INTEGRATED SCIENCE UNIT

TEACHER GUIDE

THE POWER OF THE NUCLEUS

SCIENCE

DIGITAL MEDIA ARTS

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Unit Overview

The topic of nuclear chemistry is one of the best opportunities to demonstrate to students the importance of science knowledge in everyday life. To prepare themselves for citizenship and personal decision-making, students need to be able to answer questions such as these: Should I purchase foods that have been irradiated? What should I do if I have radon in my basement? Should my town permit the construction of a nuclear power plant?

More broadly, students need to know how to inform themselves about a science-based societal issue, and how to use this information to make better decisions as a consumer, citizen, patient, employee, or family member.

This unit provides framing activities to serve as a context for teaching about nuclear chemistry, including:

- *a project- and inquiry-based framework for learning about this topic*
- *options for student projects that connect to other units from the Digital/Media/Arts program of study*
- *guidance for students to inform themselves about a science-based societal issue*

Students generate questions about nuclear chemistry based on what they need to know to complete the unit project—a media piece that informs or persuades a target audience about a political, environmental, or health issue related to nuclear chemistry. With students' questions as the organizing scheme for the materials you usually teach with (such as reading assignments, laboratory exercises, other hands-on activities, and direct instruction) you can cover all the required content in a context that is meaningful and motivating for students.

Unit Length

5 or 6 sessions, plus additional in-class and/or out-of-class time to complete the unit project

Unit Project Description

Students create a media project about a political, environmental, or health issue related to nuclear chemistry. They can choose from several project topics in which they work for a specific hypothetical client, or they can generate their own project ideas. Possible topics include nuclear weapons, irradiated foods, nuclear power, nuclear waste storage, and radon. Students apply what they have learned throughout *Foundations in Visual Arts*, particularly what they have learned about social art in *Unit 6: Games for Good*, to the creation of informative and/or persuasive media. For example, students may create:

- a poster or brochure explaining the risks and benefits of nuclear medicine
- a public service announcement about radon
- an image or images to warn people away from nuclear waste storage sites thousands of years in the future

Assessment

Unit activities can serve as formative assessment tools. Use student work to gather information about progress and identify concepts or skills to reinforce within your instructional practice. **Handout 5: Research for Your Media Project** is particularly useful for formative assessment.

The project-based nature of the unit allows students to demonstrate their learning through an authentic application. This unit's summative assessment is a media project educating the public or advocating for a position on a science-based societal issue related to nuclear chemistry.

Assessment Checklist 1 provides criteria for assessment and a suggested weight for each. If you wish to use a rubric, work with teachers in your grade level or subject area to develop a tool that is consistent with your school's assessment system.

Framing Questions

- How do people put the power of the nucleus to work in a variety of useful applications?
- How can I find and evaluate the information I need to make good decisions about science-based societal issues?
- How can arts and media be used to communicate with the public about science-based societal issues?

Understandings

- There are many practical applications of nuclear chemistry in industry, agriculture, medicine, and national defense.
- When addressing societal issues related to nuclear chemistry, understanding the underlying science should precede decision-making.
- Different sources of information about science and science-based societal issues have different strengths and weaknesses.

Where the Unit Fits In

The Power of the Nucleus provides activities that serve as a context for teaching about nuclear chemistry.

- Part 1 activities should take place immediately before you begin teaching nuclear chemistry.
- The activities in Part 2 should occur during the same time period in which you are teaching nuclear chemistry.
- Part 3 activities can take place immediately following or sometime after you finish teaching about nuclear chemistry.

Integration with Foundations Courses

This unit integrates science content and career and technical education (CTE) knowledge and skills. It can be taught before, at the same time as, or after the related unit in *Foundations in Visual Arts*.

Foundations in Visual Arts Unit 6: Games for Good. Students learn about ways that art and media can be used to advocate for issues and even spur people to take action. Students focus on the potential of video games as tools for education and for making a better world. They explore how the design, interactivity, and visual elements of a video game can engage and teach audiences about a particular issue. For their unit project, students create the preliminary design and artwork for a video game that will inspire, inform, or motivate players to act on an issue of the students' choosing. Some options for integrating *The Power of the Nucleus* with *Games for Good* include:

- Asking the *Games for Good* teacher to use examples related to nuclear chemistry during Activity 1A.1: Looking at Art and Media as Catalysts for Change.
- Having the students do a joint project for the two units, by developing a concept for a video game on a topic related to nuclear chemistry. In addition to the products students create for *Games for Good*, they would complete all the steps in **Handout 2: *The Power of the Nucleus* Project Description**, basing their work on the game (rather than using the media formats, such as posters and public service announcements, listed in Handout 3).

Foundations in Media and Digital Design: Animation & Gaming, Unit 1: Principles of Game Design. Students play and analyze a variety of games, exploring their structure, how they are played, and how a game's visual environment affects the player experience. For their unit project, students work in teams to design and create a simple video game.

One option for integrating *The Power of the Nucleus* with *Principles of Game Design* is to have students develop a concept for a video game on a topic related to nuclear chemistry, and create the game. (Students may need to substantially simplify their concept when they create the game.) In addition to designing and creating the game as part of *Principles of Game Design*, they would complete all the steps in **Handout 2: *The Power of the Nucleus* Project Description**, basing their work on the game (rather than using the media formats, such as posters and public service announcements, listed in Handout 3).

Multi-Disciplinary Teams

Use the following integrated units and integration suggestions for multi-disciplinary projects.

Cold War Games (World History). Students take on the role of video game researchers to learn about the complex web of events, conflicts, and policies that constituted the global Cold War. Students then use their understanding of this era to come up with an idea for a historically accurate video game based on a pivotal event during this period of history. Students' understanding of the Cold War, particularly the fear of nuclear weapons that was so widespread during that time, will be enhanced by learning about the biological effects of nuclear radiation in this unit. To strengthen the connection between *Cold War Games* and *The Power of the Nucleus*, you may want to focus your students' projects on issues related to nuclear weapons rather than offering them a choice of all the topics in Handout 3.

Math. The understanding of half-lives in science class can be enhanced by the study of exponential functions (in Algebra II) and probability (in Probability and Statistics or in an integrated math course). Ask the math teacher to use radioactive decay as an example when teaching these topics.

Art and Media. Collaborate with an art or media teacher and have students work on their *Power of the Nucleus* unit projects in their art or media class.

Student Prerequisites

Students should be familiar with the periodic table and should know about atomic structure.

Adapting the Unit

Other Science Topics. The unit activities and project may be adapted to any science topic that is connected to a social, political, environmental, or health issue.

Biology. This unit can be adapted for use as a biology enrichment unit by focusing the project on those topics most closely related to biology and focusing instruction on

- medical uses, both diagnostic and therapeutic, of radiation and radioactive materials
- how the effect of ionizing radiation on atoms affects in turn molecules, cells, tissues, organs, and the whole body

See ***Additional Resources for Teachers*** for further information about the biological effects of radiation.

Pacing and Sequencing

The number of class sessions needed will depend on how much in-class time you give the students to work on their projects.

Table of Activities

Part 1: Before Teaching About Nuclear Chemistry

Students are introduced to the topic of nuclear chemistry, the unit, and the unit project.

Activity 1A: Connecting to Nuclear Chemistry

Students share what they know about nuclear chemistry, and consider the ways in which it touches their lives.

Activity 1B: Exploring Project Topics

Students discuss the science-based political, environmental, and health issues that they can choose for their unit projects. They then generate questions about nuclear chemistry based on what they need to know in order to complete their projects.

Part 2: While Teaching About Nuclear Chemistry

Students engage in activities in support of their work on the unit project.

Activity 2A: Media Projects That Inform and Persuade

2A.1: ***Examining Examples***	Students critically review media projects about science-based societal issues.
2A.2: ***About the Media Fair***	Students are introduced to requirements for the artists' statements and the Media Fair.

Activity 2B: Sources of Science Information

Students critically review different types of sources of science information.

Part 3: After Teaching About Nuclear Chemistry

Students complete and share their media projects.

Activity 3A: (Optional): Peer Feedback

In this optional session, teams pair up with other teams to provide each other with feedback on their drafts, outlines, or mock-ups.

Activity 3B: Media Fair

Students share their projects with their classmates.

Advance Preparation

- Internet resources, provided as links in *Media & Resources*, are recommended throughout the unit for student or in-class use.
  - These Web sites have been checked for availability and for advertising and other inappropriate content. Because Web site policies and content change frequently, however, we recommend that you preview the sites shortly before using them.
  - Address any issues, such as firewalls or filtering programs, related to accessing Web sites or other Internet links at your school.
  - Recommended computer simulations may require Java, Flash, or other software. Test any simulations on the computer(s) that will be used during the corresponding lesson.
- Look at **Materials Needed** at the end of the unit and order or prepare any needed equipment or supplies.
- Review the teacher copy of **Handout 2: *The Power of the Nucleus* Project Description**, which shows how the steps of the unit project correspond to unit activities. Decide whether and how much class time to give students for working on their projects. For those project steps that will take place in class, decide when to complete them. Choose due dates for all the materials students submit as part of the project.
- Look at **Handout 3: *The Power of the Nucleus* Project Topics** and decide which project topics are most suitable for your class. You can add, delete, or modify the project topics listed in Handout 3 and if needed, redistribute them among the categories.

Part 1: Before Teaching About Nuclear Chemistry

Students are introduced to the topic and unit, and begin to consider what science-based political, environmental, or health issue to focus on for the unit project. They then generate questions about nuclear chemistry based on what they need to know in order to complete their projects.

Length

2 50-minute sessions

Advance Preparation

- Download the slide presentation "The Power of the Nucleus" (See *Media & Resources*.)
- Prepare a long piece of paper roll (such as butcher paper, kraft paper, or easel paper) for the Chalk Talk by writing the words "nuclear" and "radiation." Leave plenty of space around each word for students' contributions.
- Prepare a "Question Board"—a flat surface where students can post the sticky notes from Activity 1. This could be a whiteboard, a blank wall, or several large adjacent sheets of chart paper. You will refer to the Question Board during each class session on nuclear chemistry, so set up the Question Board in such a way that it can remain posted throughout the entire unit.

Activity 1A: Connecting to Nuclear Chemistry

Understandings

- The science of nuclear chemistry is connected to our daily lives.
- An understanding of nuclear chemistry is essential for many decisions people need to make as individuals and as citizens.

Materials Needed

- Projector and computer
- Slide presentation "The Power of the Nucleus"
- Paper roll (such as butcher paper, kraft paper, or easel paper)
- Markers (one per student)
- **Handout 1: Unit Overview**
- **Handout 2: *The Power of the Nucleus* Project Description**
- **Handout 3: *The Power of the Nucleus* Project Topics**
- **Assessment Checklist 1: *The Power of the Nucleus* Project**

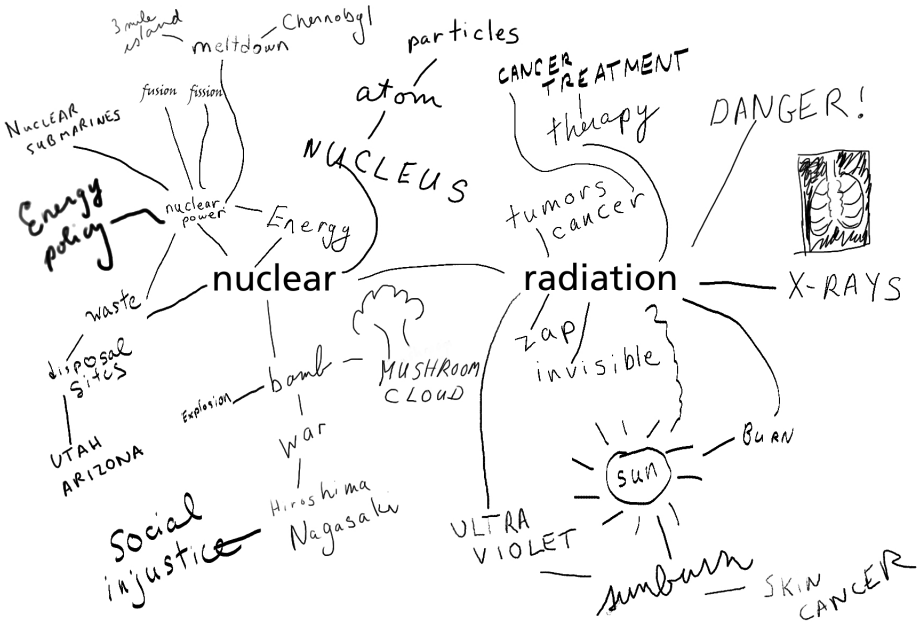
1. Introduce the topic of the unit.
Explain that the topic of this unit, nuclear chemistry, is a topic that is regularly in the news. But the words "nuclear chemistry" don't often show up in the headlines. Show students the slides from "The Power of the Nucleus" and explain that all media examples are about issues where nuclear chemistry plays a part.

2. Access students' prior knowledge of the topic using a Chalk Talk.
Direct students' attention to the paper you have prepared for the Chalk Talk. Ask students to think about the following:

- What comes to mind when you see the words "nuclear" and "radiation"?
- Do you know anyone (personally or from the news) who has been helped or harmed by nuclear radiation?

Explain to students that they will share their thoughts using an activity called Chalk Talk: Without speaking, students write words, phrases, or questions; draw pictures; and draw lines and arrows to connect things written or drawn by others. They can respond not only to the two starting words, but also to their peers' ideas.

> **Note:** Chalk Talks look similar to a concept map, but are typically less formal and hierarchical.



Give each student a marker and have students write their ideas on the Chalk Talk.

Afterward, ask the class to take a look at the results of their Chalk Talk. Discuss the following:

- What can you learn by looking at what other people wrote? (You can add students' answers to the Chalk Talk.)

Distribute blank sticky notes. Ask students:

- What questions do you have about radiation and nuclear chemistry? What would you like to know about them?

Have students write their questions on sticky notes and hold on to them for use later in this session.

3. Introduce the unit.
Building on the Chalk Talk and subsequent discussion, communicate the idea that nuclear chemistry touches our lives. Now or in the future, students will need to make decisions, as individuals and as members of a community, that depend on nuclear chemistry. Explain that during this unit, students will study nuclear chemistry in the context of personal and societal decision-making.

Ask students for their ideas about how they might be able to participate in or affect societal decision-making. Students don't need to know all of the items in the list below; they just need to be aware that there are a variety of ways to be involved.

Possible answers:

- *voting in elections for public office and writing to elected officials*
- *volunteering for or donating to political campaigns and nonprofit organizations*
- *voting in referenda*
- *writing opinion pieces for print or online media*
- *attending community meetings or protests*
- *consumer action, such as*
    - *choosing whether or not to buy a product*
    - *writing to television stations to express opinions about advertising from particular companies or about particular products*

Note: Students may not recognize their role in societal decision-making, and may need some prompting, hints, or probing questions to help them generate answers.

Distribute **Handout 1: Unit Overview**.

Note: The vocabulary list in the Unit Overview focuses on terms students are likely to encounter as they begin research for their projects, so they can make some sense of the information they are finding even if the relevant science content has not yet been covered in class. It is not a complete list of nuclear chemistry terms that students should understand.

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4. Introduce the unit project.

Distribute **Handout 2: *The Power of the Nucleus* Project Description**, **Handout 3: *The Power of the Nucleus* Project Topics**, and **Assessment Checklist 1: *The Power of the Nucleus* Project**. Explain to students that they will work with a team to follow the steps in Handout 2 to complete one of the projects listed in Handout 3. Inform students of any specific details about the project that are not in the handouts, such as:

- any limitations you are placing on the topic or the media format of the project
- team sizes
- how teams will be selected
- the due dates for the steps listed (Have them enter this information in the appropriate spaces on Handout 2.)

Let students know that the class will discuss the project topics in the next session.

Activity 1B: Exploring Project Topics

Understandings

- There are many political, environmental, and health issues that depend on an understanding of nuclear chemistry, including food irradiation, nuclear proliferation/disarmament, nuclear power, and nuclear waste disposal.

Materials Needed

- Sticky notes (several per student)
- Students' copies of **Handout 2: *The Power of the Nucleus* Project Description**
- Students' copies of **Handout 3: *The Power of the Nucleus* Project Topics**
- Students' copies of **Assessment Checklist 1: *The Power of the Nucleus* Project**

1. Have students meet in groups to learn about possible project topics and clients.
Explain to students the structure of this session: They will meet in small groups to learn about and discuss some of the project topics described on Handout 3. They will then share what they've learned with another group of students.

Divide students into groups, and assign each group one category of topics from Handout 3. Have groups read about the topics and clients in their category and discuss the following questions:

- What parts of the descriptions are easy to understand?
- What words or sentences are confusing or unclear?
- What do you already know about chemistry in general or nuclear chemistry that relates to the project topics? (Encourage students to refer to the results of the Chalk Talk, which should still be posted in the classroom.)
- What would you need to know to complete a media project about each of these topics?

Have students write their questions on sticky notes, one question per note.

2. Have students meet in new teams to share what they've learned.
Divide the class into new groups, with each group consisting of at least one student who is an expert in each of the project topic categories.

Have students briefly describe the topics and clients they have learned about, and share the questions generated on sticky notes about each topic. Groups should then write any additional questions that they generate on new sticky notes.

3. Have students choose preliminary topics for their unit projects.
Tell students to choose one or more topics they might be interested in working on. Let them know that their final choice of topic will be made later, when the class has been divided into project teams. Have students write down any additional questions they have about the topic on sticky notes.

4. Introduce the Question Board.
Explain that the Question Board will be the starting point for their learning about nuclear chemistry, because each class session will address one or more of the clusters of questions posted.

Have students post their sticky notes on the Question Board. As students are posting their questions, ask them to try to place the notes near other similar questions. Explain that they can move other notes or groups of notes to bring related questions together.

After students have posted all their questions, ask them to spend a few minutes reading each other's questions and finalizing the placement of the notes.

Teacher's Notes:
Connecting Nuclear Chemistry Topics to Students' Questions

Before beginning to teach the nuclear chemistry content, you will need to review the questions generated in Activity 1B and *map questions or clusters of questions to the learning experiences you will implement*. Leave the Question Board posted in the classroom throughout the nuclear chemistry unit. Then, at the start of each nuclear chemistry lesson, indicate which cluster(s) of questions will be addressed.

Appendix A shows how some questions students may ask relate to the topics covered in standard high school chemistry textbooks. The table in Appendix A is *just an example*—you will need to create your own mapping, specific to your students' questions and to the teaching resources available to you.

Note that it is not necessary to teach a lesson for every question: some topics are appropriate for students to research on their own. You should inform students at the start of the unit which questions you will not address in class, and suggest resources for them to consult. (See *Media & Resources* for suggestions.)

Handout 1:
Unit Overview

Should you purchase foods that have been irradiated? What's radon, and what should you do if you have it in your basement? Should your town permit the construction of a nuclear power plant?

To answer these questions, and many more that you will face as a citizen, consumer, patient, homeowner, employee, or family member, you need to understand an area of science called nuclear chemistry. Nuclear chemistry is the study of reactions in which the nucleus of an atom changes.

Your work in this unit will revolve around the following questions:

- *How do people put the power of the nucleus to work in a variety of useful applications?*
- *How can I find and evaluate the information I need to make good decisions about science-based societal issues?*
- *How can arts and media be used to communicate with the public about science-based societal issues?*

Unit Project

You will create a piece of media—such as a brochure, poster, Web site, or public service announcement—about a political, environmental, or health issue related to nuclear chemistry. In your project, you may try to educate others about an issue by presenting an unbiased picture, or you may advocate for a particular perspective on an issue.

What You Will Do in This Unit

Learn about nuclear chemistry. Through a variety of experiences, such as lab activities, animations and simulations, and classroom discussions, learn about the types of nuclear reactions, the energy released during those reactions, and the effects of this energy on living things.

Analyze different sources of information about science-based societal issues. Read news articles, opinion pieces, and other information sources and learn how to decide if what you read can be trusted.

Create an informative or persuasive media project. Working as part of a team, create a brochure, poster, Web site, public service announcement, or other media project that informs or persuades young adults about a possibly controversial topic related to nuclear chemistry.

Vocabulary Used in This Unit

Nucleus: The positively charged center of an atom, which contains protons and neutrons. Plural: nuclei.

Isotopes: Atoms of the same element (same atomic number, same number of protons) that have different numbers of neutrons and therefore different atomic masses. Isotopes are represented by using the atomic symbol followed by the number of neutrons. For example, U-235 is an isotope of uranium with 235 neutrons, and U-238 is an isotope of uranium with 238 neutrons.

Radiation: Transfer of energy as waves or particles traveling through a medium or through empty space.

Ionizing radiation: Radiation with enough energy to create ions (charged atoms) by removing electrons from atoms.

Note: Strictly speaking, radiation includes both ionizing radiation and non-ionizing radiation, but in common usage, the word *radiation* often refers only to ionizing radiation. Non-ionizing radiation includes radio waves, microwaves, and visible light.

The word *radiation* is also sometimes used to refer to *radiation therapy*, which is the use of radioactive materials to treat diseases such as cancer.

Radioactivity: The process in which an unstable atomic nucleus gives off ionizing radiation, such as alpha particles, beta particles, and/or gamma rays.

Radioisotopes: Isotopes that are radioactive.

Irradiation: Exposure to ionizing radiation. Irradiation does not usually result in the target becoming radioactive, but damage to the target can occur.

Half-life: The time it takes for half of the atoms in a sample of a radioisotope to decay.

Fission (nuclear fission): The splitting of an atomic nucleus into two smaller nuclei of approximately the same size.

Fusion (nuclear fusion): The merging of two or more atomic nuclei to create a single heavier nucleus.

Handout 2:
The Power of the Nucleus Project Description

Using what you learn during this unit, you will work as part of a team to produce a media project—such as a poster, audio or video public service announcement (PSA), or brochure—about a science-based societal issue related to nuclear chemistry.

Your project will need to explain the relevant chemistry content to your audience. What do you need to know about nuclear chemistry in order to create your project?

Note: During Step 3, you and your team members will each complete Handout 5 independently. All other steps should be completed working as a team.

Step 1: Explore project topics

Students complete Step 1 during Activity 1B: Exploring Project Topics.

Make a preliminary choice from Handout 3. (You will have a chance to change your mind later, after you've done a little research about your topic.) Then, come up with a list of questions you will need to answer in order to complete the project. Write each question on a sticky note, and post it in the Question Board.

Step 2: Look at media examples

Students complete this step during Activity 2A.1: Examining Examples.

See how other organizations have gotten their message out about science-based societal issues. Your teacher will show you examples or recommend Web sites to look at.

Step 3: Begin your research and make your final topic selection

This begins during Activity 2B: Sources of Science Information. It can be completed in class if you allow extra time, or it can be completed as homework.

Learn more about the topic you have chosen. Be sure to look at different types of sources—this is especially important when studying a controversial issue.

During this research on your topic, you may decide one of the other topics from Handout 3 is more interesting. Or, as you learn about both sides of an issue, you may decide that you disagree with the client's position so strongly you don't want to help them get their message out! This is your chance to change your mind.

Once you and your partner have made a final choice of topic, complete **Handout 5: Research for Your Media Project**. Each of you should complete the handout individually, using difference sources.

Handout 5 due date: _____

Steps 4 through 7 can be completed during the same time period in which you are teaching the nuclear chemistry content, or after you have finished teaching. These steps can be completed in class if you schedule time for teams to work on their projects, or can be completed as homework.

Step 4: Write a statement of purpose

Will your project educate and inform in an unbiased way, or will it advocate for a particular position? Write a statement of purpose—a single sentence that describes what you intend to do. Your statement should include the format of your media project, your audience, and the outcome. For example,

- Our poster (media format) will help patients undergoing radiation therapy (audience) understand how the therapy works. (outcome)

- Our brochure will convince consumers that food irradiation is a good idea and that irradiated foods are safe to eat.
- We will present consumers with balanced information about food irradiation, so they can decide for themselves whether or not to eat irradiated foods.

Statement of purpose due date: _____

Step 5: Finish your research and write a bibliography

What scientific information will you need to accurately and clearly communicate about your topic? You will learn a lot about the science behind your topic in class. But you may need to learn more to complete your project.

You will also need some non-scientific information: You may also want to know

- How does the public feel about the issue?
- What organizations—businesses, nonprofits, government agencies—have a stake in the issue?

Continue your research until you have found all the information you need to achieve the objective expressed by your statement of purpose. Then write a bibliography listing all the sources. The bibliography should include the sources you each used for Handout 4, but it should include additional sources as well.

Bibliography due date: _____

Step 6: Explain the science

Write an explanation of the science related to the topic you have chosen. For example, if your project is about the dangers of nuclear energy, describe

- the decay process for the isotopes used as fuel
- the possible biological effects of radiation from reactor leaks and from nuclear waste

Explain the science thoroughly, even if you don't plan to include that amount of detail in your media project.

Science explanation due date: _____

Step 7: Do a draft, outline, or mock-up and get feedback

Decide whether students will get feedback from you or from their peers. If from their peers, schedule class time for this. Activity 3A provides suggestions for the peer feedback process.

Conduct any additional research needed and keep a record of your sources. Make preliminary decisions about the content of your project. For example, if you are working on an audio PSA, write a rough draft of the script. If your project is a poster, draft the text for the poster and do a sketch of what the poster will look like.

You will either submit the draft to your teacher for feedback, or meet with another team to provide each other feedback.

Draft due date: _____

Step 8: Complete the project and an artists' statement for the team

This should take place after you have finished teaching the nuclear chemistry content. Selection of the due date depends on how much class time you allocate for students to work on their projects, and whether students work on their projects during the same time frame in which you are teaching the nuclear chemistry content or wait until afterwards to begin.

Create the final version of your media project. In addition, write a short artists' statement describing

- why you chose the topic
- the decisions you made about what position to take, what information to include, and how to present this information

Project and artists' statement due date: _____

Step 9: Share Your Work at the Media Fair

The Media Fair takes place in class during Activity 3B. It can be scheduled for any time after the project due date.

Set up a display of your work for other students to view. Include the following:

- Project
- Bibliography
- Artists' statement
- Statement of purpose

Be prepared to answer questions about the science content and your team's design decisions. View other teams' projects and complete peer assessments of several projects using **Assessment Checklist 2: Media Fair Peer Assessment**.

Date of Media Fair: _____

Handout 3:
The Power of the Nucleus Project Topics

With any science-based societal issue, there are organizations that try to inform or persuade the public. A variety of different media can be used to do this.

You work for a media production company that specializes in communicating with teens and young adults. You and your partner will produce a piece of media for one of the clients described below.

> **Note:** Unless otherwise noted, your audience is high school and college students and recent graduates. Assume your audience has a basic knowledge of chemistry.

Category 1: Radiation in Everyday Life

Topic 1A: Irradiated foods

Client: A supermarket chain

Food irradiation is the process of exposing food to ionizing radiation. A main purpose of this is to destroy microorganisms, bacteria, viruses, or insects, which helps prevent food-borne illnesses and also reduces spoilage. A supermarket chain wants a brochure or poster about the pros and cons of irradiating food. The brochure or poster must explain why foods are irradiated and what the possible drawbacks are, in a way that helps food shoppers make an informed decision about whether or not to purchase irradiated foods. This explanation should address people's concerns about whether irradiation makes foods radioactive.

Topic 1B: Radon

Client: State department of environmental protection

Radon is a naturally occurring colorless, odorless, radioactive gas that is found in many homes. While many states already have programs in place to inform homebuyers about radon, this client wants to inform young adults who rent housing about radon. They want a public service announcement (PSA) to play on radio stations. The PSA should give an overview of the health hazards of radon, how to test for it, and what to do if you have radon in your home. It should also motivate listeners to visit the department's (hypothetical) Web page for further details.

Category 2: Nuclear Energy

Topic 2A: Nuclear power plants

Client: A nonprofit environmental group

Nuclear fission releases a lot of energy, and this energy can be used to generate electricity. Facilities that do this are called nuclear power plants. A nonprofit environmental group believes that nuclear power is a key part of any plan to reduce greenhouse gas emissions. The nonprofit wants a script and storyboard for a video public service announcement (PSA) that will convince young voters that nuclear power plants are safe. The PSA should address the environmental and safety concerns about the power plants themselves and about the nuclear waste produced by these plants.

Topic 2B: Cold fusion

Client: A university

Nuclear fusion, a reaction in which two or more nuclei join together, also releases a lot of energy. Fusion typically occurs at very high temperatures, like those found in the sun and other stars. Because such high temperatures are needed, it has not been possible to build nuclear power plants that use nuclear fusion. If scientists could find a way to make fusion occur at low temperatures (called "cold fusion"), nuclear fusion power plants could be built. However, ever since a couple of scientists' claims about achieving cold fusion turned out to be a hoax, the topic of cold fusion has become a joke. But if cold fusion could be achieved, it would solve the world's energy crisis, so there are many organizations that want to pursue research in this area. A university wants to convince potential donors that cold fusion is more than a joke. Create a brochure or Web page explaining what cold fusion is, why it's worth investing in, and how researchers are approaching it.

Category 3: Scientific and Medical Applications

Topic 3A: Radioactive dating

Client: A natural history museum

Radioactive isotopes occur naturally throughout the universe, including Earth. These radioactive isotopes decay over time. By looking at the percentage of a material that is still radioactive, scientists can estimate the age of rocks, fossils, and archeological artifacts. (This technique is called radioactive dating, radiometric dating, or radiochemical dating.) As part of a campaign to educate high school and college-aged visitors about evolution and the age of the Earth, a natural history museum wants a brochure or poster explaining how carbon dating and other types of radioactive dating provide evidence of the Earth's age and of the number of years life has been evolving on Earth.

Topic 3B: Radiation therapy for cancer

Client: A hospital

Radiation therapy is one of the primary ways to treat cancer. In radiation therapy, cancer cells are killed through exposure to radioactive substances. A hospital wants to educate its teen and adult cancer

patients about how radiation therapy works and its pros and cons. Many people are confused by the idea that radiation both causes cancer and can be used to treat cancer, so be sure to address this in your project.

Topic 3C: Nuclear medicine

Client: A hospital

Nuclear medicine is the use of radioactive materials to diagnose disease. In one common type of procedure, a radioactive tracer is swallowed, inhaled, or injected into a vein. The patient is then scanned using a special camera, such as a gamma ray camera or a PET scanner. A hospital wants a poster to display in waiting rooms that explains how the potential benefits are weighed against the health risks when deciding whether a patient should undergo a nuclear medicine procedure.

Category 4: Nuclear Legacy

Topic 4A: Nuclear weapons

Client: A nonprofit environmental organization

A nonprofit environmental organization has decided to launch a campaign advocating that the U.S. begin reducing its stockpiles and arsenals of nuclear weapons. As part of their campaign, they want a computer game or simulation that demonstrates the possible negative consequences of continuing to store these weapons. The game or simulation can focus on any aspect of this issue, such as the biological effects of these weapons or the political maneuvering involved in nuclear proliferation and disarmament. Your task is to develop the concept for the game or simulation: write and/or draw a description of the rules, the player's role, and the outcomes that might result from the player's choices.

Topic 4B: Long-term nuclear waste disposal

Client: A nonprofit arts organization

Radioactive waste is produced when radioactive materials are used in a wide variety of applications. Waste from nuclear reactors is of particular concern. Currently, this waste is stored at the sites where it is produced, often in concrete, steel-lined pools of water. This is only a temporary solution, as these sites will eventually run out of storage space. The United States currently has no long-term storage facility for this waste, and such storage is definitely needed.

The storage facility must safely contain the nuclear waste for a long time: 10,000 years is agreed to be the absolute minimum, but many believe the storage facility must contain the waste for a million years. One major challenge of building such a facility is to create a universal warning system that will be understood by whoever—or whatever—is living on Earth in a million years. Some people think that art, with its ability to communicate across cultures and languages, should be part of this warning system. A nonprofit arts organization is holding a competition for artists, asking them to submit drawings or sculptures that will communicate to beings of the distant future: "Danger. Stay away. Do not dig here. What is buried here gives off a type of energy that can kill." The organization has invited your company to submit an entry in the competition. Your art should incorporate scientific concepts about atoms, radiation, and biological effects of radiation, without using words.

Invent-Your-Own

You can imagine that for many of the topics above, there are organizations with other points of view. Choose one of these topics, invent a new client, and present a different perspective on the issue. Alternatively, choose one of the client/topic combinations above, but use a different media format. Get your teacher's approval for the client, topic, and media format before proceeding.

Assessment Checklist 1:
The Power of the Nucleus Project

Use this assessment to help you produce your media project. Make sure to include all the requirements. Your teacher will use this assessment to evaluate your work.

Requirements	Percentage of Total Grade	Comments	
Written Explanation of Science		**Student Comments**	**Teacher Comments**
Explains the relevant chemistry content thoroughly and correctly.	**30%**		
Media Project			
Shows the connection between chemistry and the social, political, environmental, or health issue.	**25%**		
Presents a balanced picture of the issue OR argues persuasively for a particular point of view.	**10%**		
Uses appropriate techniques to be appealing and engaging to the target audience.	**10%**		
Uses voice, tone, language, and style appropriate to the target audience.	**5%**		
Uses proper grammar, punctuation, and sentence and paragraph structure.	**5%**		

Requirements	Percentage of Total Grade	Comments	
Artists' Statement		**Student Comments**	**Teacher Comments**
Explains the team's choice of topic and the team's decisions about what position to take, what information to include, and how to present this information.	**10%**		
Uses proper grammar, punctuation, and sentence and paragraph structure.	**5%**		
Total	**100%**		

Part 2: While Teaching About Nuclear Chemistry

In parallel with learning nuclear chemistry content, students engage in two activities in support of their work on the unit project: They critically review sources of science information, and see how other organizations have informed or advocated with the public on science-based societal issues.

Length

2 50-minute sessions

Advance Preparation

- For Activity 2A.1, choose examples of media about science-based societal issues (other than those related to nuclear chemistry) that have the following characteristics:
  - contain science content
  - are the same or similar in format to the projects your students will do, for example, brochures, posters, and public service announcements
  - demonstrate how the same topic is presented by different organizations and/or in different formats

  For media examples on the topic of global climate change, see *Media & Resources*. If you would like to use examples on a different topic, see *Additional Resources for Teachers*.

  Note: Many brochures you will find online as PDFs were not designed for viewing online. We recommend printing a few hard copies of any such brochures you want your students to see.

- For Activity 2B, choose examples of information sources about nuclear chemistry topics. Have at least one example for each type of information source listed in **Handout 5: Research for Your Media Project**:
  - News article (from a printed newspaper or the Web site of a major printed newspaper)
  - Editorial, blog post, or other opinion piece (on the Web or in print)
  - Information from a governmental, educational, or advocacy organization (on the Web or in print)
  - Textbook or other science reference book (in print, not on the Web)

  For examples of the first three types of sources, see *Media & Resources*. (Obtain science reference books from your school or community library.)

Activity 2A:
Media Projects That Inform and Persuade

Sequence

2A.1: ***Examining Examples***	Students critically review media projects about science-based societal issues.
2A.2: ***About the Media Fair***	Students are introduced to requirements for the artists' statements and the Media Fair.

Understandings

- Art and media about science-based societal issues can be used to inform and persuade.

Materials Needed

- Computer and projector, or one computer per pair of students
- Students' copies of **Handout 2: *The Power of the Nucleus* Project Description**

2A.1: Examining Examples

1. Show students examples of media about science-based societal issues.
You can use computers to show Web sites, videos, or audio PSAs. Print materials can be posted or passed around; some print materials may also be available on the Web and can be viewed using a computer.

For two or three of the examples, ask students the following questions:

- Is it persuasive? Why or why not?
- What techniques do the creators use to try to hold your attention?
- What scientific information does it include?
- How would you sum up its message in just one sentence?

> **Note:** If you would like to explore some of these ideas in greater depth, you may want to adapt Activity 1A.1: Looking at Art and Media as Catalysts for Change, from *Foundations in Visual Arts, Unit 6: Games for Good*.

2A.2: About the Media Fair

1. Discuss the artists' statement.
Have students read Step 8 from Handout 2, and answer any questions students have about the artists' statement or any other aspect of the project.

2. Describe the Media Fair process to students.
Explain that after students have completed their media projects, they will share their work with their classmates (and, optionally, other students and guests) at a Media Fair.

During the fair, each student team will set up a display of its project that can be viewed by other students and guests. For example,

- A team that created an audio PSA sets up a computer or MP3 player that fair attendees will use to listen to the PSA.
- A team that created a brochure will set out multiple copies of the brochure for people to read.
- A team that created a storyboard for a video will set up easels displaying the storyboard.

Each team should also have several copies of their science explanation, bibliography, and artists' statement.

Remind students of when the Media Fair will take place. Answer any questions students have about the Media Fair.

3. Form project teams.
Assign students to project teams or allow them to form teams based on what project topics they are interested in.

> **Note:** Unless you plan to provide students with several class sessions in which to work on their projects, it's best to have students work in teams of two; larger team sizes will make it difficult for students to find time to work together outside of class.

Activity 2B: Sources of Science Information

Students learn to identify and evaluate different types of sources of science information.

Understandings

- When learning about a science-based societal issue, you must critically evaluate the information sources you use.

Materials Needed

- **Handout 4: Consider the Source**
- Examples of information sources about nuclear chemistry and related issues (see *Advance Preparation*)
- **Handout 5: Research for Your Media Project**

1. Discuss sources of information about science and science-based societal issues. Tell students that while some of the information they need for their projects will be learned in class, they will also need to do additional research. Ask students:

- How would you go about finding the answers to your questions?
- Where would you look?
- Who might you ask?

Possible answers:

- *Look in your science textbook*
- *Look in a local library or bookstore*
- *Do a Web search*
- *Look at newspapers and magazines*

Write down and display all of the sources students suggest. Add or prompt students to add any important ones not mentioned.

2. Show and evaluate examples of different types of information sources. Distribute **Handout 4: Consider the Source**. Show students at least one example of each of the four types of sources they will need to look at later when completing Handout 5:

- News article (from a printed newspaper or the Web site of a major printed newspaper)
- Editorial, blog post, or other opinion piece (on the Web or in print)
- Information from governmental, educational, or advocacy organizations (on the Web or in print)
- Textbook or other science reference book (in print, not on the Web)

Discuss as a class how each characteristic on Handout 4 applies to each of the four examples.

> **Note:** For more information about evaluating information sources, see *Additional Resources for Teachers*. You may want to have students read one of the articles listed there, "Evaluating Scientific Information on the World-Wide-Web," which discusses issues particular to evaluating scientific information.

Let students know that there are information sources that don't fit into any of these categories, but the same rules apply when evaluating them.

3. Assign students to begin research for their media projects.
Distribute **Handout 5: Research for Your Media Project**. Answer any questions students have, and remind them of the due date. Let them know whether they will have class time to complete it, or will be expected to complete it for homework.

Inform students that when completing Handout 5, students on the same team should coordinate their choice of sources to avoid duplication, and then each should complete the handout independently. (A team of two would therefore consult a minimum of eight sources.)

Explain that for each information source, students will be asked to explain how it contributed to their understanding of, or beliefs about, the topic. "It didn't contribute" is not an acceptable answer—students should continue their research until they find a source of each type that *does* contribute to their understanding or beliefs.

For a list of Web sites that provide a good starting point for your students' research, see *Media & Resources*.

4. Announce schedule for completion of the projects.
Tell students that once they have completed Handout 5, they should begin work on the next steps of the project. Let them know whether you will be providing class time for this. If not, make sure they understand that they need to work on their projects for homework. Remind them of the due dates of Steps 5 through 9 for their unit project (the steps listed on Handout 2). Let them know whether they will be submitting their drafts to you for feedback or will be meeting with another team during class time to exchange feedback.

Handout 4:
Consider the Source

Science is just facts, not opinions, right? So can you believe everything you read in a science book, magazine, newspaper, or Web site?

Not really.

Science-based societal issues can be very controversial. Sometimes there is disagreement about the interpretation of scientific data or the data's reliability. More often, people's differing values and priorities lead them to different points of view even when they are starting with the same science information.

As you conduct research for your media project, you will need to be a critical consumer of information. No matter where you find your sources, on the Internet or on the library shelves, you should consider the same criteria when deciding what to believe.

Authorship and publisher: Is the author qualified to write on the subject? What is his or her connection to the subject? Who published the material? Does it come from an educational institution or the government, or from an individual or private organization?

Currency: When was the material published? For books and printed materials, the copyright date gives some idea of how recent the information is. For Web sites, it may be harder to tell—a date on the site, even on the same page, can be updated without updating the other information.

Perspective: Does the source present a variety of perspectives on the subject? If it presents a single perspective, does that perspective seem well supported by scientific information?

Handout 5:
Research for Your Media Project

On a separate piece of paper, indicate what project topic you and your partner have chosen, and then answer the questions below using information sources related to this project topic.

News article

Article from a printed newspaper or the Web site of a major printed newspaper

1. Bibliographic information, including title, author, publication date, and publisher or Web address.
2. Currency: When was the article written? Does the information in the article seem like something that would change over time? How could you find out?
3. Perspective: Does the article seem to present a balanced perspective on the issue? What features of the article make it seem balanced? What features make it seem biased?
4. What you know: How does the article relate to things you already know about nuclear chemistry? Is the article consistent with what you know, or does it contradict something you have learned?
5. Your position: How did the article contribute to your understanding and/or beliefs about the topic?

Opinion piece

An editorial, blog post, or other opinion piece, on the Web or in print

1. Bibliographic information, including title, author, publication date, and publisher or Web address.
2. Currency: When was the piece written? Is the author's opinion based on information that might change over time?
3. Perspective: What are the author's beliefs or opinions about the topic? How does the author support these beliefs or opinions?
4. Your position: Did the opinion piece influence your beliefs about the topic? Why or why not?

Information from governmental, educational, or advocacy organizations

Books, Web sites, brochures, and other printed or Web-based materials from state, local, or federal government agencies; nonprofit organizations; trade associations; or universities

1. Bibliographic information, including title, author, publication date, and publisher or Web address.
2. Currency: Can you tell or estimate when the materials were written? Is the information likely to have changed since the creation of the materials?
3. Perspective: Based on the identity of the author and publisher, would you expect the informational materials to present a balanced perspective, or to take a side on an issue? Would you describe the materials as advocacy or informational? What features support your conclusion?
4. Your position: How does the information contribute to your understanding of and beliefs about the topic?

Science reference book

Printed textbook or other science reference book

1. Bibliographic information, including title, author, publication date, and publisher or Web address.
2. Currency: How recently was the book published? Could the information have changed since the publication date?
3. Your knowledge: How did this source contribute to your understanding of the topic?

Part 3: After Teaching About Nuclear Chemistry

Students complete their media projects and write artists' statements explaining the decisions they made during the creation process. They share their projects with their classmates and guests at a Media Fair.

Length

1 or 2
50-minute sessions

Advance Preparation

- Arrange to have any media equipment needed for the Media Fair. Since all the projects will be on view simultaneously, each team will need its own equipment. If many of the students' projects use electronic media, you may want to conduct the Media Fair in a computer lab.
- Optional: Invite guests or other classes to attend the Media Fair.

Activity 3A (Optional): Peer Feedback

In this optional session, teams pair up with other teams to provide each other with feedback on their drafts, outlines, or mock-ups.

> **Note:** If you choose not to have students give each other feedback during class, you will need to collect the drafts, outlines, and mock-ups and provide the teams with feedback yourself. Regardless of which option you choose, be sure to leave enough time between the draft due date and the project due date for students to incorporate the feedback they receive from you or their peers.

Understandings

- Art and media can be used to inform or persuade people about science-based societal issues.

Materials Needed

- Students' drafts, outlines, or mock-ups of their projects

1. Have students review each other's drafts.
Have each team of students pair up with another team to review each other's work thus far on the project. You may want to have students use one or more of the following prompts during their discussion:

- Based on what I read in your draft, I would explain your topic in my own words by saying . . .
- Before I could make up my own mind about the issue discussed in your project, I would want to know . . .
- One aspect of the topic that is not completely clear to me is . . .
- To help your project hold your audience's attention, you might try . . .

Activity 3B: Media Fair

Students share their projects with their classmates.

Understandings

- An understanding of nuclear chemistry is essential for many decisions students will need to make as individuals and as citizens.

Materials Needed

- Students' completed projects, bibliographies, science explanations, and artists' statements
- **Assessment Checklist 2: Media Fair Peer Assessment** (3 copies per student)
- Equipment such as DVD players, TVs, or computers with speakers to display students' projects. (There should be enough equipment for several students to play clips at the same time.)

1. Welcome guests and briefly describe the Media Fair process.
Explain to guests and students that one team member will be at the team's display to answer questions (and to provide technical assistance, if needed, with hearing or seeing the project), while other team members view the other projects. Team members will take turns staying with the team's display, so that everyone has a chance to view other teams' projects.

Explain that each student will complete peer assessments of three of the projects viewed during the Media Fair. If you are assigning students to assess particular projects, do so at this time; otherwise let the students know they can choose which projects to assess. Distribute three copies of **Assessment Checklist 2: Media Fair Peer Assessment** to each student. Tell students that teams will see the peer assessments of their projects, so students should take extra care to be fair in their comments and constructive in their criticism.

2. Provide time to view the projects.
Remind students to take turns viewing projects and staying with their own projects, so that every team member has a chance to view and assess three projects.

3. Optional: Hold a concluding discussion or reflection.
If time permits, discuss one or more of the following questions or have students reflect on a question in writing:

- Which project did you find most persuasive or informative, and why?
- What were the characteristics of the projects that best held your attention?
- What would you do differently if you were to do this project again?

Assessment Checklist 2:
Media Fair Peer Assessment

Use this assessment to evaluate your peers' media projects.

Team member names:

Project topic:

What was one interesting thing that you learned from this media project?

What did the project's creators do well?

How could the project be improved?

Appendix A: Mapping Student Questions to Nuclear Chemistry Topics

The table below shows how some questions students may ask relate to the topics covered in standard high school chemistry textbooks. This table is just an example—you will need to create your own mapping, specific to your students' questions and to the teaching resources available to you.

At the start of each nuclear chemistry lesson, indicate which cluster(s) of questions from the Question Board will be addressed. Note that many of the students' questions may not be fully answered by in-class learning experiences, but what they learn in class will give them a foundation for understanding material they find during their project research. You can inform students at the start of the unit which questions they will need to research on their own, and suggest resources for them to consult. (See *Media & Resources* for suggestions.)

Questions about . . .	**Common Textbook Topics**
what radiation is	radioactive decay; alpha particles, beta particles, and gamma rays
radioactivity causing cancer, why people are afraid of radioactivity, why nuclear weapons are so feared	biological effects of ionizing radiation, including types of radiation damage (genetic and somatic)
why someone would want to irradiate food, why someone would oppose irradiating food	biological effects of ionizing radiation
what makes something radioactive, why some materials are radioactive and some are not	nuclear stability strong nuclear force neutron-proton ratios the band of stability
how and when something becomes less radioactive or stops being radioactive	radioactive decay series; half-life
how nuclear power plants work, fears related to nuclear power plants, failure modes of nuclear power plants	fission; chain reactions; critical mass; fusion and the cold fusion controversy; mass defect
how nuclear weapons work	fission, fusion
why cancer can be treated with radiation	biological effects of ionizing radiation
what radon is, why it is harmful	alpha radiation, biological effects of radiation

Materials Needed

Throughout the Unit

- Projector and computer

Part 1: Before Teaching About Nuclear Chemistry

Writing Supplies and Other Equipment

- Paper roll (such as butcher paper, kraft paper, or easel paper)
- Markers (one per student)
- Sticky notes (several per student)

Handouts

- **Handout 1: Unit Overview**
- **Handout 2: *The Power of the Nucleus* Project Description**
- **Handout 3: *The Power of the Nucleus* Project Topics**
- **Assessment Checklist 1: *The Power of the Nucleus* Project**

Media Resources

- Slide presentation "The Power of the Nucleus"

Advance Preparation

- Download the slide presentation "The Power of the Nucleus" (See *Media & Resources*.)
- Prepare a long piece of paper roll (such as butcher paper, kraft paper, or easel paper) for the Chalk Talk by writing the words "nuclear" and "radiation." Leave plenty of space around each word for students' contributions.
- Prepare a "Question Board"—a flat surface where students can post the sticky notes from Activity 1. This could be a whiteboard, a blank wall, or several large adjacent sheets of chart paper. You will refer to the Question Board during each class session on nuclear chemistry, so set up the Question Board in such a way that it can remain posted throughout the entire unit.

Part 2: While Teaching About Nuclear Chemistry

Writing Supplies and Other Equipment

- Computer and projector, or one computer per pair of students

Handouts

- **Handout 4: Consider the Source**
- **Handout 5: Research for Your Media Project**

Media Resources

- Examples of media about science-based societal issues (see *Advance Preparation*)
- Examples of information sources about nuclear chemistry and related issues (see *Advance Preparation*)

Items Students Need to Bring

- Students' copies of **Handout 2: *The Power of the Nucleus* Project Description**

Advance Preparation

- For Activity 2A.1, choose examples of media about science-based societal issues (other than those related to nuclear chemistry) that have the following characteristics:
  - contain science content
  - are the same or similar in format to the projects your students will do, for example, brochures, posters, and public service announcements
  - demonstrate how the same topic is presented by different organizations and/or in different formats

  For media examples on the topic of global climate change, see *Media & Resources*. If you would like to use examples on a different topic, see *Additional Resources for Teachers*.

  Note: Many brochures you will find online as PDFs were not designed for viewing online. We recommend printing a few hard copies of any such brochures you want your students to see.

- For Activity 2B, choose examples of information sources about nuclear chemistry topics. Have at least one example for each type of information source listed in **Handout 5: Research for Your Media Project**:
  - News article (from a printed newspaper or the Web site of a major printed newspaper)
  - Editorial, blog post, or other opinion piece (on the Web or in print)

- Information from a governmental, educational, or advocacy organization (on the Web or in print)
- Textbook or other science reference book (in print, not on the Web)

For examples of the first three types of sources, see *Media & Resources*. (Science reference books can be found at your school or community library.)

Part 3: After Teaching About Nuclear Chemistry

Writing Supplies and Other Equipment

- Equipment such as DVD players, TVs, or computers with speakers to display students' projects. (There should be enough equipment for several students to play clips at the same time.)

Handouts

- **Assessment Checklist 2: Media Fair Peer Assessment** (3 copies per student)

Items Students Need to Bring

- Students' drafts, outlines, or mock-ups of their projects
- Students' completed projects, bibliographies, and artists' statements

Advance Preparation

- Arrange to have any media equipment needed for the Media Fair. Since all the projects will be on view simultaneously, each team will need its own equipment. If many of the students' projects use electronic media, you may want to conduct the Media Fair in a computer lab.
- Optional: Invite guests or other classes to attend the Media Fair.

Media & Resources

These recommended Web sites have been checked for availability and for advertising and other inappropriate content. However, because Web site policies and content change frequently, we suggest that you preview the sites shortly before using them.

Media & Resources are also available at http://dma.edc.org and at http://dmamediaandresources.pbworks.com, a Wiki that allows users to add and edit content.

Part 1: Before Teaching About Nuclear Chemistry

Activity 1A: Connecting to Nuclear Chemistry

Slide Presentation: The Power of the Nucleus

Use this slide presentation to introduce your students to a variety of ways in which nuclear chemistry touches their lives. (Download the presentation from the *Media & Resources* area on the Digital / Media / Arts Web site.)

Part 2: While Teaching About Nuclear Chemistry

Activity 2A.1: Examining Examples

Global Climate Change

Brochures

Climate Change. The NEED Project.
www.need.org/needpdf/infobook_activities/SecInfo/GlobalS.pdf

Climate Change: NOAA National Weather Service
www.weather.gov/om/brochures/climate/Climatechange.pdf

Poster

Global Warming. RLM Arts.
www.rlmarts.com/products/posters/health-environment/p820.html

Web-based computer game

Climate Challenge.
www.bbc.co.uk/sn/hottopics/climatechange/climate_challenge/

Video

Climate Change (approximate length 2 minutes).
www.youtube.com/watch?v=AO7OOzgdHfA

Note: A great many sources of information incorrectly explain the science behind the "Greenhouse Effect." Looking at media about global climate change is a good opportunity to encourage your students to be critical consumers of information.

Activity 2B: Sources of Science Information

Examples of Science Sources for Class Discussion in Activity 2B

News articles

Irradiation could curb food illnesses. *Los Angeles Times*.
http://articles.latimes.com/2008/apr/11/nation/na-greens11

Promise Seen for Detection of Alzheimer's. *The New York Times*.
www.nytimes.com/2010/06/24/health/research/24scans.html

Editorial, blog post, or other opinion pieces

The Food Irradiation Plot. *Natural News*.
www.naturalnews.com/023015_food_foods_USDA.html

Going Nuclear: A Green Makes the Case. *The New York Times*.
www.washingtonpost.com/wp-dyn/content/article/2006/04/14/AR2006041401209.html

Don't let politics drive a nuclear-waste decision. *The Washington Post*.
www.washingtonpost.com/wp-dyn/content/article/2010/07/18/AR2010071802520.html

Information from a governmental, educational, or advocacy organization

Nuclear Weapons. Nuclear Age Peace Foundation.
www.wagingpeace.org/menu/issues/nuclear-weapons/

Radon. U.S. Environmental Protection Agency.
www.epa.gov/radon/

Recommended Online Information Sources for Student Projects

General Information Relevant to All Project Topics

Nuclear Physics. HyperPhysics.
http://hyperphysics.phy-astr.gsu.edu/hbase/nuccon.html

Biological Effects of Radiation. *Nuclear Reactor Concepts Workshop Manual*, U.S. NRC.
www.nrc.gov/reading-rm/basic-ref/teachers/09.pdf

EPA Radiation Protection: Health Effects.
www.epa.gov/radiation/understand/health_effects.html

Natural and Man-Made Radiation Sources. *Nuclear Reactor Concepts Workshop Manual*, U.S. NRC.
www.nrc.gov/reading-rm/basic-ref/teachers/06.pdf

Category 1: Radiation in Everyday Life

Topic 1A: Irradiated foods

Irradiation of Food. *The New York Times*.
http://topics.nytimes.com/topics/reference/timestopics/subjects/i/irradiation_of_food/

Food Irradiation. Centers for Disease Control and Prevention.
www.cdc.gov/ncidod/dbmd/diseaseinfo/foodirradiation.htm

Irradiated Food and Packaging. U.S. Food and Drug Administration.
www.fda.gov/Food/FoodIngredientsPackaging/IrradiatedFoodPackaging/default.htm

Backgrounder: Food Irradiation. Food Marketing Institute.
www.fmi.org/media/bg/foodirradiation.pdf

Irradiation could curb food illnesses. *Los Angeles Times*.
http://articles.latimes.com/2008/apr/11/nation/na-greens11

Topic 1B: Radon

Radon. U.S. Environmental Protection Agency.
www.epa.gov/radon/

Radon and Cancer: Questions and Answers.
www.cancer.gov/cancertopics/factsheet/Risk/radon

Effects of Exposure to Radon Gas. United Nations Scientific Committee on the Effects of Atomic Radiation.
www.unscear.org/docs/Radon-distrib.pdf

How Radon Works. HowStuffWorks.
http://home.howstuffworks.com/home-improvement/household-safety/tips/radon.htm

Category 2: Nuclear Energy

Topic 2A: Nuclear power plants

NewsWatch: Energy: Nuclear. *Houston Chronicle*.
http://blogs.chron.com/newswatchenergy/archives/nuclear/

Nuclear Energy. *The New York Times*.
www.nytimes.com/info/nuclear-energy/

Nuclear industry takes new path for new plants. MercuryNews.com.
www.mercurynews.com/ci_15948744

Going Nuclear: A Green Makes the Case. *The Washington Post*.
www.washingtonpost.com/wp-dyn/content/article/2006/04/14/AR2006041401209.html

Nuclear Reaction: Why Do Americans Fear Nuclear Power? Frontline, WGBH Educational Foundation.
www.pbs.org/wgbh/pages/frontline/shows/reaction/

Topic 2B: Cold fusion

New Cold Fusion Evidence Reignites Hot Debate. *IEEE Spectrum*.
http://spectrum.ieee.org/energy/nuclear/new-cold-fusion-evidence-reignites-hot-debate

A Tempest in a Test Tube, 10 Years Later. *The New York Times*.
http://partners.nytimes.com/library/national/science/032399sci-cold-fusion.html?scp=3&sq=cold%20fusion&st=cse

Cold Fusion Is Hot Again. 60 Minutes.
www.cbsnews.com/stories/2009/04/17/60minutes/main4952167.shtml

Category 3: Scientific and Medical Applications

Topic 3A: Radioactive dating

Mystery of the First Americans: The Dating Game. Nova.
www.pbs.org/wgbh/nova/first/radiocarbon.html

Carbon Dating. *The New York Times*.
http://topics.nytimes.com/topics/news/science/topics/carbon_dating/

Radioactive Dating. Hyperphysics.
http://hyperphysics.phy-astr.gsu.edu/hbase/nuclear/raddat.html

Topic 3B: Radiation therapy for cancer

Radiation Therapy for Cancer. National Cancer Institute.
www.cancer.gov/cancertopics/factsheet/Therapy/radiation

Radiation Therapy. MedlinePlus, U.S. National Library of Medicine.
www.cancer.gov/cancertopics/factsheet/Therapy/radiation

Radiation Boom. *The New York Times*.
http://topics.nytimes.com/top/news/us/series/radiation_boom/index.html

Topic 3C: Nuclear medicine

General Nuclear Medicine. RadiologyInfo.org.
www.radiologyinfo.org/en/info.cfm?pg=gennuclear

Health Guide: Isotope Study. *The New York Times*.
http://health.nytimes.com/health/guides/test/isotope-study/overview.html

www.asrt.org/content/ThePublic/AboutRadiologicProcedures/Nuclear_Medicine.aspx

PET scan. MedlinePlus, U.S. National Library of Medicine.
www.nlm.nih.gov/medlineplus/ency/article/003827.htm

Radiation Boom. *The New York Times*.
http://topics.nytimes.com/top/news/us/series/radiation_boom/index.html

Category 4: Nuclear Legacy

Topic 4A: Nuclear weapons

Nuclear Weapons. *The New York Times*.
http://topics.nytimes.com/top/news/science/topics/atomic_weapons/index.html

Race for the Superbomb. American Experience.
www.pbs.org/wgbh/amex/bomb/index.html

Nuclear Weapons. *USA Today*.
http://content.usatoday.com/topics/topic/Nuclear%20Weapons

Nuclear Weapons. Nuclear Age Peace Foundation.
www.wagingpeace.org/menu/issues/nuclear-weapons/

Topic 4B: Long-term nuclear waste disposal

Nuclear Waste. *The New York Times*.
http://topics.nytimes.com/top/reference/timestopics/subjects/n/nuclear_wastes

Yucca Mountain. *The New York Times*.
http://topics.nytimes.com/top/news/national/usstatesterritoriesandpossessions/nevada/yucca-mountain

Don't let politics drive a nuclear-waste decision. *The Washington Post*.
www.washingtonpost.com/wp-dyn/content/article/2010/07/18/AR2010071802520.html

Half-Life: The Lethal Legacy of America's Nuclear Waste. *National Geographic*.
http://ngm.nationalgeographic.com/static-legacy/ngm/0207/feature1/index.html

Nuclear Waste Disposal. Nuclear Energy Institute.
www.nei.org/keyissues/nuclearwastedisposal/

Additional Resources for Teachers

Part 1: Before Teaching About Nuclear Chemistry

Activity 1A: Connecting to Nuclear Chemistry

Glossary from the Nuclear Regulatory Commission
www.nrc.gov/reading-rm/basic-ref/glossary/full-text.html

Understanding Radiation in Our World (Introduction, Chapter 1, and Chapter 2)
http://downloads.nsc.org/PDF/063105_Radiation.pdf

Teachers' Domain

Teachers' Domain is a library of free digital media resources produced by public television. Guest users can view a limited number of resources; unlimited access to the site requires free registration. The following Teachers' Domain science subtopics have high-quality media related to nuclear chemistry:

- Science → Physical Science → Energy → Nuclei and Radiation
  www.teachersdomain.org/collection/k12/sci.phys.energy.nucrad/
- Science → Physical Science → Matter → Atomic Nucleus
  www.teachersdomain.org/collection/k12/sci.phys.matter.atnuc/

Activity 1B: Exploring Project Topics

Nuclear Chemistry Applications and Issues

Use these Web sites to familiarize yourself with the ways in which nuclear chemistry is important in social, political, environmental, and health issues.

Key Issues of the Nuclear Age
www.nuclearfiles.org/menu/key-issues/

International Atomic Energy agency: News Centre: In Focus
www.iaea.org/NewsCenter/Focus/index.html

Understanding Radiation in Our World (Chapters 3 and 4)
http://downloads.nsc.org/PDF/063105_Radiation.pdf

Biological Effects of Ionizing Radiation

"Biological Effects of Radiation" from the *Nuclear Reactor Concepts Workshop Manual*, U.S. NRC.
www.nrc.gov/reading-rm/basic-ref/teachers/09.pdf

EPA Radiation Protection: Health Effects
www.epa.gov/radiation/understand/health_effects.html

Part 2: While Teaching About Nuclear Chemistry

Activity 2A.1: Examining Examples

Public Service Announcements. The Museum of Broadcast Communication.
www.museum.tv/eotvsection.php?entrycode=publicservic

AdCouncil Campaigns.
www.adcouncil.org/default.aspx?id=15

Activity 2B: Sources of Science Information

Evaluating Scientific Information on the World-Wide-Web.
www.lib.flinders.edu.au/info/branch/medical/evaluation.pdf

Critically Analyzing Information Sources. Cornell University Library.
www.library.cornell.edu/olinuris/ref/research/skill26.htm

Evaluating Web Pages: Techniques to Apply & Questions to Ask.
www.lib.berkeley.edu/TeachingLib/Guides/Internet/Evaluate.html

Evaluating Information Found on the Internet. Johns Hopkins University.
www.library.jhu.edu/researchhelp/general/evaluating/index.html

Standards

This unit was developed to frame coverage of the following standards.

California Academic Content Standards for Chemistry, Grades 9–12

11. Nuclear processes are those in which an atomic nucleus changes, including radioactive decay of naturally occurring and human-made isotopes, nuclear fission, and nuclear fusion. As a basis for understanding this concept:

a. Students know protons and neutrons in the nucleus are held together by nuclear forces that overcome the electromagnetic repulsion between the protons.
b. Students know the energy release per gram of material is much larger in nuclear fusion or fission reactions than in chemical reactions. The change in mass (calculated by E=mc2) is small but significant in nuclear reactions.
c. Students know some naturally occurring isotopes of elements are radioactive, as are isotopes formed in nuclear reactions.
d. Students know the three most common forms of radioactive decay (alpha, beta, and gamma) and know how the nucleus changes in each type of decay.
e. Students know alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and have different penetrations.

This unit was developed to meet the following standards.

California Academic Content Standards for Investigation and Experimentation, Grades 9–12

1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:

l. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.
m. Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.

CTE AME Industry Sector Foundation Standards

1.0 Academics

Students understand the academic content required for entry into postsecondary education and employment in the Arts, Media, and Entertainment sector.

1.2 Science

Specific applications of Investigation and Experimentation standards (grades nine through twelve):

(1.l) Analyze situations and solve problems that require combining and applying concepts from more than one area of science.

2.0 Communications

Students understand the principles of effective oral, written, and multimedia communication in a variety of formats and contexts.

2.1 Reading

Specific applications of Reading Comprehension standards (grades nine and ten):

(2.2) Prepare a bibliography of reference materials for a report using a variety of consumer, workplace, and public documents.
(2.3) Generate relevant questions about readings on issues that can be researched.

2.2 Writing

Specific applications of Writing Strategies and Applications standards (grades eleven and twelve):

(1.1) Demonstrate an understanding of the elements of discourse (e.g., purpose, speaker, audience, form) when completing narrative, expository, persuasive, or descriptive writing assignments.

(2.6) Deliver multimedia presentations:
a. Combine text, images, and sound and draw information from many sources (e.g., television broadcasts, videos, films, newspapers, magazines, CD-ROMs, the Internet, electronic media-generated images).
b. Select an appropriate medium for each element of the presentation.
c. Use the selected media skillfully, editing appropriately and monitoring for quality.

Bibliography

National Safety Council. (2005, July). *Understanding Radiation in Our World*. Retrieved September 16, 2010 from http://downloads.nsc.org/PDF/063105_Radiation.pdf

U.S. Nuclear Regulatory Commission. (2010, April 27). *Teachers' Lesson Plans*. Retrieved September 16, 2010 from www.nrc.gov/reading-rm/basic-ref/teachers.html