DUKE UNIVERSITY

Radiation

How much is too much?

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RISE

Contents

Introduction

The purpose of this unit is to introduce students to the world of radiation that they live in and for them to take part in the debate regarding use of nuclear power. With cell phones, MP3 players, laptops, microwaves, wireless internet, x-rays, MRIs, nuclear power, holes in the ozone layer and other sources of radiation becoming an increasing part of our lives it is important for students to understand what radiation is, and be able to judge when they are safe and when they may not be. This unit aims to achieve this goal and meet the Georgia Performance Standards outlined below so that it will be a viable project in high schools that need to adhere to the standards. It is my hope that this unit could be taught in chemistry, physics or physical science at the high school level.

This unit will address the standards below and will help students look at science from personal and social perspectives (personal health; populations, resources and environments; natural hazards; risks and benefits; and science and technology in society).

Broader objectives of the project

1. Students will research and evaluate the risks and benefits of radiation and create a presentation, have a debate to demonstrate their understanding of the risks and benefits of radiation
2. Students will be able to discuss their opinions regarding use of radiation in society, with evidence to support them.
3. Students will create a digital story to present their views. These digital stories can be presented to local energy people (can be fictitious), or to middle school children to educate them about nuclear power.
4. Students learn to work as part of a team and be held accountable for their work.
5. Students learn to conduct research on the internet

The Georgia Performance Standards for Science 9-12:

Co-Requisite – Characteristics of Science. Habits of Mind

SCSh1. Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.

a. Exhibit the above traits in their own scientific activities.
b. Recognize that different explanations often can be given for the same evidence.

SCSh2. Students will use standard safety practices for all classroom laboratory and field investigations.

a. Follow correct procedures for use of scientific apparatus.
b. Demonstrate appropriate techniques in all laboratory situations.
c. Follow correct protocol for identifying and reporting safety problems and violations.

SCSh3. Students will identify and investigate problems scientifically.

a. Suggest reasonable hypotheses for identified problems.
b. Develop procedures for solving scientific problems.
c. Collect, organize and record appropriate data
d. Graphically compare and analyze data points and/or summary statistics.
e. Develop reasonable conclusions based on data collected.
f. Evaluate whether conclusions are reasonable by reviewing the process and checking against other available information.

SCSh4. Students will use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.

a. Develop and use systematic procedures for recording and organizing information.
b. Use technology to produce tables and graphs.

SCSh5. Students will demonstrate the computation and estimation skills necessary for analyzing data and developing reasonable scientific explanations.

a. Trace the source on any large disparity between estimated and calculated answers to problems.
b. Consider possible effects of measurement errors on calculations.
c. Recognize the relationship between accuracy and precision.
d. Express appropriate numbers of significant figures for calculated data, using scientific notation where appropriate.
e. Solve scientific problems by substituting quantitative values, using dimensional analysis and/or simple algebraic formulas as appropriate.

SCSh6. Students will communicate scientific investigations and information clearly.

a. Write clear, coherent laboratory reports related to scientific investigations.
b. Write clear, coherent accounts of current scientific issues, including possible alternative interpretations of the data
c. Use data as evidence to support scientific arguments and claims in written or oral presentations.
d. Participate in group discussions of scientific investigation and current scientific issues.

Chemistry Co-Requisite - Content

SC1 Students will analyze the nature of matter and its classifications.

a. Relate the role of nuclear fusion in producing essentially all elements heavier than helium.

SC3 Students will use the modern atomic theory to explain the characteristics of atoms.

a. Discriminate between the relative size, charge, and position of protons, neutrons, and electrons in the atom.

c. Explain the relationship of the proton number to the element's identity.

d. Explain the relationship of isotopes to the relative abundance of atoms of a particular element.

SC4. Students will use the organization of the Periodic Table to predict properties of elements.

a. Use the Periodic Table to predict periodic trends including atomic radii, ionic radii, ionization energy, and electronegativity of various elements.

b. Compare and contrast trends in the chemical and physical properties of elements and their placement on the Periodic Table.

Physical Science Co-Requisite - Content

SPS1. Students will investigate our current understanding of the atom.

a. Examine the structure of the atom in terms of
   a. proton, electron, and neutron locations.
   b. atomic mass and atomic number.
   c. atoms with different numbers of neutrons (isotopes).
   d. explain the relationship of the proton number to the element's identity.

SPS3. Students will distinguish the characteristics and components of radioactivity.

a. Differentiate among alpha and beta particles and gamma radiation.

b. Differentiate between fission and fusion.

c. Explain the process half-life as related to radioactive decay.

d. Describe nuclear energy, its practical application as an alternative energy source, and its potential problems.

SPS7. Students will relate transformations and flow of energy within a system.

a. Identify energy transformations within a system (e.g. lighting of a match).

b. Investigate molecular motion as it relates to thermal energy changes in terms of conduction, convection, and radiation.

Physics Co-Requisite - Content

SP2. Students will evaluate the significance of energy in understanding the structure of matter and the universe.

a. Relate the energy

b. Explain how the instability of radioactive isotopes results in spontaneous nuclear reactions.

RISE

Outline of the unit

Lesson 1: Introduction to the project and atomic structure

1. Present students with the **entry document** for the project.
2. Students identify "knows and need to knows."
3. Students get into groups and create contracts with their groups.
4. Give students **rubric** for the project so they know how they will be assessed.
5. **Lecture** on atomic structure and isotopes
6. Students complete atomic structure worksheet for homework.

Lesson 2: Introduction to radioactivity

1. Review atomic structure
2. Go over knows and need to knows for the project.
3. Students work in their groups to design atoms and isotopes of those atoms using gummy bears, marshmallows and toothpicks. Complete sheet requiring them to identify the physical differences between the isotopes
4. Lecture on radioactivity, alpha, beta and gamma particles, x-rays
5. Students research uses of radioactivity
6. Homework – drawing isotopes

Lesson 3: Introducing half-lives

1. Pop-quiz on atomic structure and radioactivity
2. Students share uses of radiation they have researched
3. Lecture on half-lives

Lesson 4: Half-lives

1. Teacher does half-life problems with class
2. Students practice half-life problems in a group
3. Students carry out half-life lab
4. Discuss importance of half-life and radiation
5. Homework – half-life problems

Note: Could do a field trip to a local hospital to show students some benefits of radiation, and hear from a doctor how radiation poisoning is treated.

Lesson 5: Radiation in everyday life and exposure

1. Cloud chamber demonstration to see radiation track
2. Students compare radiation levels of different everyday items. Compare differences in measurements made in classroom and those reported online. Why might there be a difference?
3. Students calculate radiation exposure and devise ways of reducing their annual exposure.

Lesson 6: Nuclear power benefits/disasters

1. Discuss uses of radiation learned about
2. Watch video on how nuclear power works.
3. Assign groups, students will research either benefits of nuclear power or one of the 3 disasters
4. Teacher will go over content of presentations with each group.

Lecture 7: Presentations on benefits/disasters of nuclear power

1. Students rehearse and fine-tune presentations
2. Students present to the class
3. Review genetics with students
4. Observe SEEK video of bacterial plates exposed to UV light.
5. Students prepare yeast plates to be treated with sunscreen/sunglass lenses and exposed to UV light.

Lesson 8: Acute radiation syndrome

1. Students observe results from yeast plates
2. Discuss pros and cons of using Wikipedia
3. Give students acute radiation syndrome Wikipedia page. Divide the article among the groups for
4. Have students read through their part of the article, and search for additional information. They need to then put this together on a poster or PowerPoint to explain it to the rest of the class.
5. Groups present to each other. Students take notes on each other's presentations.
6. Homework – students complete lab write up of yeast and sunscreen/sunglasses investigation

Lesson 9: Starting the digital stories (Lesson 9-11 could be done as part of an information technology curriculum)

1. The students must now make a decision of what message their public service announcement will be.
2. High tech: Teach students how to use IMovie or just PowerPoint to create a movie
3. Teach students about obtaining copyright free images from creative commons.
4. Students map out their digital stories on paper. Each group has a meeting with the teacher to discuss their ideas.
5. Students start collecting images to use in their digital story.

Lesson 10

1. Students write a script to accompany their PSA.
2. Teach students how to add music to digital story
3. Teach students how to record voice clips and add them to digital stories.
4. Provide students with microphones and head phones to record the voice over for their digital stories

Lesson 11

1. Students put their images, voice over and music into a digital story and submit the final product which will be graded.
2. Review of physical science that has been learned through the unit

Lesson 12

1. The final digital stories are shared with local “energy firms” if possible, or to younger students to educate them about nuclear power.
2. End of unit test

PBL Lesson plans

Lesson 1: Introduction to the project

Objectives to be met:

- Students will create a list of knows and need to knows to demonstrate they understand the purpose of the project, and what they need to focus on in this project.
- Students will create a contract to learn how to hold their team members accountable for their actions in the team.
- Students will interpret and answer questions on a basic atomic structure worksheet to demonstrate their understanding of basic atomic structure.

Materials needed:

- Projector and Internet connection for videos.
- Entry document for each group,
- Possible laptops for each group
- Basic atomic structure worksheet.

Opening/anticipatory set/review:

Show students video of benefits of nuclear power and anti-nuclear power
http://www.youtube.com/watch?v=Qay1up9TNQI&feature=related
National geographic – Japan and 3 mile islands. http://www.youtube.com/watch?v=LH79LAMQl60
(20 min)

Lesson activities

Time	Teacher	Students
10 min	Divide students into their groups and present students with *entry* document.	Read the entry document and outline knows and need to knows as a group.
10 min	Go over knows and need to knows as a class. Give students *scaffolding* questions if needed. Place paper on the wall/or write on white board that can be seen throughout the project so it can be amended as the project proceeds	Volunteer the knows and need to knows
10 min	Tell students to make group contracts	Students make group contracts outlining the roles and responsibilities of each member of the group and how problems like tardiness and not doing work will be dealt with.
10 min	Give students *rubric* of the unit	Students observe rubric and summarize key points they must work on.

30 min	Lecture on atomic structure, covering protons, neutrons and electrons, atomic number, relative atomic mass and isotopes.	Students take notes on atomic structure
H/W	Give students basic atomic structure worksheet for homework	Students complete worksheet to reinforce basic atomic structure

Assessments

- Students submit knows and need to knows. If in a classroom with laptops, students can submit them as Google document forms so that the teacher and students can look at them at any time.
- As a class students verbally answer questions relating to atomic structure during the lecture.
- Students complete basic atomic structure worksheet individually to reinforce the concepts.

Class Handouts

Entry document

[enter date]

[enter teacher name]
[enter school address]
Atlanta, GA 30305

Dear [enter teacher name],

I hope you are doing well. I enjoyed our meeting thoroughly last week! As I mentioned, The United States Nuclear Energy Foundation (USNEF) is researching the possibility of opening a $7 billion nuclear power facility in Macon, Georgia. 85 miles away from Atlanta this facility will be able to supply 90% of the city's power needs and 50% of the state's power needs. With Atlanta's population growing so rapidly, having a sustainable power supply is extremely important, and nuclear power does just that.

Given the large investment using state funds, approval of this facility will be heavily influenced by public opinion. We are collecting data from people of all demographics, and appreciate your help with the young-adult segment of the community. We request that your students present a 1 to 2 minute long digital presentation outlining their opinions regarding the use of nuclear power and radioactivity in the 21st century. In this presentation we are interested in their opinions on the benefits and risks of nuclear power and radioactivity on the environment, public health and safety, and a message as to whether they would support or oppose the building of this facility and why.

Either I or a colleague from the USNEF's office or Public Affairs will be available in 3 weeks' time to review the presentations.

I look forward to collaborating with you on this project that will shape the future of Georgia.

Kind regards,

Kristine L. Svinicki
Commissioner of U.S. Nuclear Regulatory Commission

Scaffolding if needed: Problem Statement

How can you create a digital presentation that represents your opinions on nuclear power and use of radioactivity, to the U.S. NRC that:

1. Focuses on and explains the importance of environmental impacts
2. Focuses on and explains the benefits and risk to public safety
3. Clearly states whether the presenters are for or against nuclear power.
4. Uses evidence to support all statements
5. Is easily understandable.
6. Is respectful and non-threatening.

Group Contracts for Radiation Project

As you probably know, group work isn't always easy—group members sometimes cannot prepare for or attend group sessions because of other responsibilities, and conflicts often result from differing skill levels and work ethics. When groups work and communicate well, however, the benefits more than compensate for the difficulties. One way to improve the chances that a group will work well is to agree beforehand on what everyone on the group expects from everyone else. It is a good idea to make a list of your expectations and keep it on hand.

Governing Rules for Team:

1

2

3

4

How will you handle those that are not pulling their weight?

1.

2.

3.

Goals for the group: Make sure they are specific and reasonable.

1.

2.

3.

Signatures

Group roles for each assignment:

Each group must decide what role each member will do during each assignment. The roles are outlined below**. Everyone must rotate** their roles after each assignment.

- **Coordinators** are like team leaders and are responsible for ensuring that all materials are available, all objectives of the project are fully understood and ensuring that work is carried out in a responsible manner.
- **Checkers** are responsible for proof reading answers/summaries. There should be no grammatical errors or false information. Checkers also ensure that all objectives have been met
- **Creative artist** is responsible for the appearance and layout of presentations.
- **Summarizer** will write or outline a summary of the research done by the group
- **Presenter** will present the information to the class either through posters, a speech or PowerPoint presentations

Graded group assignments due on this project and potential roles

Assignment 1. Fill out group contracts (Lesson 1) - **All students participate in this activity.**
Assignment 2. Build isotope models (Lesson 2)

Group Member	Assignment 2. roles
	Coordinator
	Checker #1
	Checker #2
	Builder #1
	Builder #2

Assignment 3. Research uses of radiation, write a summary and present the summary to the class (Lesson 2 and 3). **All students research**

Group Member	Assignment 3. roles
	Coordinator
	Summarizer
	Checker
	Creative Artist
	Presenter(s)

Assignment 4. Data collection for half-life lab (Lesson 4)

Group Member	Assignment 4. roles
	Coordinator
	Experimenter
	Data Recorder
	Checker #1
	Checker #2

Assignment 5. Measure/research radiation levels in radioactive materials (Lesson 5)

Group Member	Assignment 5. roles
	Coordinator
	Researcher
	Data Collector
	Checker #1
	Checker #2

Assignment 6. Research either benefits/dangers of nuclear power and present to the class (Lesson 6 and 7). **All students research**

Group Member	Assignment 6. roles
	Coordinator
	Summarizer
	Creative Artist
	Checker
	Presenter(s)

Assignment 7. Analysis of radiation damage on bacteria and yeast (Lesson 7). **All group members participate**

Assignment 8. Students research an aspect of acute radiation syndrome and present to the class (Lesson 8). **All students research**

Group Member	Assignment 8. roles
	Coordinator
	Summarizer
	Creative Artist
	Checker
	Presenter(s)

Assignment 9. In the form of a digital story, students create a public service announcement voicing their opinion for or against nuclear power (Lesson 9-13).
All students research

Group Member	Assignment 9. roles
	Coordinator
	Summarizer
	Creative Artist
	Checker
	Technical leader
	Presenter(s)

Rubric Nuclear Power Project

CRITERIA	UNSATISFACTORY (Below Performance Standards)	PROFICIENT (Minimal Criteria)	ADVANCED (Demonstrates Exceptional Performance)
Organization, Mechanics, & Vocabulary **(20%)**	• Introduction does not state the purpose of the presentation • Little information about the benefits or dangers of nuclear power • The main part of the presentation is disorganized and/or non-sequential • The closing is either unclear or absent from the presentation • The presentation lacks key academic language or is limited in the specific area (4 or more lapses) • The presentation is less than 2 or more than 4 minutes 0 - 10	• The introduction states the purpose of the presentation • pro or against nuclear power? • The main part of the presentation is organized and sequential with some supporting evidence • The closing provides a basic summary of most of the major points • Vocabulary is appropriate to the topic (three or less lapses) • The presentation is between 2 and 4 minutes 11 - 16	**In addition to meeting the PROFICIENT criteria** • The main part of the presentation is well organized, sequential, and well supported by detail. Both sides of the argument are addressed and supported by evidence. • The final opinion is justified with clear and logical reasoning • The closing provides a thorough summary of all of the major points. • The presentation demonstrates a rich vocabulary appropriate to the topic (1 or less errors) 17 - 20
Content Specific Benefits and dangers of nuclear power **(50%)**	• At least 3 benefits or dangers of nuclear power are NOT described. • The presentation lacks evidence to support the points made. • The conclusion is unclear or lacks evidence to support it. • Sources are not provided or are not from reputable sources 0 - - - - - - - - - -15 - - - - - - - - - - 36	• The presentation describes at least 3 benefits or dangers of nuclear power. • All points are justified by evidence • A conclusion on what stance the group takes on nuclear power is clearly stated • Reputable sources are provided 37 - - - - - - 39- - - -40 - - - - - - - - - - 45	**In addition to meeting the PROFICIENT criteria** • Explains succinctly how nuclear power works/what it is. • The presentation contrasts and evaluates the dangers and benefits of nuclear power • The stance that the presentation takes is logically justified. 46 - - - - - - - - - - - - - -48 - - - - - 50
Technological Implementation **(30%)**	• The digital story lacks clear sound • The presentation lacks words (written or spoken) or images to convey its message • Images used are of poor quality and difficult to see. • The presentation does not flow smoothly and there are more than 3 stops and starts in the presentation. 0 - - - - - - - - - - - - 10 - - - - - - - - - - - - 19	• The digital story has clear sound. • The presentation contains words and images to convey the message • The images used are of good quality • The presentation flows smoothly. There are no more than 2-3 stops and starts in the presentation 20- - - - - - - - - - - - 22 - - - - - - - - - - - - 24	**In addition to meeting the PROFICIENT criteria** • The digital story uses a variety of methods to convey its message: e.g. 3 or more of the following: written words, images, music, spoken words or other modes • The presentation flows smoothly. There are less than 1-2 stops and starts in the presentation 25 - - - - - - - - - - - -27- - - - - - - - - - - - 30

Atomic structure lecture key points.

I prefer to do a lecture like this on the board rather than a power point as it is more interactive, and students will find it easier to follow along.

- **Every atom has:**
  - Protons (P^+) positive charge relative mass 1
  - Neutrons (n^0) neutral/no charge relative mass 1/1844
  - Electrons (e^-) negative charge relative mass 1

- **How do atoms differ from one another?**
  - In the number of protons, neutrons and electrons. The number of protons defines a particular element. Refer students to the periodic table and show them how to identify the number of protons or the **atomic number**.
  - e.g. atomic number of oxygen is 8 and it has 8 protons.
  - Atomic number determines the position in the periodic table.

Check for understanding: How many protons are there in Lithium, Neon, and Magnesium?

- All stable atoms are neutral in charge. Therefore to balance the positive proton charge, there must be an equal number of electrons.
- Atomic number = number of protons = number of electrons

Check for understanding: How many electrons are there in Lithium, Neon, and Magnesium? Which element has an atomic number of 9? How many electrons does it have?

- Isotopes – all stable atoms of an element have the same number of protons and electrons, but the number of neutrons can vary. E.g. Carbon -12 has 6 protons and 6 neutrons, Carbon-13 has 6 protons and 7 neutrons, and Carbon-14 has 6 protons and 8 neutrons.
- Most elements in nature have isotopes, and the relative proportions of each isotope are always constant.

Check for understanding: Would isotopes of the same element differ in mass? Yes! Remember protons and neutrons each have a relative mass of 1.

- Relative atomic mass and mass number - see PowerPoint.

Basic Atomic Structure Worksheet 1

1. The 3 particles of the atom are:
a. ___________________________
b. ___________________________
c. ___________________________

Their respective charges are:
a. ___________________________
b. ___________________________
c. ___________________________

2. The number of protons in one atom of an element determines the atom's ______________________, and the number of electrons determines the ____________________________ of the element.

3. The atomic number tells you the number of ______________________________ in one atom of an element. It also tells you the number of _____________________________ in a neutral atom of that element. The atomic number gives the "identity" of an element as well as its location on the periodic table. No two different elements will have the ______________________ atomic number

4. The ________________________ of an element is the average mass of an element's naturally occurring atom, or isotopes, taking into account the ______________________ of each isotope.

5. The _________________________ of an element is the total number of protons and neutrons in the _____________________ of the atom.

6. The mass number is used to calculate the number of ________________________ in one atom of an element. In order to calculate the number of neutrons you must subtract the ________________________ from the ________________________.

(modified from http://staff.fcps.net/jswango/unit2/atomic_structure/Basic%20Atomic%20Structure%20Worksheet.pdf)

Lesson 2 : Introduction to radiation

Lesson Objectives

- Using the periodic table, students will be able to derive the identity of an atom if given the number of protons, electrons or symbol.
- Students will be create isotopes of different atoms, and identify the differences between the isotopes.
- Student research uses of alpha, beta and gamma radiation and create a summary explaining how these work.

Materials needed:

- Gummy bears, marshmallows, toothpicks
- Basic Atomic Structure Handout
- Source from which students can research uses of radiation.

Opening/anticipatory set/review:

- Go over homework as a class. Call on students for answers and explanations.
- Go over knows and need to knows list. Emphasize atomic structure and understanding radioactivity. Amend as needed. (10 mins)

Lesson activities

Time	Teacher	Students
20 min	Teach students how to look up atoms on the periodic table and understand the information presented. Give examples to practice with atomic number, mass number and symbols. Students complete 2nd part of basic atomic structure sheet to practice atomic structure. Go over with class.	Students take notes and complete basic atomic structure sheet to practice atomic structure.
20 min	Give instructions on how to build isotopes using gummy bears, marshmallows and toothpicks. Prepare 16 gummy bears (8 of one color and 8 of another, these are protons and neutrons of similar mass); 8 marshmallows (these are electrons, of lighter mass); and a few toothpicks for each group. Teacher will go around each group and ask students to explain their models. What part are the protons. Neutrons and electrons.	In groups, students decide on which atom they will make. (Atomic number must be less than 8, if only giving 8 protons). They then build this atom and an isotope of it to visualize the difference between atoms and isotopes. Fill in the sheet provided.
20 min	Lecture on radioactivity (see attached PowerPoint).	Take notes
15 min	In groups asks ask students to look up relevant uses of alpha, beta and gamma radiation. Where it is found. Resources one could use are text books, internet, and school library. Scaffolding: the teacher may need to assign roles for each student in a group to ensure everyone knows how to contribute and learn.	Research uses of alpha, beta and gamma radiation and summarize them into a paragraph to be submitted. The summaries should explain why these types of radiation can be used in the

		manner they are. (Can submit as a Google form and show them to the class next lesson to discuss.
H/w	Give instructions for homework	Students will pick two isotopes of an element and draw them out individually. They must include the number of protons, neutrons and electrons, and write a sentence on what is different between two isotopes.

Assessments

- Complete Basic atomic structure sheet to reinforce atomic structure.
- Students build model atoms and isotopes and then identify the differences between the chosen element and it's isotopes to demonstrate understanding of atomic structure and isotopes.
- Students research and summarize some uses of radiation to about the benefits of radiation.

Class Handouts

Basic Atomic Structure Worksheet 1

1. Give the symbol of and the number of protons in one atom of:
Lithium ________________________________
Iron ________________________________
Oxygen ________________________________
Krypton ________________________________
Bromine ________________________________
Copper ________________________________
Mercury ________________________________
Helium ________________________________

2. Give the symbol of and the number of electrons in a neutral atom of:
Uranium ________________________________
Boron ________________________________
Chlorine ________________________________
Iodine ________________________________
Xenon ________________________________

3. Give the symbol of and the number of neutrons in one atom of:
(Mass numbers are ALWAYS whole numbers…show your calculations)
Barium _________________________________
Carbon _________________________________
Fluorine _________________________________
Europium _________________________________
Bismuth ________________________________
Hydrogen ________________________________
Magnesium_______________________________
Mercury ________________________________

4. Name the element which has the following numbers of particles:
a. 26 electrons, 29 neutrons, 26 protons ____________________________
b. 53 protons, 74 neutrons _____________________________
c. 2 electrons (neutral atoms) _______________________________
d. 20 protons ________________________________
e. 86 electrons, 125 neutrons, 82 protons _______________________________
f. 0 neutrons __________________________________

5. If you know ONLY the following information can you ALWAYS determine what the element is? (Yes/No)
a. Number of protons _______________________________
b. Number of neutrons ______________________________
c. Number of electrons in a neutral atom ______________________________
d. Number of electrons ____________________________
6. Fill in the missing items in the table below.

NAME	SYMBOL	Z	A	# PROTONS	# ELECTRONS	# NEUTRONS	ISOTOPIC SYMBOL
a.	Na						
b.		17			18		
c. Potassium							
d.	P						
e. Iron					24		
f.				53			
g. Silver							
h.		36					
i.	W						
j.		29					
k.				49			
l.				79	78		
m.		16			18		

(modified from http://staff.fcps.net/jswango/unit2/atomic_structure/Basic%20Atomic%20Structure%20Worksheet.pdf)

Model atom sheet; Name ______________________

Chosen element ______________________
Symbol ____________________________
Atomic number ______________________
Mass number ________________________
Number of protons in element __________
Number of electrons in element _________
Number of neutrons in element __________
Isotope of element ____________________
Atomic number of isotope ______________
Mass number of isotope ________________
Number of protons in isotope ____________
Number of electrons in isotope __________
Number of neutrons in isotope ___________

Draw and label atom

Draw and label isotope

Lesson 3: Uses of radiation and half-lives

Objectives to be met:

- Students will answer questions in a pop quiz and listen to explanations to solidify their understanding of atomic structure and radioactivity.
- Students will research, summarize and share relevant uses of radiation to differentiate between uses of alpha, beta and gamma radiation.
- Students calculate half-lives of isotopes if given starting mass, ending mass and length of time the isotope has been decaying
- Students calculate the age of something if given the ratio of parent/daughter isotopes and the half-life of the isotope.

Materials needed:

- Research materials for radiation uses
- Pop quiz

Opening/anticipatory set/review:

- Collect isotope drawings
- **Pop quiz** on atomic structure and radioactivity. Give feedback immediately. Students answer pop quiz questions, submit work and then as a class, volunteer the correct answers, explaining their reasoning. (15min)

Lesson Activities

Time	Teacher	Students
40 min	Ask a student from each group to explain some of the uses of radiation they have found to the rest of the class. They must explain why being, alpha, beta or gamma radiation allows for this use of radiation.	Students continue to research uses of radiation in everyday life and write a summary of the use they researched. One member of each group then shares this with the class.
30 min	Lecture on half-lives. Discuss common unstable atoms like uranium-238, carbon 14. Introduce students to radioactive dating. If a student has discussed it in the earlier activity, it can be elaborated upon. See PowerPoint	Students take notes and ask questions

Assessments

- Students take a pop quiz to demonstrate understanding of atomic structure and radioactivity.
- Students research uses of radiation, create a written summary and verbally share their research with the class to demonstrate knowledge of some common uses of radiation.

Class Handouts

Pop quiz

1. Complete the following table of proton, electron and neutron characteristics

Particle	Symbol	Location in atom	Relative Charge	Relative Mass
Proton				
	n^0			
				1/1840

2. Explain why atoms are neutral even though they have charged particles?
3. What do the numbers 39, 40 and 41 after potassium refer to?
4. Which charged plate are alpha particles attracted to and why?
5. Why do gamma rays not bend toward electrically charged plates?
6. Complete each sentence below:
    a. Nuclear reactions change the composition in the atom's ________________________
    b. Atoms with too many or too few ______________________ are unstable
    c. ____________________ particles are fast moving electrons

Lesson 4: Half-lives

Objectives to be met:

- Students are able to carry out simple calculations to determine the half-life of an isotope if given the mass of the isotope before and after decay, and the length of time of decay.
- Students are able to calculate the age of a substance if given the ratio of carbon-12/carbon- 14 and the half-life of carbon-14

Materials needed:

- Half-life problems for the class to do as a whole
- Lab handouts
- 100 pennies and 2 containers per group
- Graphing paper
- Half-life problems for homework

Opening/anticipatory set/review:

Have some half-life problems on the board to teach the class how to do more complex half-life calculations.
For example:

1. Element A has a half-life of 3 days. If you start with 100 grams of element A, how much will be left after 18 days?

2. Element B has a half live of 45 years. When object A was made many years ago and when it was made it had 306 grams of Element A in it. Today object A was analyzed and found to contain .2988 grams of element B. How many years ago was Object A made?

3. The half-life of Zn-71 is 2.4 minutes. If one had 100.0 g at the beginning, how many grams would be left after 7.2 minutes has elapsed?
7.2 / 2.4 = 3 half-lives
$(1/2)^3$ = 0.125 (the amount remaining after 3 half-lives)
100.0 g x 0.125 = 12.5 g remaining

4) Os-182 has a half-life of 21.5 hours. How many grams of a 10.0 gram sample would have decayed after exactly three half-lives?
$(1/2)^3$ = 0.125 (the amount remaining after 3 half-lives)
10.0 g x 0.125 = 1.25 g remain
10.0 g - 1.25 g = 8.75 g have decayed
Note that the length of the half-life played no role in this calculation.

10 min

Lesson activities

Time	Teacher	Students
20 min	Divide students into groups. Give each group a white board and markers. Have 5 half-life problems and 5 radioactivity questions for the students to review. Once answered, have students place the white boards at the front of the room, and go through the problems together.	Each member of each group will attempt at least 1 half-life problem and 1 radioactivity question.
45 min	Prepare half-life lab in advance. Each group will be given 100 pennies in a container and a lab handout. During the lab have a group meeting with team leaders. Differentiation – advanced students can plot their data on log paper. Ask them to interpret the straight line/loss of a straight line. What errors may cause deviations?	Complete the lab to calculate and graphically represent half-lives. Each student independently will complete the analysis portion of the lab.
10 min	Explain importance of half-lives in producing nuclear energy. Ask students why it is important to keep the reactions under control? Why will it not be safe for people to live near Chernobyl for 26,000 years?	Listen and brainstorm answers and then the whole class will discuss the answers.
5 min	Explain homework and answer any more questions on half-lives. Give students problems on half-lives to work on independently.	Write down homework and ask any questions they need to.

Assessments

- Students are able to complete half-life problems in class with the help of peers and the teacher.
- In groups, students carry out a lab and are able to graphically represent their data on half-lives to demonstrate graphing abilities and understanding of half-lives.
- Students independently complete analysis questions of half-life lab to demonstrate understanding of half-lives.
- Students independently calculate half-lives and deduce the age of something based on relevant decay information.

Class Handouts

Half-life problems to do in class

1. If 70% of a radioactive isotope decays in 45 minutes. What is its half-life?
2. An object taken from a cave has a carbon-14 fraction which is 0.89 of the amount in a living organism. How old is the object? (Half-life for C-14 is 5730 yrs.)
3. An oil painting supposed to be by Rembrandt (1606 – 1669) is checked by carbon-14 dating. The carbon-14 level in the painting is 0.961 times that of a living plant. Could the painting have been by Rembrandt?
4. Three grams of Bismuth-218 decay to 0.375 grams in one hour. What is the half-life of this isotope?
5. 100.0 grams of an isotope with a half-life of 36.0 hours is present at time zero. How much time will have elapsed when 5.00 grams remains?

Radiation problems

Complete the following nuclear equations

1. $^{226}_{88}\text{Ra} \rightarrow$ ________ + $^{222}_{86}\text{Rn}$

2. $^{18}_{8}\text{O} \rightarrow {}^{0}_{-1}\beta$ + __________

3. Alpha decay of potassium-41

4. Beta decay of helium-5

5. Given the equation: $^{228}_{90}\text{Th} \rightarrow {}^{224}_{88}\text{Ra} + \text{X}$. What particle is represented by the letter X?

a. an alpha particle
b. a beta particle
c. a neutron
d. an electron

Lab handout: Calculating half-lives!

Your name__________________________
Other group members____

Methods

You have been given a container with 100 pennies, and another empty container.

1. Hold the container about one meter from a flat, horizontal surface and gently pour the pennies onto the surface

2. Count the number of pennies that land "heads" side up. Record this number in the blanks below. Assume heads side up pennies to be unchanged and tails side up pennies to be changed.

3. Put the heads side up pennies back into the container so they may be poured out again and put the tails side up pennies into the other container.

4. Continue the series 1 – 3 until all the pennies have landed tails side up or until you have completed 9 shakes.

Question: Why is it important to hold the container the same distance from the table during the entire experiment? ____
____
____
____

Results

Shake	Tails side up pennies left	Shake	Tails side up pennies left
0		5	
1		6	
2		7	
3		8	
4		9	

Graph your data. On the Y-axis plot the number of tail-side up pennies remaining, and on the x-axis plot the number of the shake.

Analysis

1) If you were dealing with the decay of radioactive Carbon-14 to the stable Nitrogen-14
a) Which element would the pennies that landed tails side up represent? _____________
b) Which element would the pennies that landed heads side up represent? ___________

2) After 2 shakes, about what fraction of your penny sample had decayed? ___________

3a) Was the rate of decay change from heads side up to tail side up uniform from shake to shake? _______________
3b) What is it about your graph that caused you to answer question 3a as you did?
____
____

*****IF EACH POURING OUT OF YOUR PENNIES ELEMENT TOOK 87 DAYS*****

4) How many days would it take for ½ of your penny element sample to decay? ______
Show your working

5) What, in this case, is the half-life of your penny element? _______________
Show your working

6) Define the term half-life ____
____
____

7) An old piece of cotton cloth is found to contain .0000156 grams of C-14 in it. A sample of new cotton cloth of equal mass is determined to contain .00200 grams of C-14. How old is the old cotton cloth? (The half like of C-14 is 5730 years.)
Show your working

This lab is modified from http://www.uwlax.edu/mvac/pdffiles/neh/arnie%20chamberlain.pdf

Lesson 5: Radiation in everyday life and exposure

Objectives to be met:

- Students will observe a demonstration of a cloud chamber to learn visualize radiation, and understand that even though it cannot be seen, it is still present.
- Students will become more literate on the benefits and hazards of radiation through detection and measurement of radiation using a Geiger counter.
- Students will measure radiation levels in some common everyday items to understand that radiation is everywhere and a part of their everyday life.

Materials needed:

- Cloud chamber demonstration (see teacher instructions)
- Handout for Geiger counter experiment
- Geiger counters
- Radioactivity sources (see below)
- Shielding materials (see below)
- Laptops for calculating daily radiation dose.

Opening/anticipatory set/review:

Set up cloud chamber demonstration (see instructions at the end). While radiation cannot be seen, the cloud chamber allows you to see the tracks it leaves in a dense gas. **Do you see radiation in the cloud chamber? Because you could not see the radiation, what kind of observation did you experience? What is happening to the radioactive source? What radiation "footprints" did you see? Describe them.** 20 min

Lesson activities

Time	Teacher	Students
40 min	• Set up Geiger counter. Get brazil nuts and "no salt" salt (KCL) which is radioactive to demonstrate different radiation levels. Other items can be glow-in-the heads products, cellular telephones, laptops, "radioactive red pottery", smoke alarms. More ideas at http://www.angelfire.com/electronic/cwillis/rad/rad.html. Then give students shielding materials to test effective shields. Suggestions – paper, aluminum foil, brick, jar of water, piece of wood, glass pane, sheet of lead Note, if Geiger counters are not available for the whole class, the teacher can do this as a demonstration, or select students to help the teacher. Or the teacher can use a virtual Geiger counter at http://www.csupomona.edu/~pbsiegel/Geiger_Counter/Geiger.html and then give students radioactivity levels of	Students must realize that radiation is everywhere. Give students data recording sheets and Geiger counters. One item at a time, students test each item by placing 2 inches away from the probe. Then using the item with the highest reading (it will be useful to have multiple of these) test each shielding material by placing them between the source and counter. Then answer questions on the sheet.

	more common substances. Differentiation:	 Students who finish sooner could research what a Geiger counter is and how it works. Students could also look at discrepancies between class measurements and those reported online for the materials under question.
10 min	Display the picture of radiation exposure and discuss some causes of radiation exposure in the USA.	Students discuss ideas as a class.
20 min	Give students laptops and have them calculate their annual radiation exposures at http://www.nrc.gov/about-nrc/radiation/around-us/calculator.html . Point out that this calculator does not include mobile phones. Give them this website http://www.sarshield.com/english/radiationchart.htm . They can find their phone and the radiation it emits. Ask them to write a summary on how they can reduce their annual exposure. Discuss Japanese weekly logging of children's radiation exposure. Is it enough? What other precautions might the government take?	Students calculate annual radiation exposure, look up the exposure from their mobile phone and write a summary on how they can reduce radiation exposure.

Assessments

- Students verbally answer questions regarding cloud chamber to demonstrate that they understand that radiation is present even though it cannot be seen.
- Students complete questions after Geiger counter lab and write a summary on how to reduce radiation exposure to show that they understand that everyday materials have radiation, and that we can be protected by a variety of materials.

Class Handouts

Geiger counter measurements

Radiation lab data recording sheet

Substance tested	Level of radiation	Rank of radioactivity

Shielding material used	Substance tested	Change in radioactivity levels?

Analysis

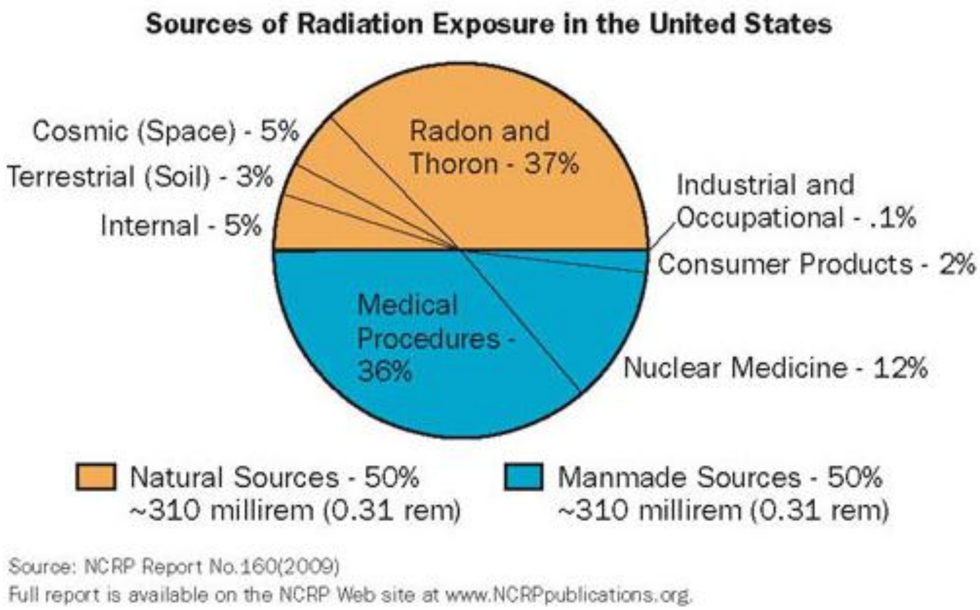
1. Why are elements that break apart called unstable?

2. How do things become less radioactive as time goes by?

3. What materials are best for shielding?

4. When you use a Geiger counter to survey a radioactive substance, why is it important to know what the background radiation level is?

5. Why do we measure radiation exposure?



This chart shows that natural sources of radiation account for about 50% of all public exposure while man-made sources account for the remaining 50%.

Teacher instructions for cloud chamber demonstration:

(Activity from http://www.nrc.gov/reading-rm/basic-ref/teachers/unit1.html#class_activities)

Materials

- small transparent container with transparent lid
- flat black spray paint
- blotter paper
- pure ethyl alcohol
- radioactive source
- masking tape
- dry ice
- Styrofoam square
- flashlight
- gloves or tongs to handle the dry ice

First, paint the bottom of the container with black paint and let it dry. Then cut the blotter paper into a strip about as wide as the height of the container. Cut two windows in the strip, as shown, and place it against the inside of the container.

Pour enough ethyl alcohol into the cloud chamber to cover the bottom of the container. The blotter paper will absorb most of it.

Place the radioactive source in the cloud chamber and seal the lid with tape.

Place the cloud chamber on the dry ice to super-chill it. Wait about five minutes. Darken the room. Shine the flashlight through the windows of the chamber while looking through the lid. You should see "puffs" and "trails" coming from the source. These are the "footprints" of radiation as it travels through the alcohol vapor. The vapor condenses as the radiation passes through. This is much like the vapor trail left by high flying jets.

Try to identify these footprints:

- **Alpha:** sharp tracks about 1 cm long
- **Beta:** thin tracks 3 cm to 10 cm long
- **Gamma:** faint, twisting and spiraling tracks

Caution: Dry ice should be handled very carefully! It can burn unprotected skin.

Questions to ask students:

1. **Do you see radiation in the cloud chamber?**
2. **Because you could not see the radiation, what kind of observation did you experience?**
   A: One sees the tracks left in the dense gas.
3. **What is happening to the radioactive source?**
   A: It is decaying (losing its radioactivity).
4. **Q: What radiation "footprints" did you see? Describe them.**
   A: They are "puffs" or "trails." Alpha rays produce sharp tracks about 1 cm long. Beta rays produce thin tracks from 3 to 10 cm long, and gamma rays produce twisting and spiraling tracks.

Lesson 6: Nuclear power benefits/disasters

Objectives to be met:

- Students will research an assigned aspect of nuclear power and create a presentation to give the rest of the class to demonstrate their research capabilities and ability to present relevant information.

Materials needed:

- Resources from which students can do relevant research
- Resources for creating presentations.

Opening/anticipatory set/review:

Collect half-life problem set done for homework
Discuss some of the uses of radiation that students have learned about till now. End with nuclear power to lead into the next assignment.
(10 minutes)

Lesson activities

Time	Teacher	Students
80 minutes	Present students with the next phase of the project. They now have enough background information to work on the "meat" of their project. Show students video on how nuclear power works http://www.youtube.com/watch?v=VJfIbBDR3e8&feature=related . Assign each group to research either the benefits of nuclear power or one of the disasters. The groups will present their arguments to the rest of the class. Disasters: 3 mile island, Chernobyl, Japan. Benefits: environmental, financial, sustainability Teacher will go over the contents of each presentation with the groups before they actually present. To keep the pace going – teacher can call for group leaders meeting and give instructions on making presentations more effective.	In their project groups students research the topic assigned to them and prepare a presentation (can be posters/PowerPoint's/whiteboard depending on resources. Roles of the group members may be: Researchers, writers of script, speakers, proofreader, artistic impact (images/formatting) Each group must give the teacher a verbal outline of their presentation before starting it.

Assessments

- Teacher will hear the presentation of research from each group before students make their presentations to ensure they have researched and understood their topic in sufficient depth.

Class Handouts: Rubric for nuclear power benefits/disasters presentation

CRITERIA	UNSATISFACTORY (Below Performance Standards)	PROFICIENT (Minimal Criteria)	ADVANCED (Demonstrates Exceptional Performance)
Organization, Mechanics, & Vocabulary (20%)	• Introduction does not state the purpose of the presentation • Little information about nuclear power benefits or the disasters • The main part of the presentation is disorganized and/or non-sequential • The closing is either unclear or absent from the presentation • The presentation lacks key academic language or is limited in the specific area (4 or more lapses) • The presentation is less than 2 or more than 4 minutes 0 - 10	• The introduction states the purpose of the presentation • To talk about the benefits or one of the disaster of nuclear power • The main part of the presentation is organized and sequential with some supporting evidence • The closing provides a basic summary of most of the major points • Vocabulary is appropriate to the topic (three or less lapses) • The presentation is between 2 and 4 minutes 11 - - - - - - - - - - - - - - - - - - - 16	**In addition to meeting the PROFICIENT criteria** • The main part of the presentation is well organized, sequential, and well supported by detail. • The closing provides a thorough summary of all of the major points. • The presentation demonstrates a rich vocabulary appropriate to the topic (1 or less errors) 17 - 20
Content Specific Benefits or one of the disasters of nuclear power (50%)	• The presentation lacks evidence to support the points made. • Sources are not provided or are not from reputable sources Benefits: • At least 3 benefits of nuclear power are NOT described. Disasters: • There is little background information about the nuclear reactor • No clean up strategy is suggested • The impact on the people is not well described • The current state of the reactor is not summarized 0 - - - - - - - - - -15 - - - - - - - - - - 36	• All points are justified by evidence • Reputable sources are provided Benefits: • At least 3 benefits of nuclear power are described and supported with evidence. • The economic, environmental and sustainability aspects of nuclear power are considered briefly. Disasters: • The nuclear disaster presented includes background information regarding the power plant and the actual problem with the reactor. • At least one clean-up strategy; impact on the people is described. • The current state of that reactor is summarized 38 - - - - - - 39- - - -40 - - - - - - - - - - 45	**In addition to meeting the PROFICIENT criteria** **Benefits** • The economic, environmental and sustainability aspects of nuclear power are described in detail. • The group evaluates the relative importance of each of these benefits **Disasters** • More than one clean-up strategy is described. • The group evaluates the clean-up strategies described. 46 - - - - - - - - - - - - - -48 - - - - - 50
Presentation (30%)	• The presentation lacks words (written or spoken) or images to convey its message • Images used are of poor quality and difficult to see. • The presentation does not flow smoothly and there are more than 3 stops and starts in the presentation. 0 - - - - - - - - - - - - 10 - - - - - - - - - - - - 19	• The presentation contains words and images to convey the message • The images used are of good quality • The presentation flows smoothly. There are no more than 2-3 stops and starts in the presentation 20- - - - - - - - - - - - 22 - - - - - - - - - - - - 24	**In addition to meeting the PROFICIENT criteria** • The presentation uses a variety of methods to convey its message: e.g. 3 or more of the following: written words, images, music, spoken words or other modes • The presentation flows smoothly. There are less than 1-2 stops and starts in the presentation 25 - - - - - - - - - - - -27- - - - - - - - - - - - 30

Lesson 7: Presentations on benefits/disasters of nuclear power

Objectives to be met:

- Students will give a presentation on the perspective of nuclear power they researched, and will follow presentations of nuclear power their peers have researched to build the background knowledge they will need for their public service announcements.

Materials needed:

- Materials for presentations
- Yeast plates
- Clingfilm
- Sunglass lenses
- Sunscreen SPF 30 and 75.

Opening/anticipatory set/review:

Students have 10 minutes to rehearse and fine tune their presentations.

Lesson activities

Time	Teacher	Students
30 min.	Teacher observes and grades presentations	Students make their presentations to each other. At the end of each presentation, students fill out a card for each group – ideas for improvement and things done well.
20 min	Review genetics with students (depending on the level of the students the teacher can go into more depth on this part of the lesson. This aspect of the project could also be taught in collaboration with a biology teacher). Introduce some genetic risks of radiation.	Students can take notes/complete a worksheet to reinforce knowledge as required.
30 min	Show the video of students doing experiment on bacteria http://www.rise.duke.edu/SEEK/ . Skip stage 1 – tobacco extracts. Then give students the data and ask them to analyze it. They can be told that the "tobacco plate" was exposed to very low intensity of UV light, or covered with "sun screen."	Students see experiment to test bacterial cells for radiation damage to determine what level of UV light damages DNA. Students discuss results as a class.
	Prepare yeast plates in advance (Further detail to be provided). Give students cling film, sunscreen, and sunglasses lens. Have a variety of lenses so that students can compare different quality sunglasses. Place plates under UV light overnight.	Each group of students should prepare 4 plates, one with 30 SPF sunscreen spread on Clingfilm, one with 75 SPF Clingfilm, one with sunglasses lens resting on the cling film and one control with just cling film.

Lesson 7: Presentations on benefits/disasters of nuclear power

Assessments

- Students give presentations of their assigned research area.
- Students analyze bacterial cell plates

Class Handouts

Yeast Lab – how much protection do sunglasses and sunscreen provide?

Each group requires 4 yeast plates. You will cover them in Clingfilm, and on the cling film you can apply sunscreen or sun glass lenses.

What are you investigating? ____
____
____

What is your hypothesis? ____
____
____

What is your control? ____

Why is a control important? ____

Place your plates in the UV-light incubator, and record your results tomorrow.

Draw and label your results here and describe what you see in each plate.

Lesson 7: Presentations on benefits/disasters of nuclear power

Describe your results here:

What are your conclusions based on what you found?

How could you improve this experiment (e.g. what other items could you investigate that protects from radiation damage?)

Lesson 9-13: Making and Presenting the digital story, End of Unit Test

Lesson 8: Acute radiation syndrome

Objectives to be met:

- Students research acute radiation syndrome to understand the dangers of nuclear emergencies and treatment of this condition.

Materials needed:

- Laptops
- Perhaps Wikipedia article printed out

Opening/anticipatory set/review:

10 mins: Students observe their yeast plates from the previous day and record their results.

Lesson activities

Time	Teacher	Students
45 mins	Discuss pros and cons of using Wikipedia, emphasize the importance of checking the sources and only trusting peer reviewed sources. (Perhaps change the appearance of the article for this assignment and create a word document to give to the students). Give students the "acute radiation syndrome page" from Wikipedia. Divide the article among the groups for example: a. Signs and symptoms b. Causes c. Diagnosis and treatment d. History of ARS	Have students read through their part of the article, and search for additional information. They need to then put this together on a poster or PowerPoint to explain it to the rest of the class. - Meet with group leaders to ensure groups are on track.
25 min	Teacher observes presentations and grades them.	Groups present to each other and fill out feedback forms with suggestions for improvement and strengths of the presentations.
H/w	Students complete results, conclusion and evaluation of their yeast lab.	

Assessments

- Students present research on acute radiation syndrome

Lessons 9-11: Making and presenting the digital story.

Students decide the stance that they will take on the public service announcement and start preparing the content. The content will be reviewed by the teacher before they begin to make their presentations. As they prepare to make their digital stories, the teacher will lead them through the process; emphasize the importance of not using copyright material, and giving credit where necessary.
Also review the physical science learned through the unit to prepare students for the end of unit test.

Lesson 12: Presenting the digital story

Students show their digital stories to a “representative” from the nuclear power company, and perhaps to younger students to educate them about nuclear power.
End of unit test.