Complex

Shortly after World War II, relations between the United States and the Soviet Union began to sour, and the Cold War ensued. Its most enduring legacy was the nuclear arms race. It began during the Manhattan Project, when the Soviet Union began to develop its own atomic bomb. In the United States, the nuclear arms race resulted in the development of a vast research, production, and testing network that came to be known as "the nuclear weapons complex." Some idea of the scale of this enterprise can be understood from the cost: from the Manhattan Project to the present, the United States spent approximately 300 billion dollars on nuclear weapons research, production, and testing (in 1995 dollars). During half a century of operations, the complex manufactured tens of thousands of nuclear warheads and detonated more than one thousand.

At its peak, this complex consisted of 16 major facilities, including vast reservations of land in the States of Nevada, Tennessee, Idaho, Washington, and South Carolina. In its diversity, it ranged from ***tracts of isolated desert in Nevada, where weapons were tested***, to warehouses in downtown New York that once stored uranium. Its national laboratories in New Mexico and California designed weapons with production of various components in Colorado, Florida, Missouri, Ohio, Tennessee, and Washington. Even now, long after some of the sites used in the nuclear enterprise were turned over to other uses, the U.S. Department of Energy - the Federal agency that controls the nuclear weapons complex - still owns 2.3 million acres of land and 120 million square feet of buildings.

Civilian Control

Soon after the destructiveness of nuclear weapons was demonstrated by the bombing of Hiroshima and Nagasaki in Japan during World War II, the U. S. Congress acted to put the immense power and possibilities of atomic energy under civilian control. The Atomic Energy Act of 1946 established the Atomic Energy Commission, to administer and regulate the production and uses of atomic power.

The work of the Commission expanded quickly from building a stockpile of nuclear weapons to ***investigating peaceful uses of atomic energy*** (such as research on, and the regulation of, the production of electrical power). It also conducted ***studies on the health and safety hazards of radioactive materials***.

In 1975, the Atomic Energy Commission was replaced by two new Federal agencies: the Nuclear Regulatory Commission, which was charged with regulating the civilian uses of atomic energy (mainly commercial nuclear power plants), and the Energy Research and Development Administration, whose duties included the control of the nuclear weapons complex. In 1977, these duties were transferred to the newly created U.S. Department of Energy.

Environmental Legacy of the Cold War

Like most industrial and manufacturing operations, ***the nuclear weapons complex has generated waste, pollution, and contamination***. However, many problems posed by its operations are unlike those associated with any other industry. They include unique radiation hazards, unprecedented volumes of contaminated water and soil, and a vast number of contaminated structures ranging from reactors to chemical plants for extracting nuclear materials to evaporation ponds.

Early in the nuclear age, scientists involved with the weapons complex raised serious questions about its waste management practices. Shortly after the establishment of the Atomic Energy Commission, its 12-man Safety and Industrial Health Advisory Board reported that the ***"disposal of contaminated waste in present quantities and by present methods...if continued for decades, presents the gravest of problems."***

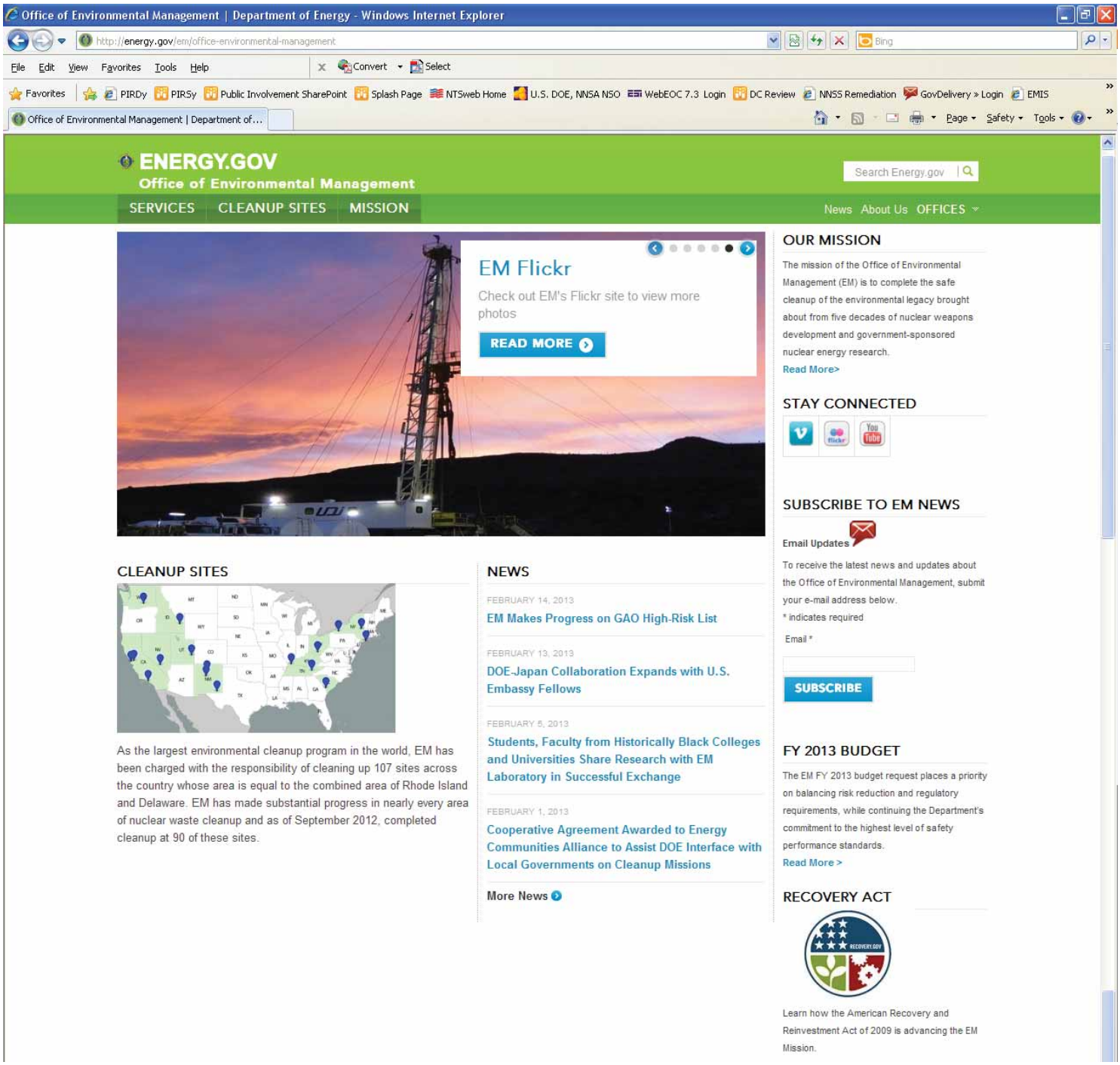
The ***imperatives of the nuclear arms race, however, demanded that weapons production and testing be given priority over waste management and the control of environmental contamination***.

Environmental Management

Although the nation continues to maintain an arsenal of nuclear weapons, as well as some production capability, the United States has entered a new era, and the U.S. Department of Energy has embarked on new missions. ***The most ambitious and far-ranging of these missions is dealing with the environmental legacy of the Cold War.***

Discussion Topic Reference

http://energy.gov/em/office-environmental-management

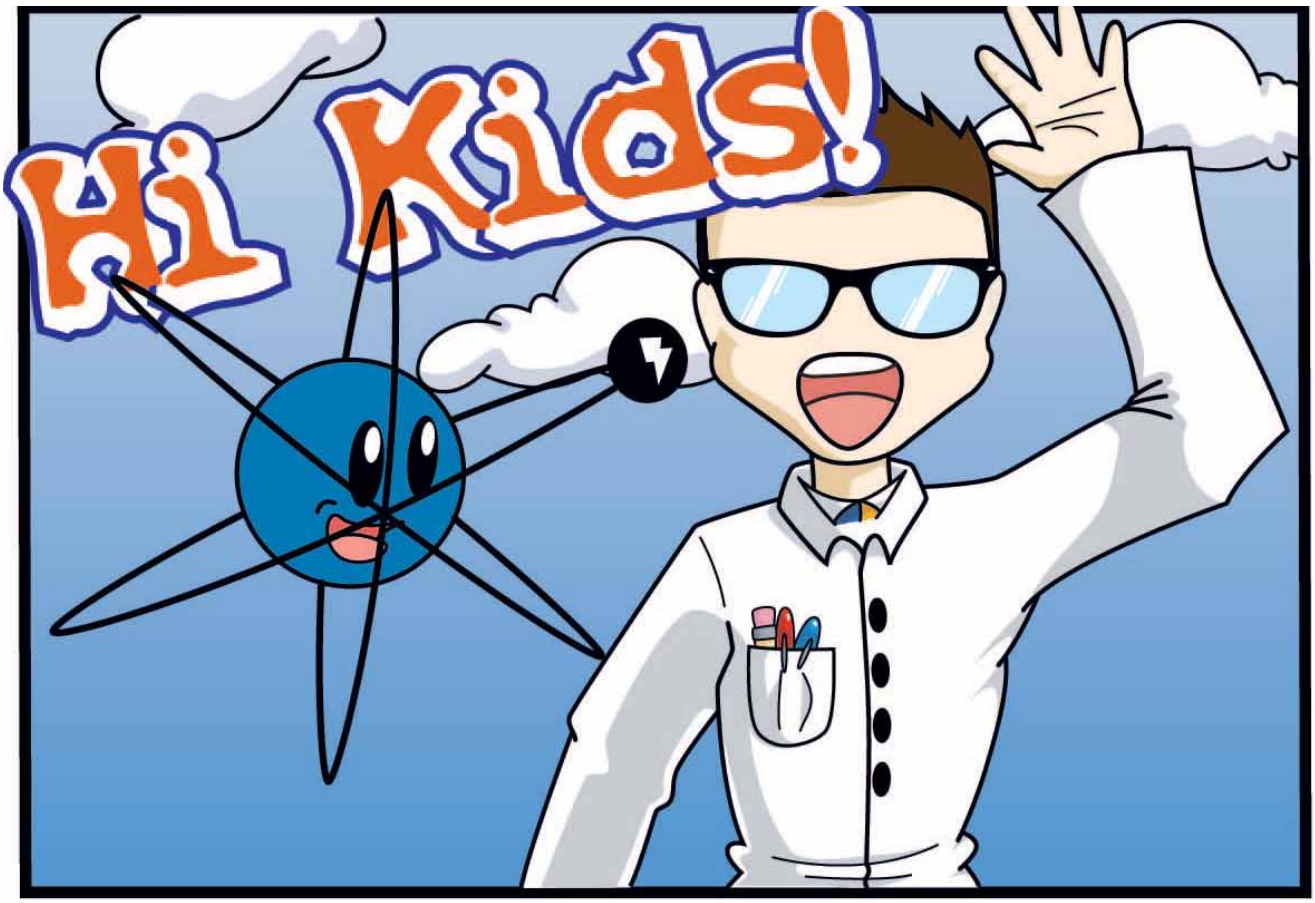


Activity Book

Teachers and students should then begin reading the activity book. This can be done as a group or on an individual basis. The teacher may choose to hand out the accompanying Student Assessment worksheet at the beginning, so students can answer the questions as they read, or they can give it at the end, so students can review the activity book while searching for the answers.

NOTE: Teachers should preview the entire lesson before beginning with students.

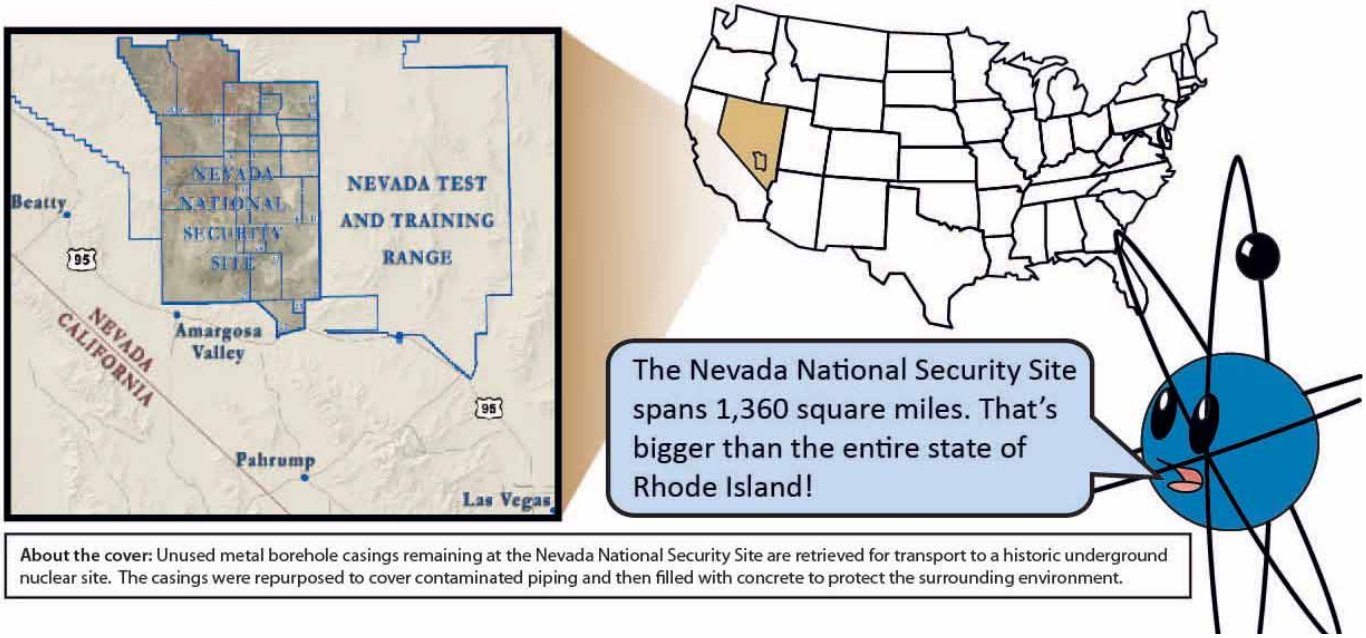
Operation Clean Desert
Activity Book (Vol. 1, Number 4)
Inside front cover



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.

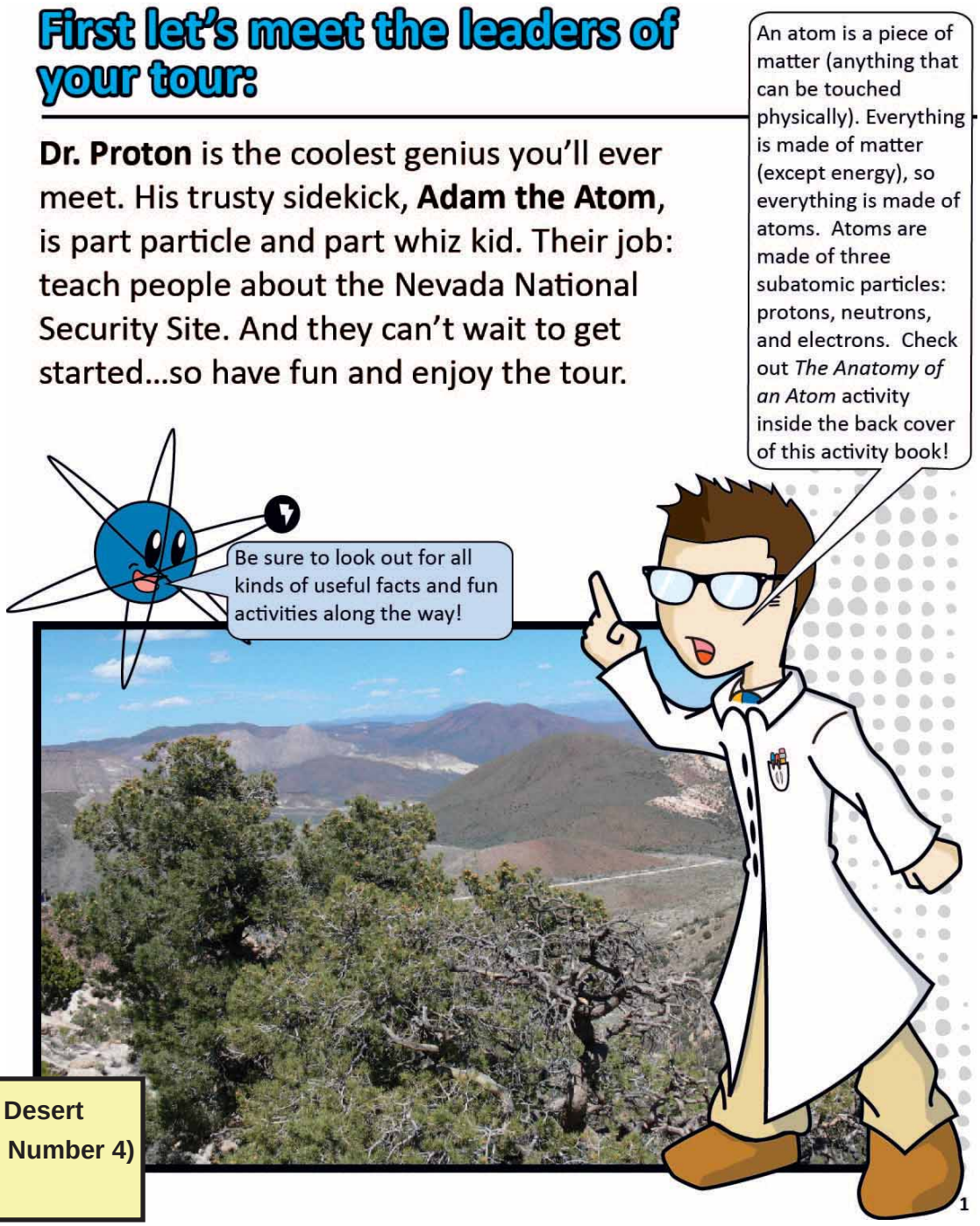
The Atom

P.8.A.6 STUDENTS KNOW MATTER IS MADE UP OF TINY PARTICLES CALLED ATOMS. E/S

Continue reading. Review atoms.

Remind students that tremendous amounts of energy are held in the nucleus of atoms and they are the source of all things in our universe.

Complete: ***Anatomy of an Atom***, included on the inside back cover. **Note:** The *Anatomy of an Atom* activity is of unknown origin. The copy here was recreated by Patricia MacLeod, but she does not take credit for the idea or design.



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.

The Bomb

P.8.A.6 STUDENTS KNOW MATTER IS MADE UP OF TINY PARTICLES CALLED ATOMS. E/S

N.8.A.5 STUDENTS KNOW SCIENTIFIC INQUIRY INCLUDES EVALUATING RESULTS OF SCIENTIFIC INVESTIGATIONS, EXPERIMENTS, OBSERVATIONS, THEORETICAL AND MATHEMATICAL MODELS, AND EXPLANATIONS PROPOSED BY OTHER SCIENTISTS. E/S

7.20 THE STUDENT WILL EXPLAIN THAT IN NUCLEAR REACTIONS, MASSIVE AMOUNTS OF ENERGY IN THE FORM OF HEAT IS GENERATED.

Again, remind students that tremendous amounts of energy are held in the nucleus of atoms. Explain that they will see this in the video they are about to watch.

Play ***AF-SFP281-TargetNevadaIntro.mp4*** video clip (45 seconds) that shows four historic atmospheric nuclear explosions at the Nevada National Security Site conducted in the 1950s (also available on YouTube at www.youtube.com/watch?v=ZZj6krRsBi8). Discuss video with students.

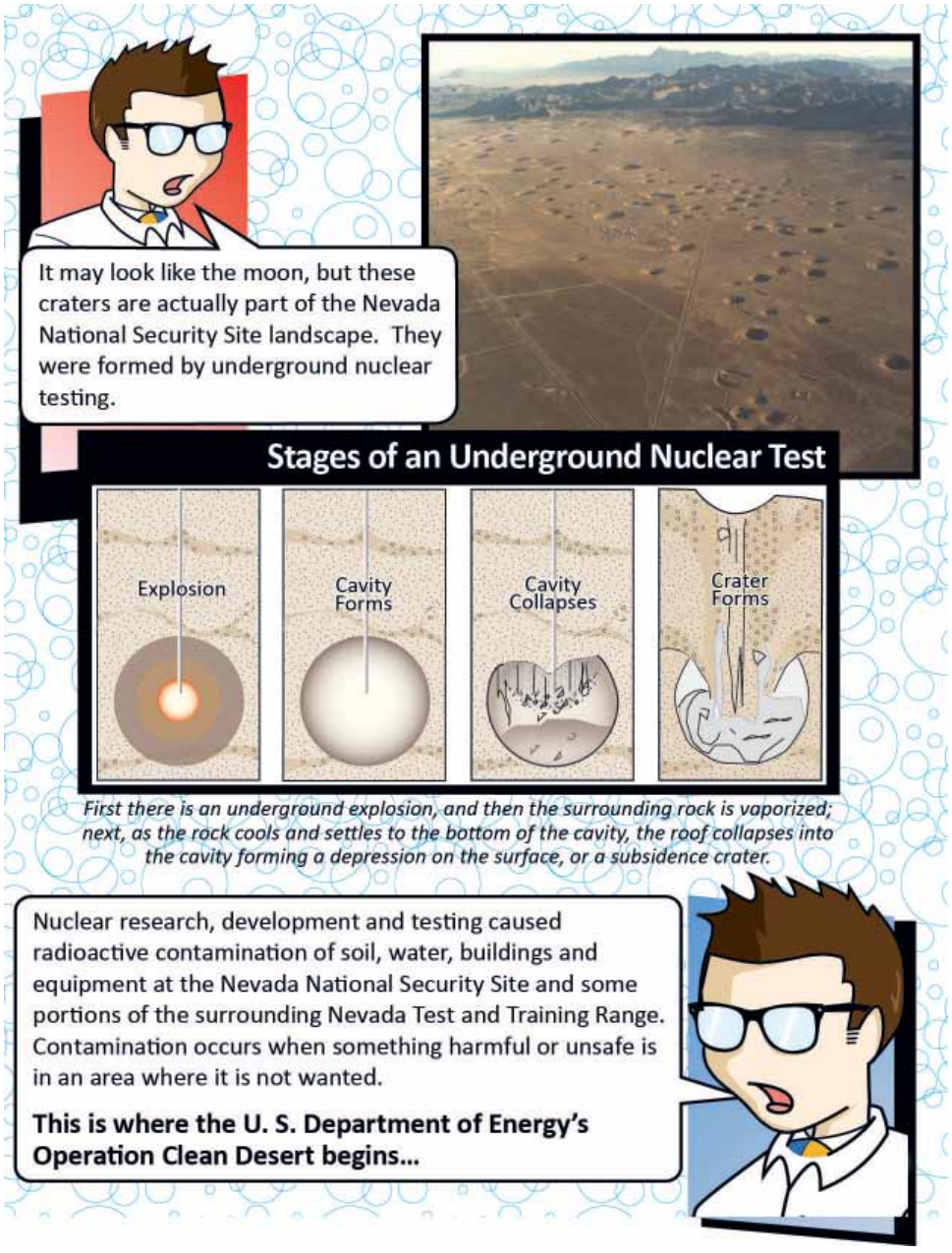
N.8.B STUDENTS UNDERSTAND THE INTERACTIONS OF SCIENCE AND SOCIETY IN AN EVER CHANGING WORLD.

N.8.B.1 STUDENTS UNDERSTAND THAT CONSEQUENCES OF TECHNOLOGIES CAN CAUSE RESOURCE DEPLETION AND ENVIRONMENTAL DEGRADATION, BUT TECHNOLOGY CAN ALSO INCREASE RESOURCE AVAILABILITY, MITIGATE ENVIRONMENTAL DEGRADATION, AND MAKE NEW RESOURCES ECONOMICAL.

L.8.C.3 STUDENTS WILL EVALUATE HOW CHANGES IN ENVIRONMENTS CAN BE BENEFICIAL OR HARMFUL. E/S

8.9 THE STUDENT WILL DISCUSS THE COSTS AND BENEFITS OF HUMAN-CAUSED CHANGES IN THE ENVIRONMENT.

Continue reading. Be sure to be available to answer any questions the students may have.



Operation Clean Desert
Activity Book (Vol. 1, Number 4)
Page 3

For grades 6 and 7, read the definition of isotopes provided. Explain this is a concept they will learn more about in grade 8.

5.3 THE STUDENT WILL DEVELOP AN OPERATIONAL DESCRIPTION OF ATOMIC THEORY.

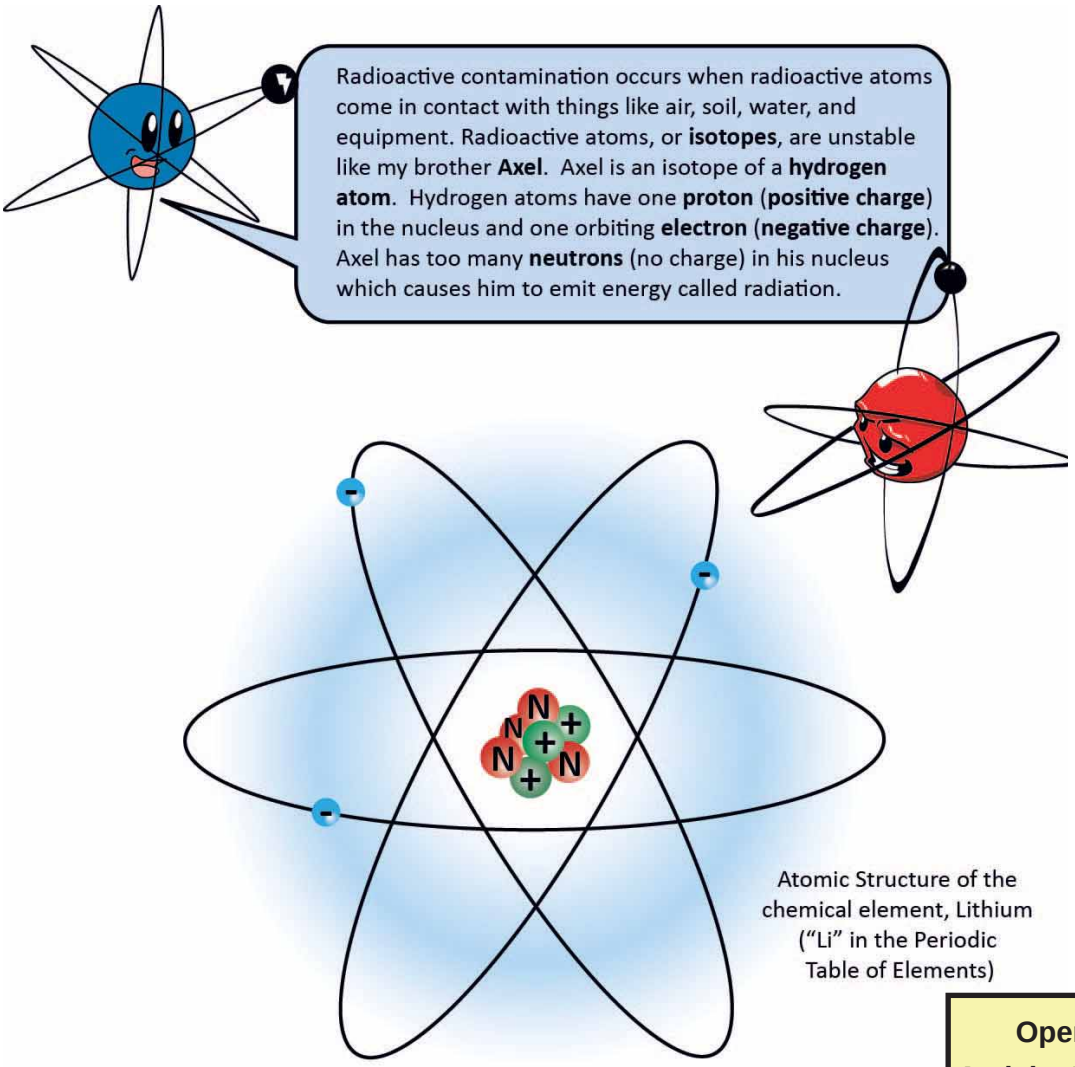
5.2 THE STUDENT WILL DESCRIBE THE CHARACTERISTICS OF PROTONS, NEUTRONS, AND ELECTRONS BASED ON RELATIVE MASS, CHARGE, AND LOCATION IN ATOM.

Review characteristics of subatomic particles with students.

Define atomic number as the number of protons in the nucleus of an atom. Remind students the atomic number determines the elements identity and that all elements have a unique atomic number.

Explain to students that an isotope is an atom of the same element having the same number of protons, but a different number of neutrons. Many isotopes emit radiation in an attempt to become stable.

The amount of radiation is different for different isotopes and not all are dangerous to living things. In fact, many radioactive isotopes are used in medicine and every day forms of technology. The sun and some rocks also emit natural radiation.



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

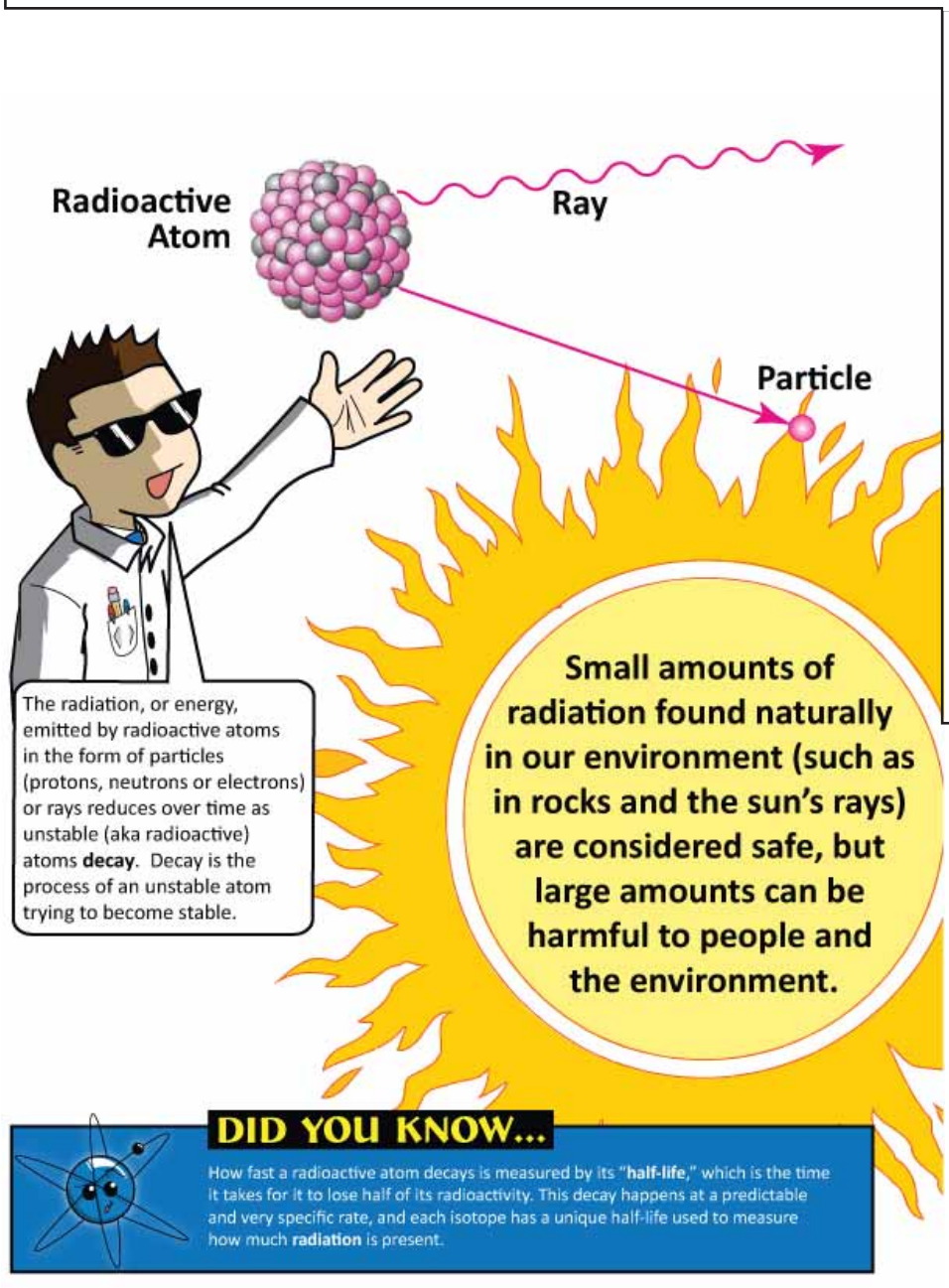
Operation Clean Desert
Activity Book (Vol. 1, Number 4)
Page 4

7.22 THE STUDENT WILL EXPLAIN THE DIFFERENCE BETWEEN FUSION AND FISSION, BASED ON THE ENERGY CHANGES.

Remind students that while both fusion and fission result in the release of enormous quantities of energy, fusion occurs when lighter atoms combine to form a heavier atom, and fission is the splitting of a heavy atom into two or more lighter atoms.

Discuss the relationship between decay and half-life.

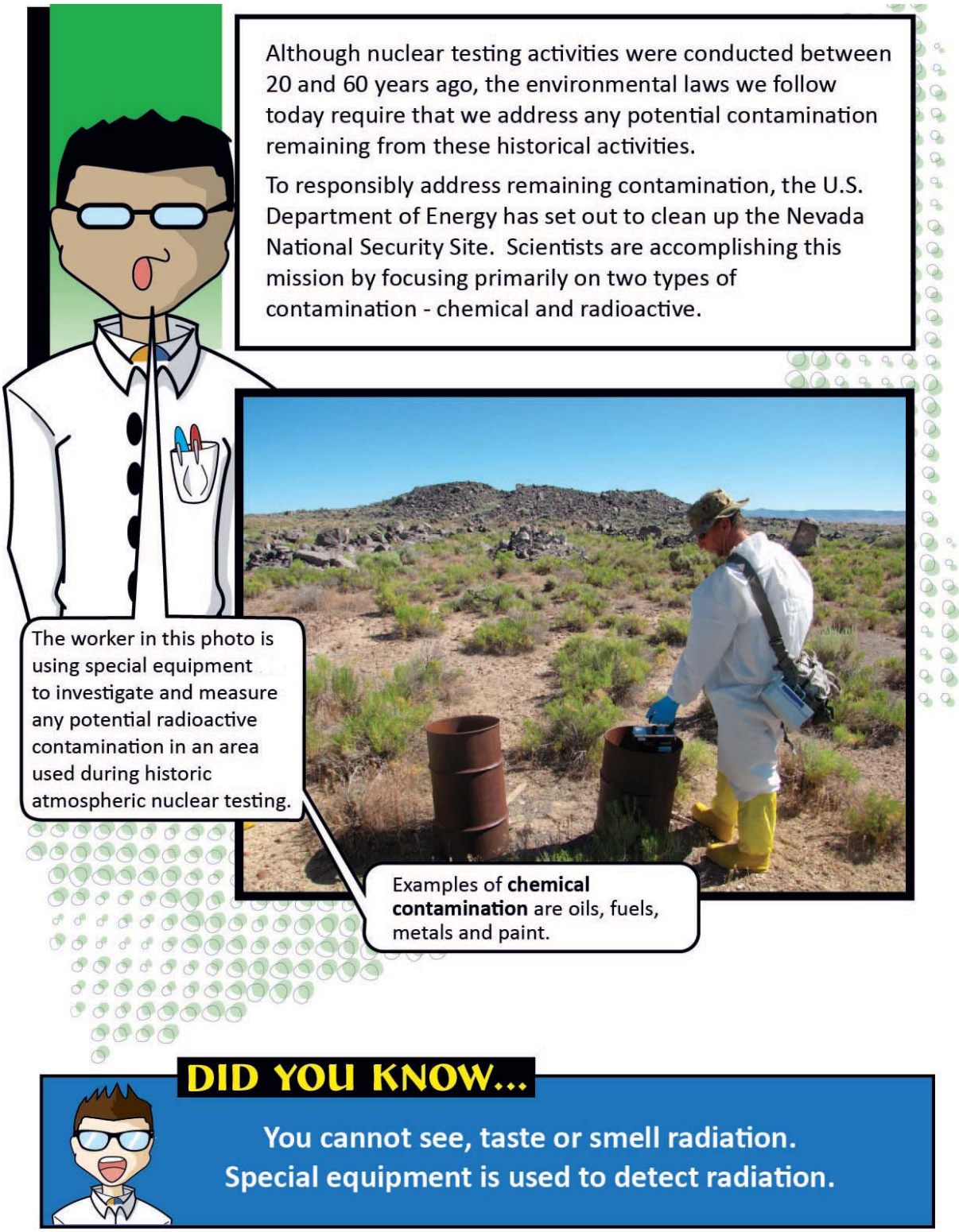
To reinforce the discussion, separate the students into groups with one student in each group responsible for keeping time on a stop watch. Then, provide each group a paper or plastic cup containing 100 pennies (or other distinctly two-sided item) which represent 100 of the same radioactive isotope. Have the students give their isotope a name. Explain to the groups that when the timer says "go," a student will ***gently*** dump over the cup with the pennies. Then, while the timer is still running, students are to remove any pennies that are "heads up," which represents atoms that have achieved stability through radioactive decay. As the stop watch continues to run, have students count the remaining pennies as they are placed back into the cup. The process continues to repeat until there are only ***50 pennies or less*** that are placed back into the cup. Once the last 50 pennies are placed back into the cup, the timer is stopped and the elapsed time recorded. This time represents the half-life of their isotope.

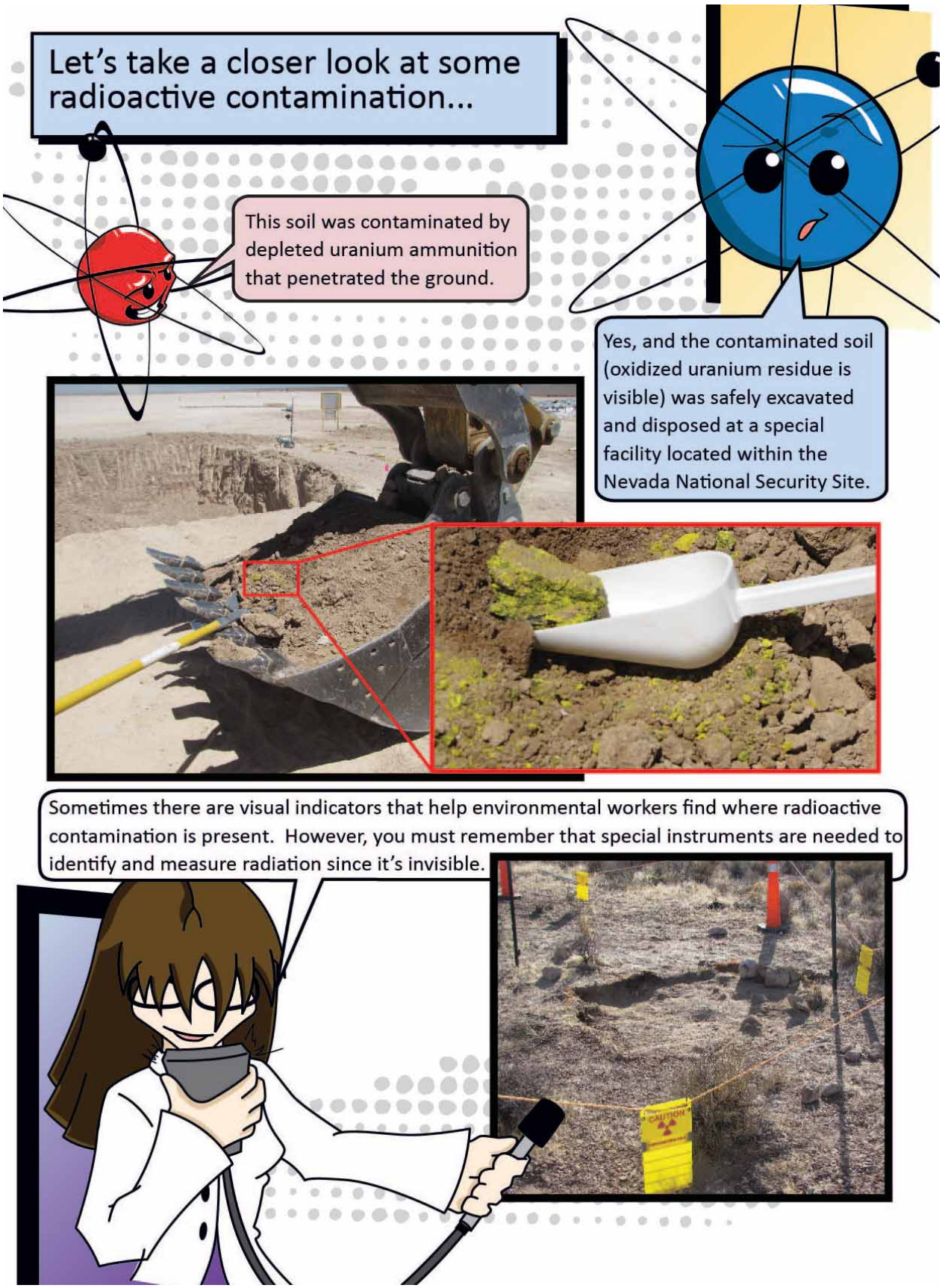


Explain to students that half-life is different for different radioactive isotopes. It can be measured in seconds, minutes, hours, and years. For example, Actinium-228 has a half-life of 6.13 hours while Carbon-14 has a half-life of 5,730 years. Polonium-211 decays in 0.516 seconds and Uranium-235 decays in 703 million years.

Note: Explain to students the number that follows the element indicates which isotope of the element is being used. It represents the mass number and by subtracting the atomic number, students can calculate the number of neutrons.

Operation Clean Desert Activity Book (Vol. 1, Number 4) Page 5


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.



Operation Clean Desert
Activity Book (Vol. 1, Number 4)
Page 7

N.8.B STUDENTS UNDERSTAND THE INTERACTIONS OF SCIENCE AND SOCIETY IN AN EVER CHANGING WORLD.

N.8.B.1 STUDENTS UNDERSTAND THAT CONSEQUENCES OF TECHNOLOGIES CAN CAUSE RESOURCE DEPLETION AND ENVIRONMENTAL DEGRADATION, BUT TECHNOLOGY CAN ALSO INCREASE RESOURCE AVAILABILITY, MITIGATE ENVIRONMENTAL DEGRADATION, AND MAKE NEW RESOURCES ECONOMICAL.

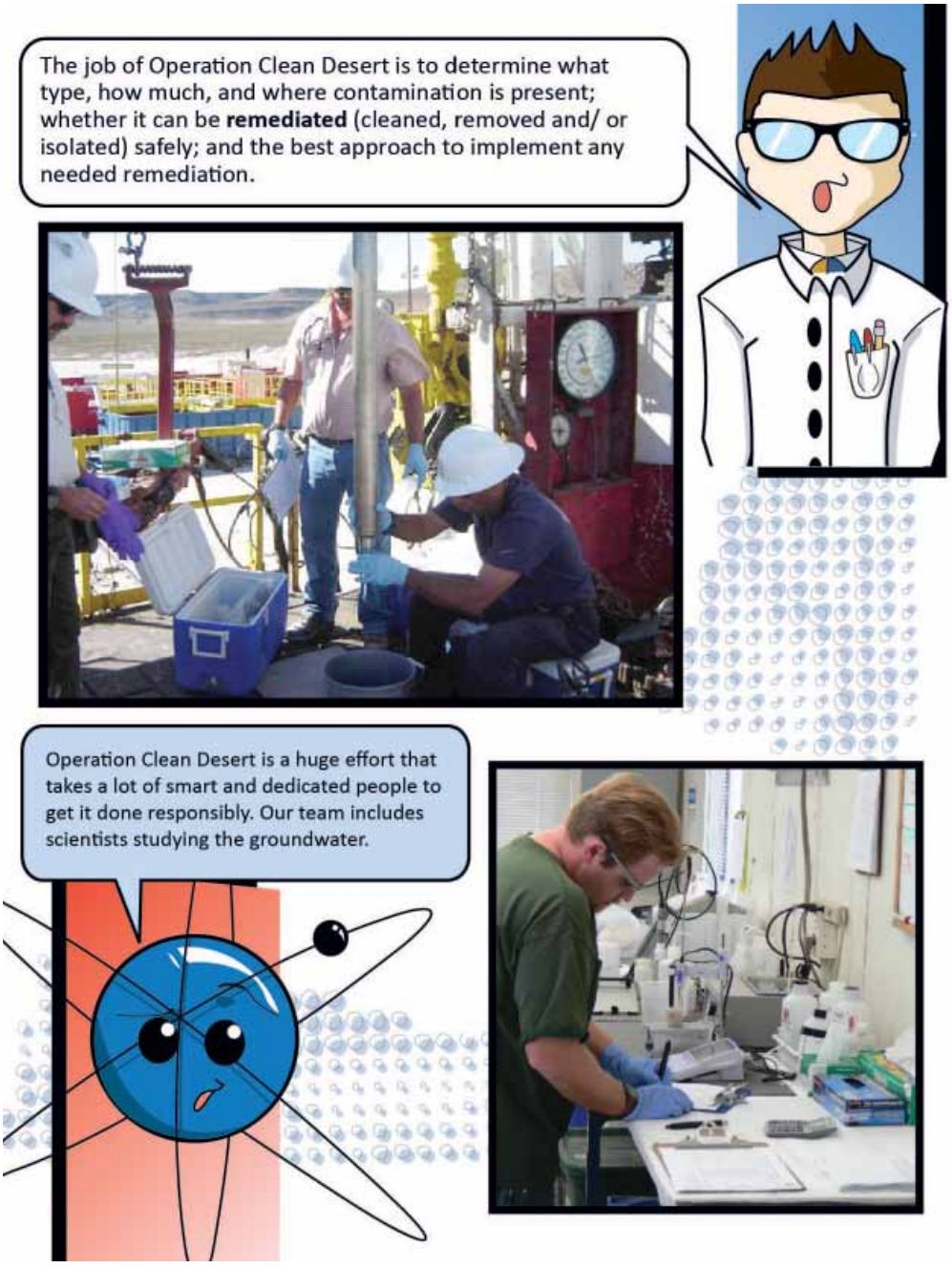
L.8.C.3 STUDENTS WILL EVALUATE HOW CHANGES IN ENVIRONMENTS CAN BE BENEFICIAL OR HARMFUL. E/S

8.9 THE STUDENT WILL DISCUSS THE COSTS AND BENEFITS OF HUMAN-CAUSED CHANGES IN THE ENVIRONMENT.

Continue reading. Discuss remediation efforts at the Nevada National Security Site.

Optional: Play ***GroundwaterVideo_TeachersGuide_LogNo2012-227.mp4*** (10 minutes, 38 seconds) to explain ongoing studies of contaminated groundwater from historic nuclear testing (also available on YouTube at www.youtube.com/watch?v=8SMYSc2enQw).

Operation Clean Desert Activity Book (Vol. 1, Number 4) Page 8

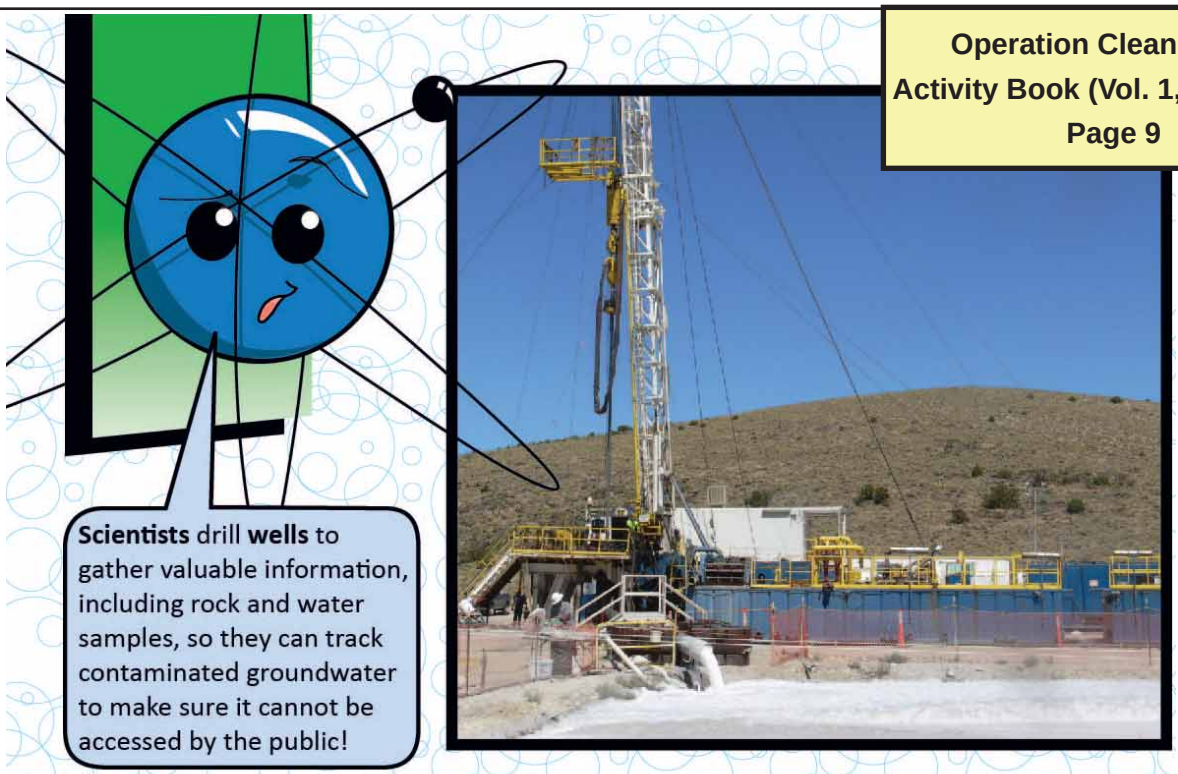


7.2 THE STUDENT WILL EXPLAIN THAT THE WATER CYCLE IS A PROCESS IN WHICH ENERGY, PROVIDED BY THE SUN, CONTINUOUSLY CYCLES WATER THROUGH EARTH'S SYSTEMS.

3.1 THE STUDENT WILL DESCRIBE THE CHARACTERISTICS OF THE LAYERS OF THE OF THE EARTH.

Continue reading and discuss groundwater as part of the geologic layers of the earth.

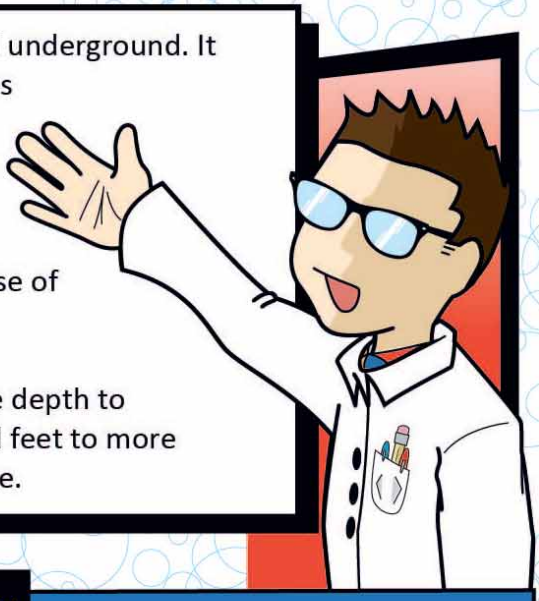
Operation Clean Desert
Activity Book (Vol. 1, Number 4)
Page 9



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.

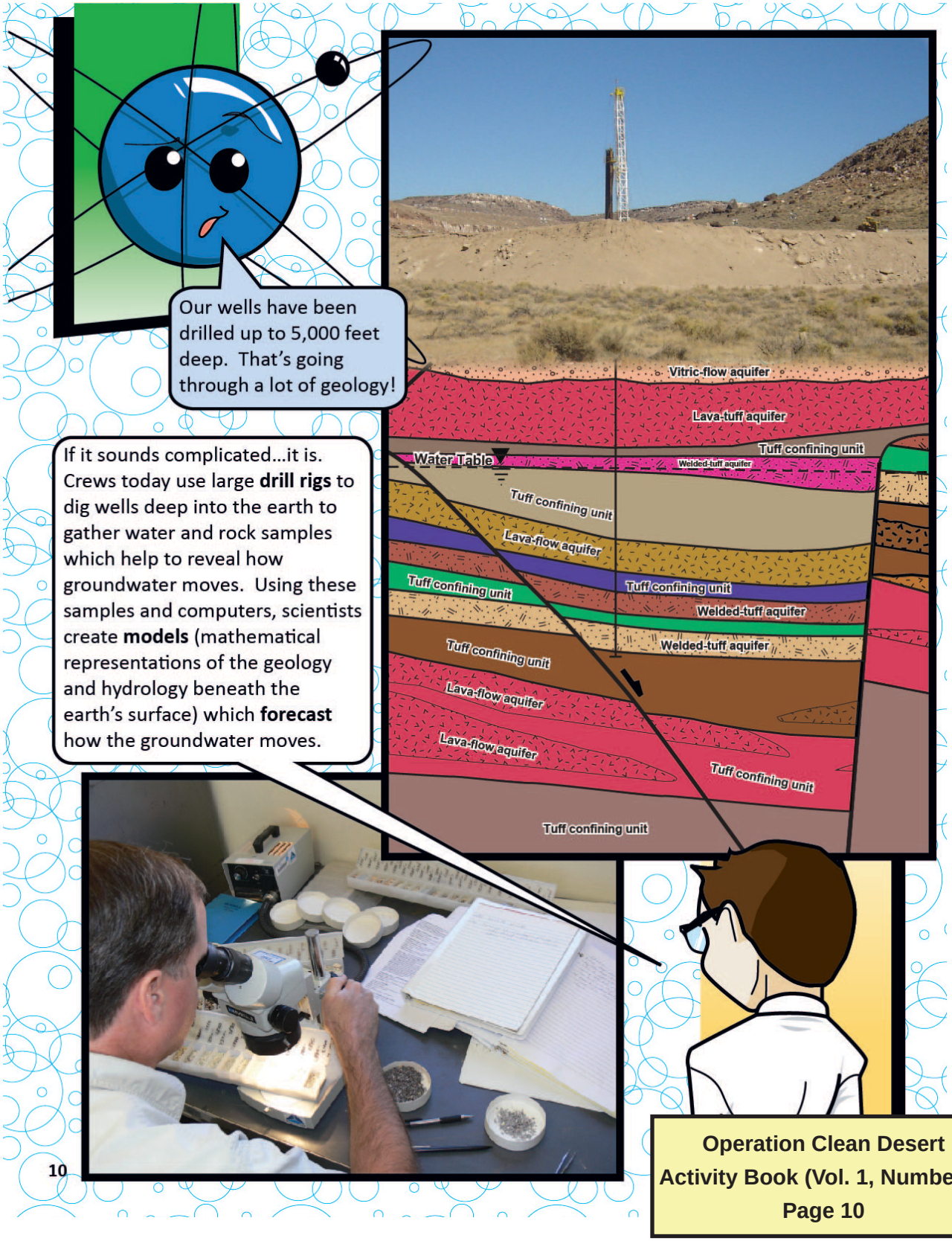


DID YOU KNOW...

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.

E.8.C.4 STUDENTS KNOW THE VERY SLOW MOVEMENT OF LARGE CRUSTAL PLATES RESULT IN GEOLOGICAL EVENTS E/S

3.1 STUDENTS WILL DESCRIBE THE CHARACTERISTICS OF THE LAYERS OF THE EARTH.



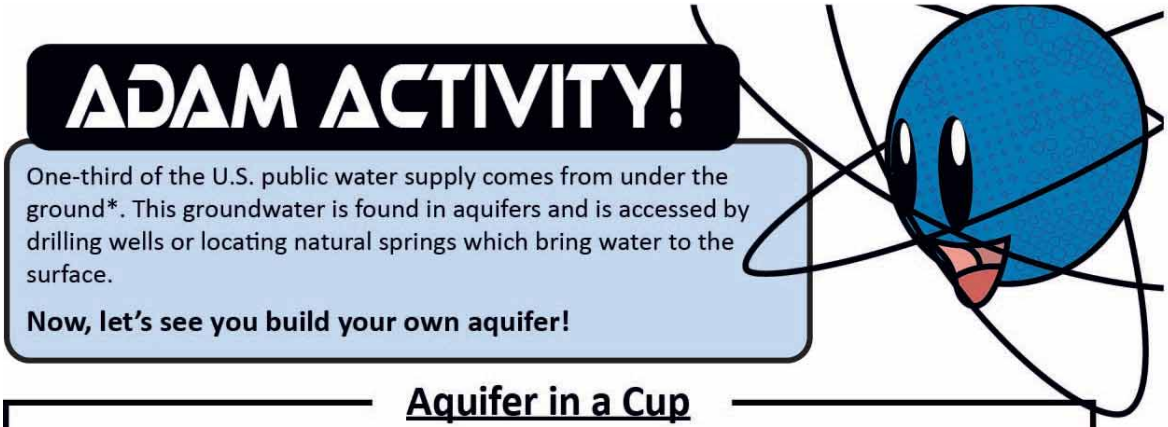
Operation Clean Desert
Activity Book (Vol. 1, Number 4)
Page 10

E.8.C.4 STUDENTS KNOW THE VERY SLOW MOVEMENT OF LARGE CRUSTAL PLATES RESULTS IN GEOLOGICAL EVENTS E/S

3.1 STUDENTS WILL DESCRIBE THE CHARACTERISTICS OF THE LAYERS OF THE OF THE EARTH.

Complete Aquifer in a Cup.

Operation Clean Desert
Activity Book (Vol. 1, Number 4)
Page 11



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?

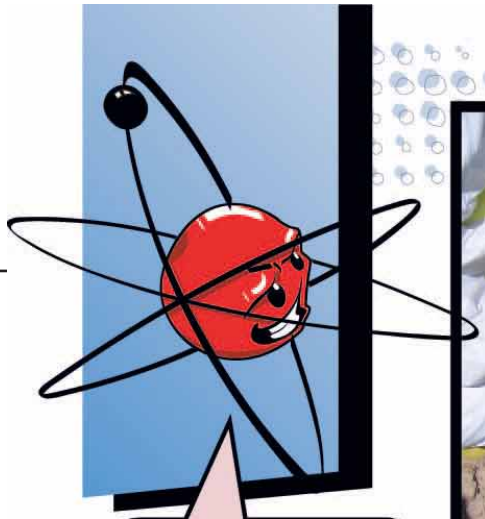
Now continue to fill this cup with water to the top (above the top of the sand and gravel). Water that is located above ground, like rivers and lakes, is called surface water. Water below the ground's surface is called groundwater. In the second cup, slowly pour water into the cup until the water line 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

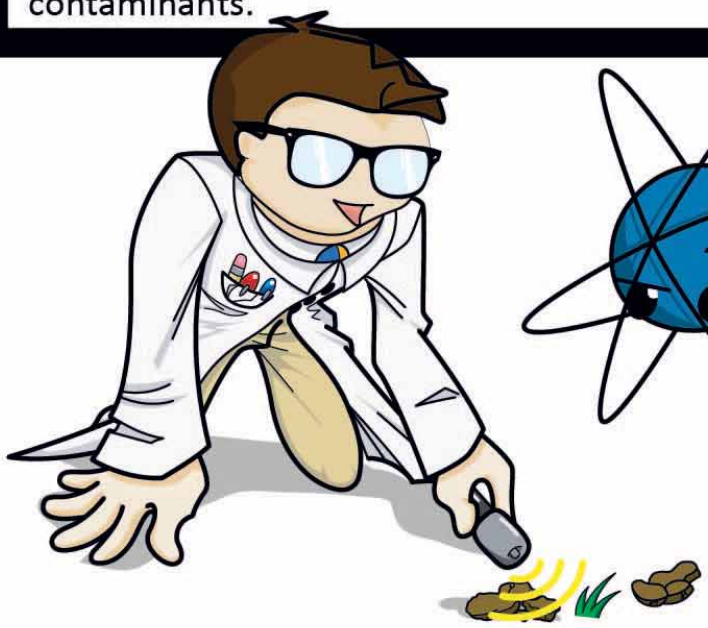
Continue reading and discussing the activity book. The teacher may choose to read the entire book and then have students complete the activities or complete each one as the class progresses through the activity book.

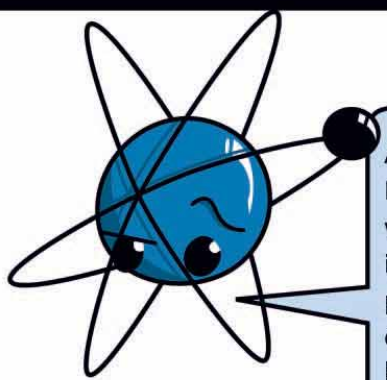


Scientists are also studying to what extent historic nuclear research, development and testing contaminated the surface soil.

Operation Clean Desert
Activity Book (Vol. 1, Number 4)
Page 12

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.



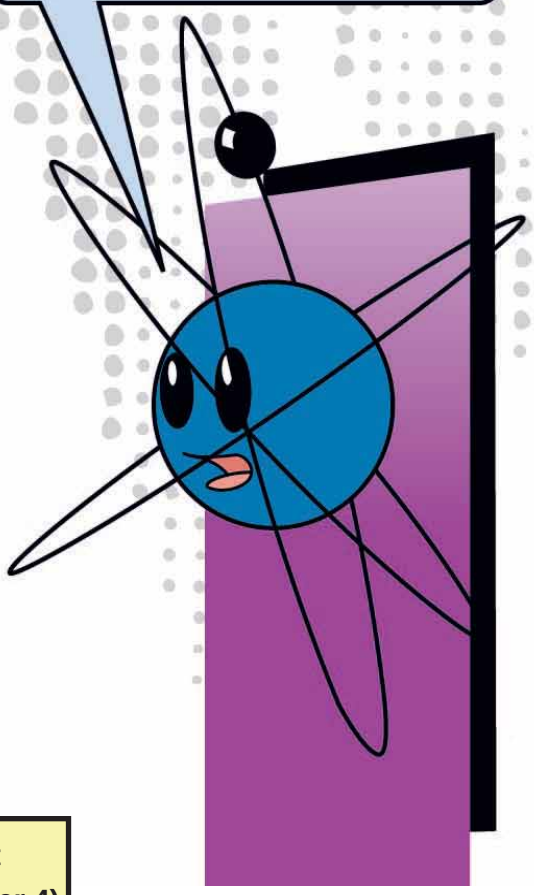


Areas on the Nevada National Security Site which have been identified as having potential soil contamination must be thoroughly analyzed and, if needed, remediated.

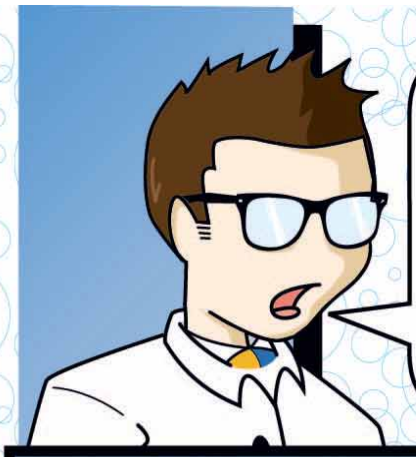
Operation Clean Desert crews are also busy at work removing contaminated industrial material like tools, protective clothing and, in some cases, entire buildings. These activities make waste.

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

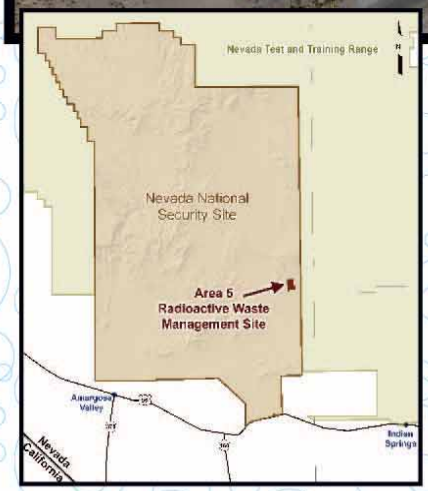
This waste, known as **low-level radioactive waste**, is placed into large drums, boxes, or cargo containers and taken to designated areas for safe and permanent burial.



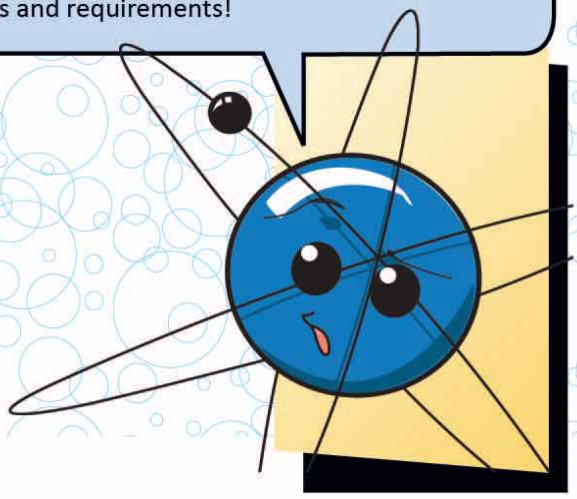
Operation Clean Desert
Activity Book (Vol. 1, Number 4)
Page 13



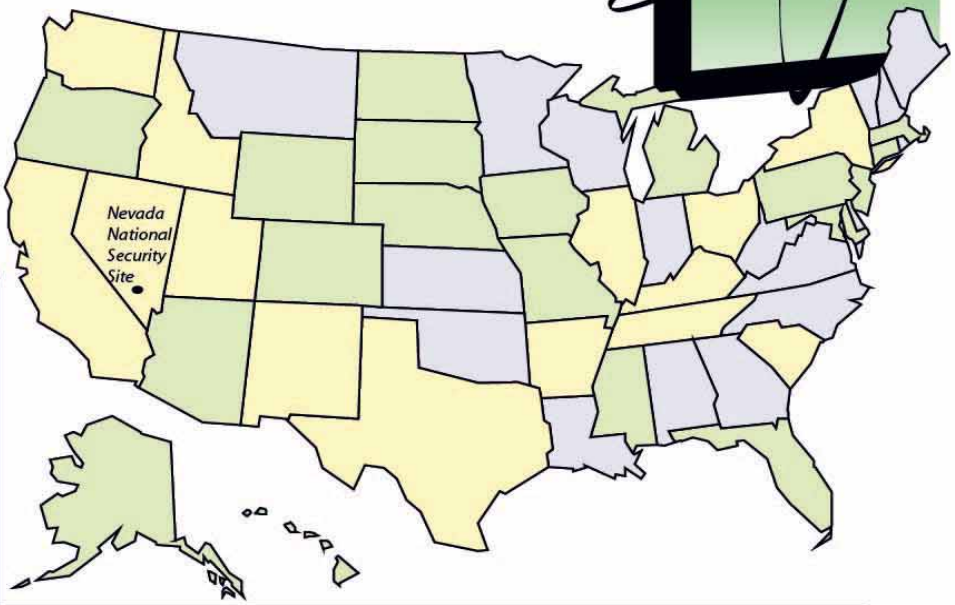
At the Nevada National Security Site, low-level and mixed low-level radioactive waste is disposed at the **Area 5 Radioactive Waste Management Site** in accordance with all applicable federal and state regulations. This facility (shown below) is located in the southeastern portion of the Nevada National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



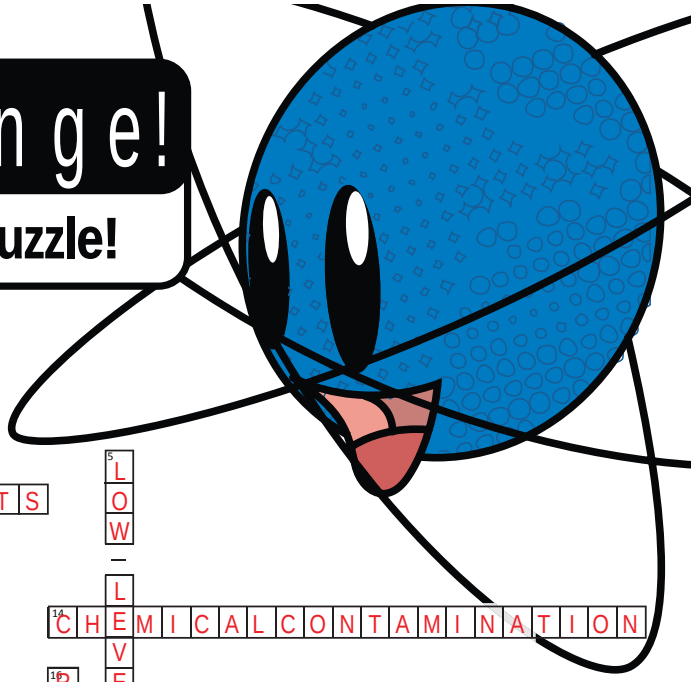
The yellow states have "active," ongoing cleanup project sites, the green states have no "active" sites, and the gray states have no cleanup sites. You can learn more about these sites at www.em.doe.gov/Pages/siteslocations.aspx

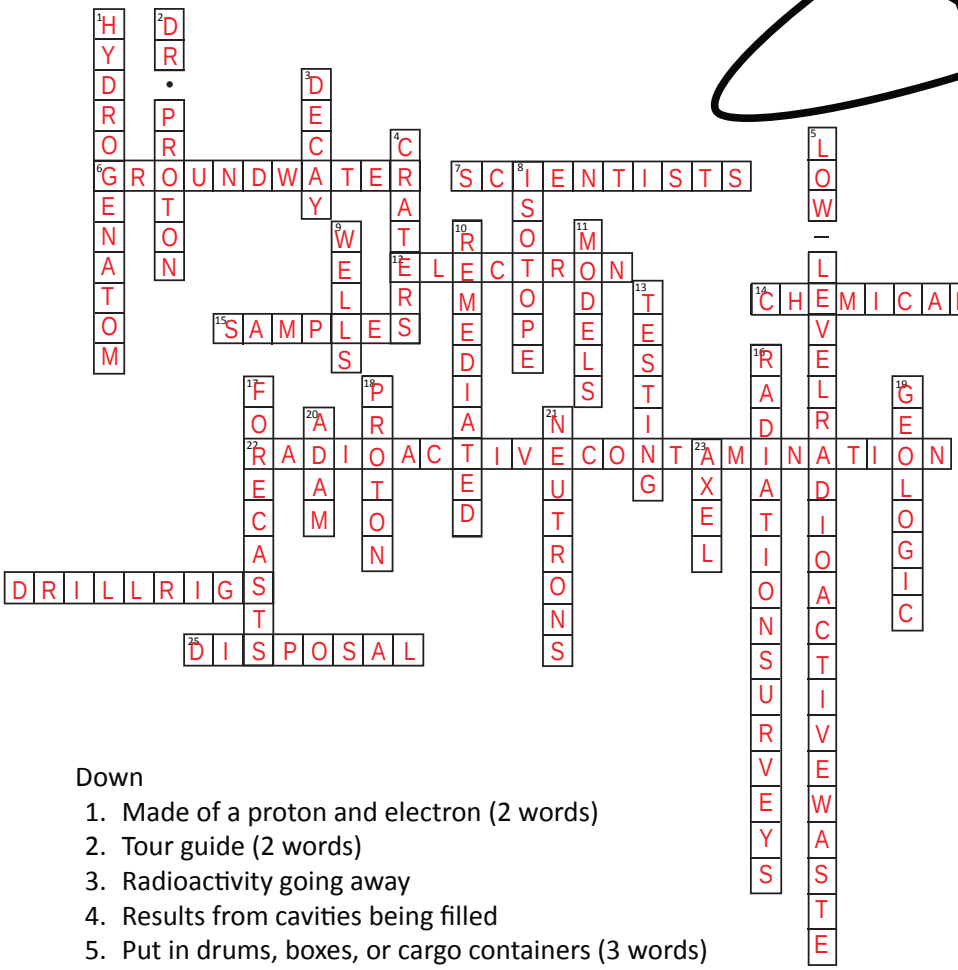
This worker is verifying documentation on a nuclear-powered generator disposed at Nevada National Security Site.

Operation Clean Desert
Activity Book (Vol. 1, Number 4)
Page 15

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.

Operation Clean Desert
Activity Book (Vol. 1, Number 4)
Page 18

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:

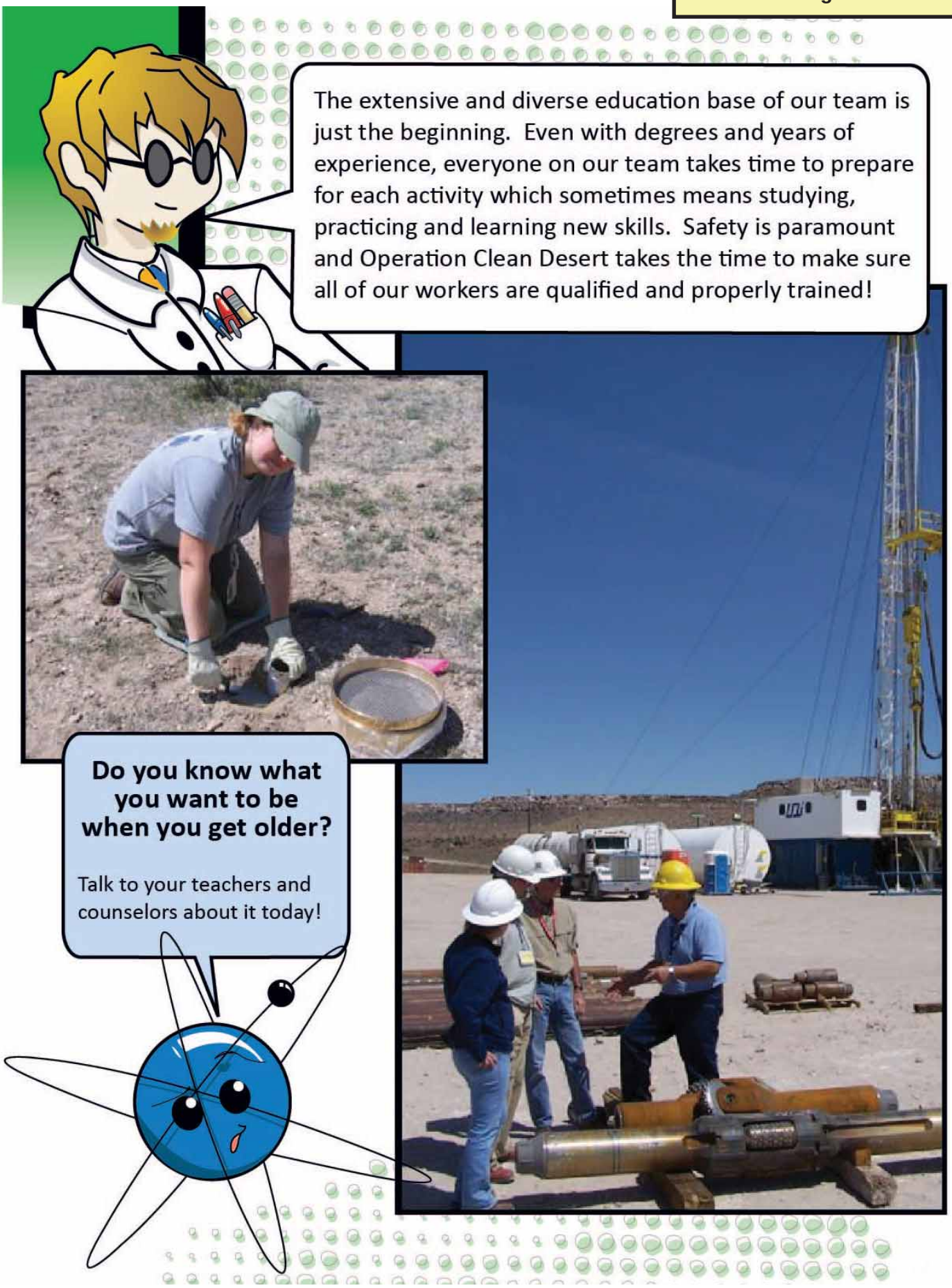
Biology	**Environmental Studies**
Chemistry	**Forensic Science**
Communications	**Geology**
Earth Science	**Petroleum Engineering**
Education	**Soil Science**
Engineering	**Zoology**

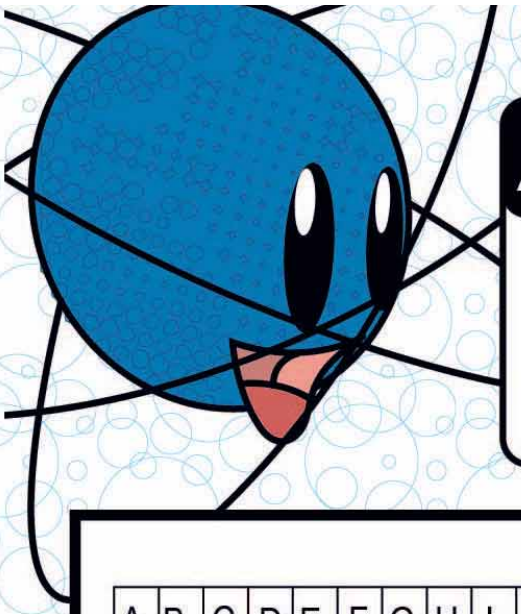
These biologists are attaching a tracking device onto a sedated 5-6 year-old male puma (mountain lion) captured in the west-central portion of the Nevada National Security Site. This activity is part of a multi-year study on pumas living on and around the Nevada National Security Site.

1.15 THE STUDENT WILL DISCUSS CAREERS RELATED TO LIFE SCIENCE.

1.16 THE STUDENT WILL DISCUSS CAREERS RELATED TO EARTH SCIENCE.

1.1 THE STUDENT WILL DISCUSS CAREERS RELATED TO PHYSICAL SCIENCE.


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
		1		25			22	2				26	23	14	15		11		8		7					

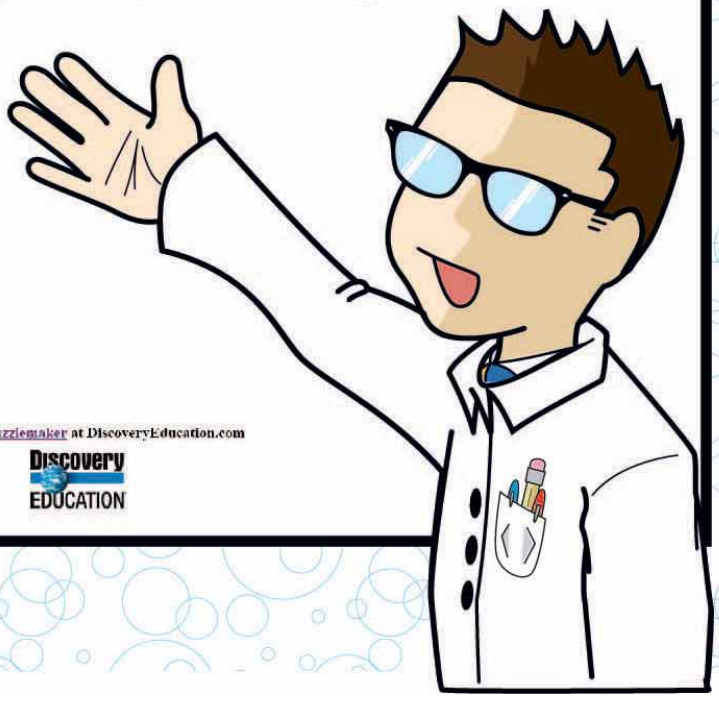
P	R	O	T	E	C	T		T	H	E		E	N	V	I	R	O	N	M	E	N	T	!
15	11	14	8	25	1	8		8	22	25		25	23	7	2	11	14	23	26	25	23	8	

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!

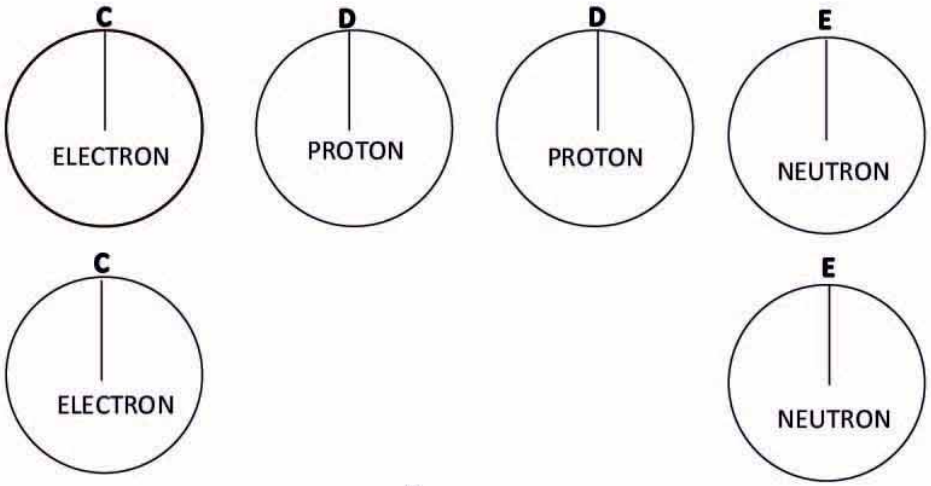


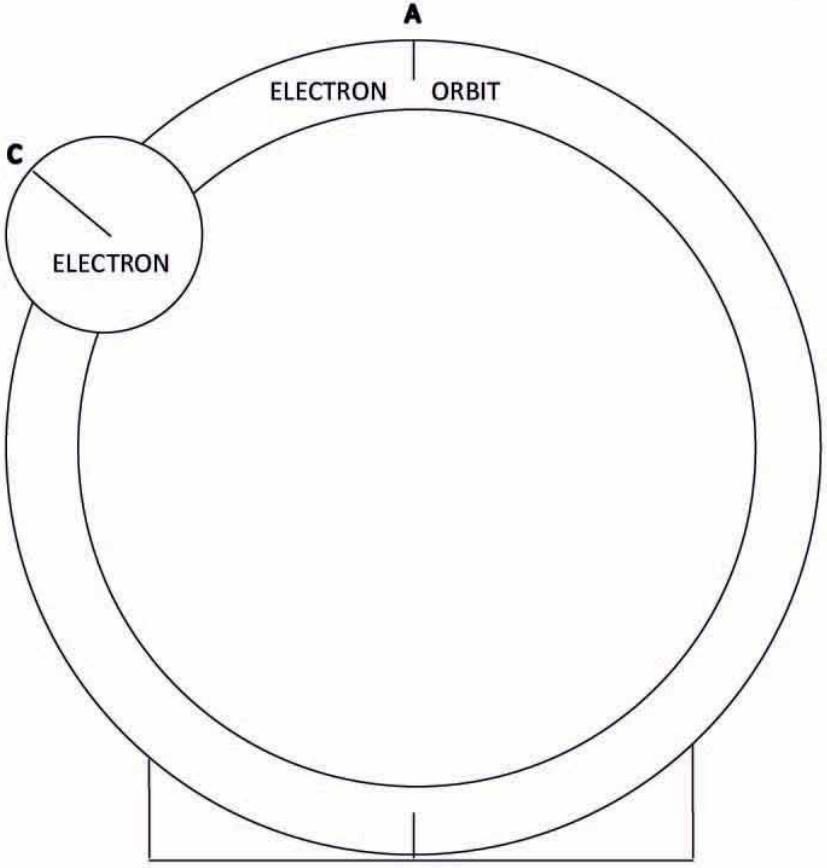
THE ANATOMY OF AN ATOM

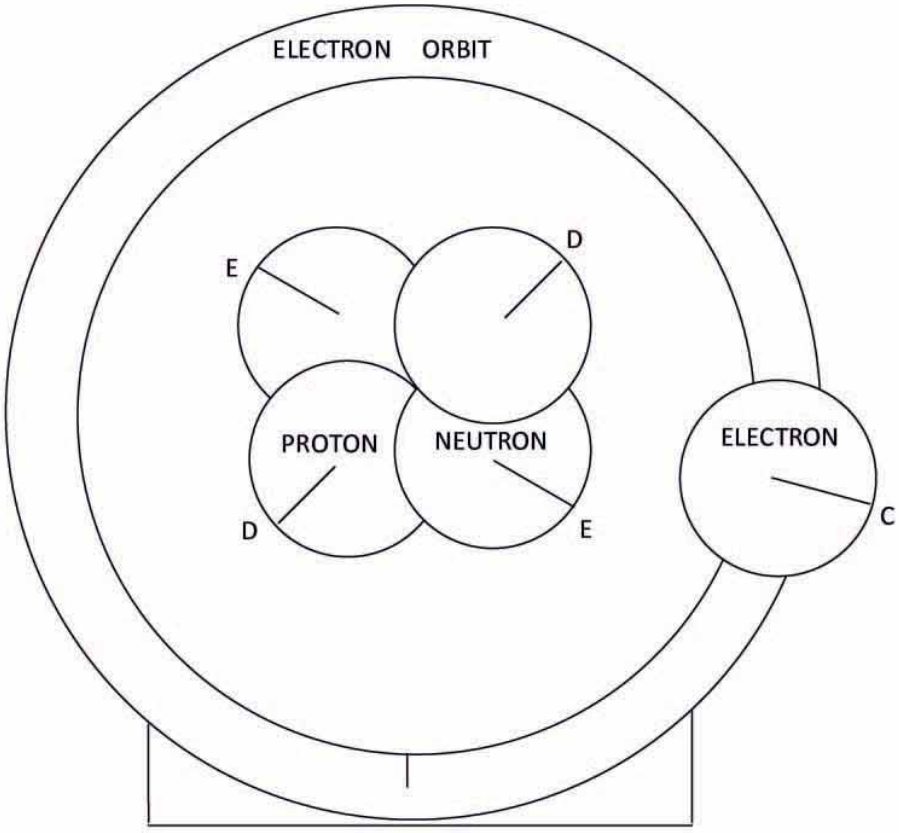
Instructions: Color each subatomic particle a different color. Cut out all atom parts. Connect orbit pieces, using slots A & B. Matching colors, letters, and slots, slip electron, proton, and neutron pieces on electron orbits and nucleus parts.

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!

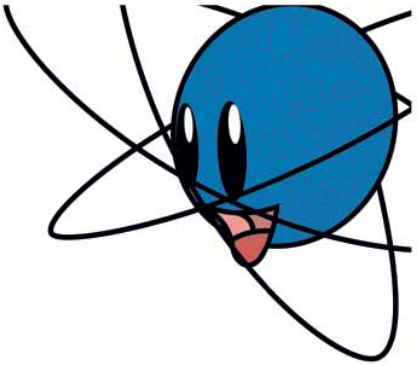






OPERATION CLEAN DESERT

Student Assessment



Multiple Choice (circle the correct answer)

1. How many different animal species can be found at the Nevada National Security Site?
   a. Less than 500
   b. Exactly 1,325
   c. More than 1,500
   d. Exactly 2,303

2. Nuclear research, development and testing caused radioactive contamination of:
   a. Buildings
   b. Clothes and tools
   c. Soil and water
   d. All of the above

3. One method used to check soil for the presence of radioactive contamination is:
   a. Use a black light to see if the soil glows
   b. Send soil samples to laboratories for analysis
   c. Check soil for extreme temperature changes
   d. Place soil sample in a cup of water to see if it reacts

4. At the Nevada National Security Site, groundwater levels can range from a few hundred feet to:
   a. Less than 2,000 feet deep
   b. More than 4,000 feet deep
   c. Approximately 8,000 feet deep
   d. More than 10,000 feet deep

5. Nevada National Security Site scientists use computer models to:
   a. Design desert habitats
   b. Study weather patterns
   c. Track the eating/drinking habits of area wildlife
   d. Create representations of subsurface geology and hydrology

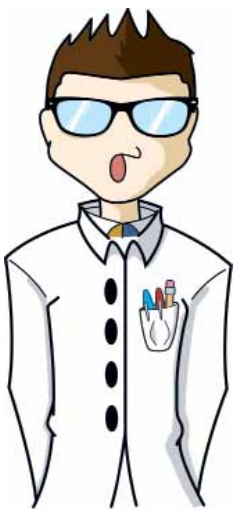
6. Oil spilled on the ground is an example of what type of contamination?
   a. Radioactive contamination
   b. Mechanical contamination
   c. Chemical contamination
   d. Liquid contamination

7. How do Nevada National Security Site scientists look for and track contaminated groundwater?
   a. Use drill rigs to dig deep into the ground to gather water and rock samples to create computer models
   b. Measure the temperature of the water; the warmer the water, the more it is contaminated
   c. Use seismic devices to test water density; the denser the water, the more it is contaminated
   d. Provide water to volunteers for taste tests

8. Low-level radioactive waste is containerized and taken to designated areas to be:
   a. Placed under water
   b. Crushed and placed in smaller bags
   c. Safely and permanently disposed in engineered cells
   d. Cleaned and reused

9. Scientists at the Nevada National Security Site:
   a. Have a variety of degrees and experience
   b. Practice and learn new skills
   c. Consider safety first
   d. All of the above

Correct False Statements (cross out and replace incorrect words to make these false statements true)



10. An aquifer is a ~~solid~~ porous layer of soil or rock that allows water to pass through it.
11. Before 1951, Nevada National Security Site land was ~~completely unused~~. used as a gunnery range
12. Scientists study rock and water samples from well drilling to help locate ~~fish.~~ contaminated groundwater
13. ~~Half~~ One-third (1/3) of the U.S. public water supply comes from underground.
14. The nucleus of an atom contains ~~three~~ two particles.
15. The Sun emits ~~groundwater.~~ radiation
16. ~~Training animals~~ Studying wildlife is another activity conducted at the Nevada National Security Site.
17. Special equipment is used to detect radiation, because it is ~~green~~ colorless and odorless and ~~smells funny.~~
18. A neutron has a ~~negative~~ no charge.
19. Workers package low-level radioactive waste into ~~glass jars and sandwich bags~~ drums, boxes, or cargo containers for disposal.

Fill in the Blank

20. A trained professional, known as an environmental _____scientist_____, may check for soil contamination by taking samples for lab analysis.

21. _____National_____ _____security_____ training is one of the current activities taking place at the Nevada National Security Site.

22. When the roof of an underground cavity collapses during a historic underground test, this forms a _____subsidence_____ _____crater_____ at the surface.

23. An _____aquifer_____ is a geologic formation of permeable rock, gravel or sand containing or conducting the movement of groundwater.

24. Atoms are comprised of three particles: protons, neutrons and _____electrons_____.

25. How fast a radioactive atom decays is measured by its _____half_____-_____life_____.

26. Full-scale nuclear testing was conducted for over 40 years at the Nevada National Security Site, between _____1951_____ and _____1992_____.

27. The process of an unstable atom trying to achieve stability is referred to as _____decay_____.

28. A radioactive atom is called an _____isotope_____.

29. Operation Clean Desert takes place at the Nevada _____National_____ _____Security_____ Site.

30. Groundwater moves in _____geologic_____ layers beneath the Earth's surface.

31. Cleanup workers must remove contaminated industrial material such as tools and protective _____clothing_____.

32. _____Contamination_____ occurs when something harmful or unsafe is in an area where it is not wanted.

33. The water _____table_____ is the underground surface of geologic layers that are wholly saturated with water.

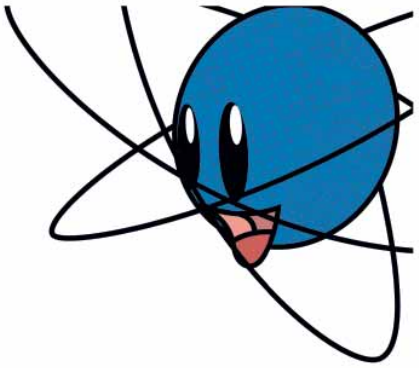
34. The Desert _____Tortoise_____ is one of many species that calls the Nevada National Security Site home.

35. Computer models use information obtained during well drilling to generate _____mathematical_____ representations of the geology beneath the Earth's surface.

Essay Question (write an essay responding to the following questions)

Do any careers described in Operation Clean Desert appeal to you? If so, which one(s) and why? If not, write about the type of career you want to pursue and why. Include how you plan to reach your goal, such as by enrolling in college, pursuing training, joining the military, etc.

OPERATION CLEAN DESERT



Student Assessment

Multiple Choice (circle the correct answer)

1. How many different animal species can be found at the Nevada National Security Site?
   a. Less than 500
   b. Exactly 1,325
   c. More than 1,500
   d. Exactly 2,303

2. Nuclear research, development and testing caused radioactive contamination of:
   a. Buildings
   b. Clothes and tools
   c. Soil and water
   d. All of the above

3. One method used to check soil for the presence of radioactive contamination is:
   a. Use a black light to see if the soil glows
   b. Send soil samples to laboratories for analysis
   c. Check soil for extreme temperature changes
   d. Place soil sample in a cup of water to see if it reacts

4. At the Nevada National Security Site, groundwater levels can range from a few hundred feet to:
   a. Less than 2,000 feet deep
   b. More than 4,000 feet deep
   c. Approximately 8,000 feet deep
   d. More than 10,000 feet deep

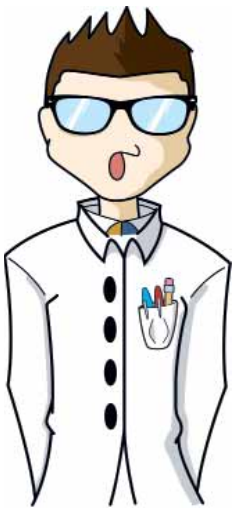
5. Nevada National Security Site scientists use computer models to:
   a. Design desert habitats
   b. Study weather patterns
   c. Track the eating/drinking habits of area wildlife
   d. Create representations of subsurface geology and hydrology

6. Oil spilled on the ground is an example of what type of contamination?
   a. Radioactive contamination
   b. Mechanical contamination
   c. Chemical contamination
   d. Liquid contamination

7. How do Nevada National Security Site scientists look for and track contaminated groundwater?
   a. Use drill rigs to dig deep into the ground to gather water and rock samples to create computer models
   b. Measure the temperature of the water; the warmer the water, the more it is contaminated
   c. Use seismic devices to test water density; the denser the water, the more it is contaminated
   d. Provide water to volunteers for taste tests

8. Low-level radioactive waste is containerized and taken to designated areas to be:
   a. Placed under water
   b. Crushed and placed in smaller bags
   c. Safely and permanently disposed in engineered cells
   d. Cleaned and reused

9. Scientists at the Nevada National Security Site:
   a. Have a variety of degrees and experience
   b. Practice and learn new skills
   c. Consider safety first
   d. All of the above



Correct False Statements (cross out and replace incorrect words to make these false statements true)

10. An aquifer is a solid layer of soil or rock that allows water to pass through it.
11. Before 1951, Nevada National Security Site land was completely unused.
12. Scientists study rock and water samples from well drilling to help locate fish.
13. Half of the U.S. public water supply comes from underground.
14. The nucleus of an atom contains three particles.
15. The Sun emits groundwater.
16. Training animals is another activity conducted at the Nevada National Security Site.
17. Special equipment is used to detect radiation, because it is green and smells funny.
18. A neutron has a negative charge.
19. Workers package low-level radioactive waste into glass jars and sandwich bags for disposal.

Fill in the Blank

20. A trained professional, known as an environmental _____, may check for soil contamination by taking samples for lab analysis.

21. _____ _____ training is one of the current activities taking place at the Nevada National Security Site.

22. When the roof of an underground cavity collapses during a historic underground test, this forms a _____ _____ at the surface.

23. An _____ is a geologic formation of permeable rock, gravel or sand containing or conducting the movement of groundwater.

24. Atoms are comprised of three particles: protons, neutrons and _____.

25. How fast a radioactive atom decays is measured by its _____-_____.

26. Full-scale nuclear testing was conducted for over 40 years at the Nevada National Security Site, between _____ and _____.

27. The process of an unstable atom trying to achieve stability is referred to as _____.

28. A radioactive atom is called an _____.

29. Operation Clean Desert takes place at the Nevada _____ _____ Site.

30. Groundwater moves in _____ layers beneath the Earth's surface.

31. Cleanup workers must remove contaminated industrial material such as tools and protective _____.

32. _____ occurs when something harmful or unsafe is in an area where it is not wanted.

33. The water _____ is the underground surface of geologic layers that are wholly saturated with water.

34. The Desert _____ is one of many species that calls the Nevada National Security Site home.

35. Computer models use information obtained during well drilling to generate _____ representations of the geology beneath the Earth's surface.

Essay Question (write an essay responding to the following questions)

Do any careers described in Operation Clean Desert appeal to you? If so, which one(s) and why? If not, write about the type of career you want to pursue and why. Include how you plan to reach your goal, such as by enrolling in college, pursuing training, joining the military, etc.

U.S. Department of Energy,
National Nuclear Security Administration
Nevada Site Office
P.O. Box 98518
Las Vegas, NV 89193-3521
Phone: 702-295-3521 • Fax: 702-295-0154
envmgt@nnsa.doe.gov • www.nv.energy.gov
DOE/NV--938 REV4
April 2012

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

Log No. 2011-357