Autoradiographs

With the Autoradiograph activity, students gain a better understanding of the different types of radiation, alpha, beta, and gamma. This is a way that students can detect invisible emissions.

This experiment is best used by students working in groups.

Grade Level

1-5 (sun paper)
6-8 (demonstration)
9-12 (activity)

Disciplinary Core Ideas (DCI, NGSS)

5-PS1-1, MS-PS1-1, MS-PS1-4, HS-PS1-8, HS-PS4-2, HS-PS4-5

Time for Teacher Preparation

30-60 minutes – To gather materials and set-up
1 Week to develop the autoradiograph

Activity Time:

30-60 minutes (1 Class Period) for set-up
30-60 minutes (1 Class Period) to develop the autoradiograph

Materials

- Pen, Marker, or Pencil
- 1 box-Polaroid Type 57 instant (3000 speed) 4x5 packet film
- Radiation Sources
  - 1 Coleman Lantern Mantle
  - Fiesta®ware plate
  - Radium-dial clock
  - Smoke-detector part (Americium)
  - Uranium ore (sealed in a plastic ziplock to prevent dust contamination)
- Rubber or plexiglass photo developing roller, rolling pin, or sturdy wooden or plastic ruler
- Sheet of aluminum foil, paper (optional)
- Student Data Collection Sheets

Safety

- Students should use care when handling aluminum foil
- Students should not touch chemicals on polaroid film on their bare hands
- Students should use care when touching radioactive materials.
- Students should wash hands after handling radioactive materials.

Science and Engineering Practices (NGSS)

- Ask questions and define problems
- Use Models
- Plan and Carry out investigation
- Analyze and interpret data
- Using mathematics, information and computers
- Argue from Evidence
- Obtain, evaluate and communicate information

Cross Cutting Concepts (NGSS)

- Patterns
- Cause and Effect
- Scale, Proportion, and Quantity
- Systems and System Models
- Energy and Matter: Flows, Cycles, and Conservation
- Structure and Function
- Stability and Change of Systems

Objectives

- To visually demonstrate the concepts of ionizing radiation.

Background

Autoradiographs

Often used to detect radiation by imaging its emissions, an autoradiograph is a representation of where radioactive substances are located. The image can be projected onto a medium such as an x-ray film, nuclear emulsion, or even photographic film. Autoradiography, which can also be digital, is used in many cases for biological and medical applications. In contrast to other methods of detecting radiation, they can show the locations of radioactive materials in a sample. The images can therefore be used with biological specimens labeled with such materials, to track cellular activity for example.

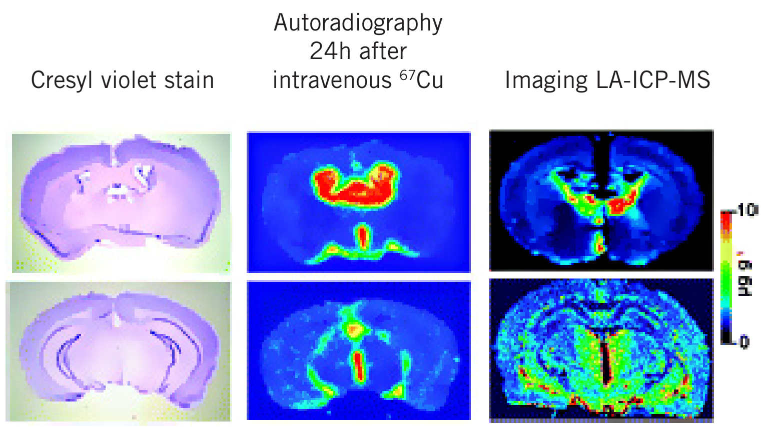

Figure 1: Bioimaging of copper alterations in the aging mouse brain by autoradiography, laser ablation inductively coupled plasma mass spectrometry and immunohistochemistry

Source: http://pubs.rsc.org/en/content/articlelanding/2010/mt/c003875j/unauth#!divAbstract

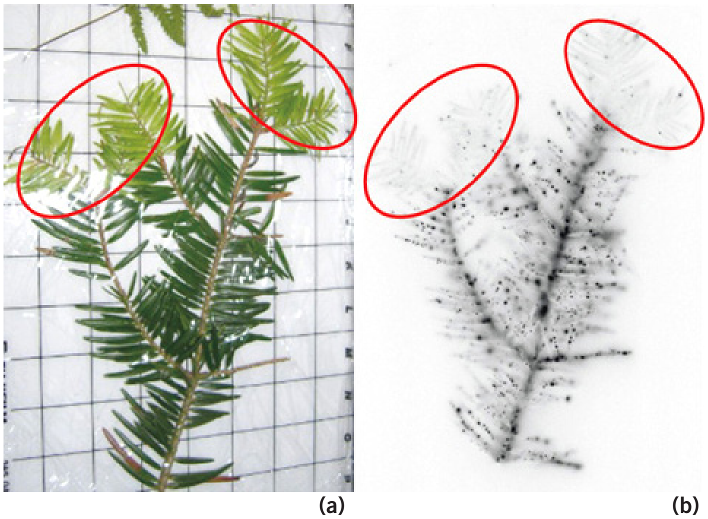

Figure 2: (a) Photograaph of Torreya nucifera, (b) autoradiograph image. Black spots in (b) showed the radiation source in branches and leaves, indicating the presence of radioactive Cs. Red circles indicate the leaves (light green colored leaves in (a)) that grew after the accident. Black spots are practically zero within the red circles, indicating that the radioactive samples from the old leaves were rarely transported to the young leaves. See details in the text.

Source: http://jolisfukyu.tokai-sc.jaea.go.jp/fukyu/mirai-en/2012/1_17.html

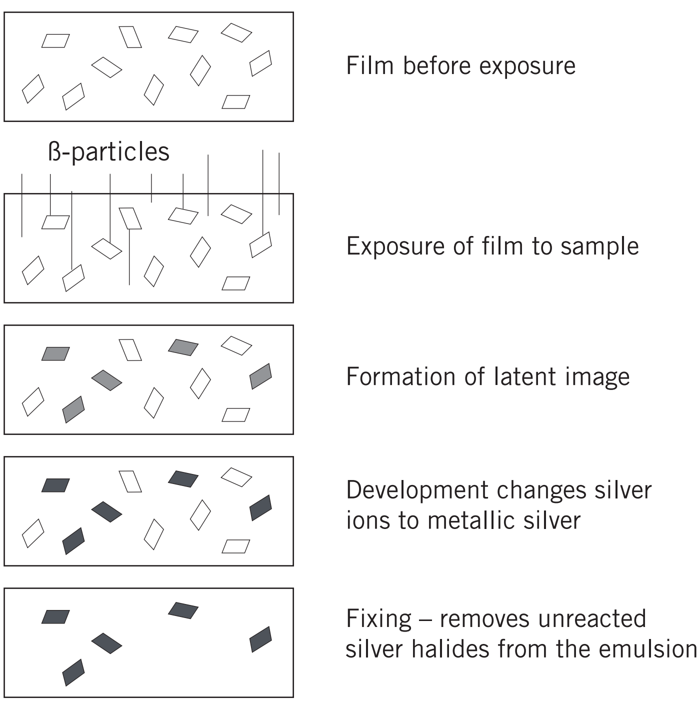

Figure 3: This shows how the beta particles fix the image on the photographic substrate and is used for the autoradiograph section of seeing the invisible.

In its basic form, an autoradiograph can require film to be exposed overnight. Radioactivity is detected through bands on an image, which are produced as particles hit crystals of silver halide. The images on the film typically depend on the activation of the crystals and the effects of particles on a gel. If each crystal is insulated by a gelatin capsule, then a permanently developed image can accurately show the sample and where it is radioactive.

An autoradiograph is often taken after biological tissue is exposed to a radioactive substance, left for a certain period of time, and examined under a microscope. Sections can be cut and a photographic image can be developed as a radioisotope decays. Samples are often stained to enhance the detail and to see the grains of silver that react with the substance. The resulting autoradiograph can be recorded and kept on file as part of an experiment or test.

While a solid film was typically used in the past, a liquid emulsion is often used in the 21st century to make an autoradiograph. This technique can take less time to complete. Liquid can flow and make the thickness of the sample uneven, but following the basic steps for coating slides and developing the film can dry the sample appropriately. A phosphor-imager screen can help detect radioactivity in gel quicker than x-ray film. It is typically used with electronic instruments and a computer system that can digitally image the sample.

Autoradiographs can show radioactive particles attached to enzymes or integrated into nucleic acid. Metabolic processes can be tracked in cells when images of radioactive particles are compared. Researchers can track proteins, photosynthesis, and the division and movement of cells. Sequences of deoxyribonucleic acid (DNA) can be tracked. Autoradiography DNA is often used to monitor cell cycles and track the progress of viruses to analyze their behavior.

Teacher Lesson Plan:

Traditional

Paper

1. Prepare **Autoradiographs** in accordance with Autoradiograph instructions:
   a. Place a key, coin, or other metal object onto the face of the film sheet. Place a Coleman lantern mantle, Fiesta®ware plate, or a radium-dial clock completely over the object. Let it sit for at least one week.
   b. Remove the mantle and object from the film sheet. Lay the sheet on a flat table with the side marked "This side toward lens" up. Locate the bulge in the sheet that contains the developer chemicals. Place a ruler, flashlight, or other stiff, heavy object (a roller works best) behind the bulge and, while applying moderate pressure, slowly and evenly drag the object across the film sheet to spread the chemicals. Even distribution of the chemicals is critical for good development. It takes lots of practice to make a good picture.

c. Wait 30 seconds for the film to develop then open the packet.

d. Students will find a dark shadow of the metal object surrounded by a white "fog". The white is due to the radiation given off by the Coleman mantle exposing the film. The dark shadow is because the metal object shielded the radiation from the film.

NOTE: You can use the three radiation sources on one film sheet in lieu of the key and Coleman lantern mantle, Fiesta®ware plate, or a radium-dial clock. Students will find that only the beta and gamma sources will expose the film. This is because the paper surrounding the film shields alpha radiation.

NOTE: Elementary school students could try to perform this experiment using SunSensitive paper rather than Polaroid film. The SunSensitive paper reacts to UV sunlight and would be a good substitution for Polaroid film for this experiment.

NGSS Guided Inquiry

1. Break students up into groups of three
2. Give each group
   - A sheet of film
   - A sheet of paper and some aluminum foil
   - An alpha, beta, and gamma source
3. Have groups design an experiment to discover what kind of radiation each source is emitting.

Student Procedure

1. Place a key, coin, or other metal object onto the face of the film sheet. Place a Coleman lantern mantle, Fiesta®ware plate, or a radium-dial clock completely over the object
2. Allow the photos to develop for a week
3. Develop the film according to your teacher's instructions
4. Observe the resulting image that is developed

Data Collection

- Attached Student Data Collection Sheets
- Students should label sources and type of radiation on film

Post Discussion/Effective Teaching Strategies

Questions provided on the Student Data Collection Sheets

Questions

1. What caused the image to develop on the sheet of film?
2. How did you use shielding principles to identify what kind of radiation each source emits?
3. For sun paper activity, how does placing an object on the sun paper and putting sun screen on skin compare to protecting an area from the sun's radiation?

Assessment Ideas

Have students identify an unknown source by experimenting with shielding, different sources, and different types of film.

Differentiated Learning/Enrichment

- Explore how autoradiography is used in DNA sequencing.
- Have students place various objects between the film and the source (coin, leaf, paperclips, etc.)

Enrichment Question

1. How did scientists use this concept in medicine?
   a. Compare the early usage of 1900's Medicine to today's application.

References

ANS Center for Nuclear Science and Technology Information

http://www.nuclearconnect.org/in-the-classroom/for-teachers/making-radiation-photographs

http://www.nuclearconnect.org/know-nuclear/applications/medical-uses

Autoradiographs Background:

http://www.wisegeek.com/what-is-an-autoradiograph.htm

Image Credits:

Figue 1: http://pubs.rsc.org/en/content/articlelanding/2010/mt/c003875j/unauth#!divAbstract

Figue 2: http://jolisfukyu.tokai-sc.jaea.go.jp/fukyu/mirai-en/2012/1_17.html

Making Atoms Visible

Autoradiographs

Student Data Collection ANSWER Sheet

Objectives

- To visually demonstrate the concepts of ionizing radiation.

Directions

1. Place a key, coin, or other metal object onto the face of the film sheet. Place a Coleman lantern mantle, fiesta-ware plate, or a radium-dial clock completely over the object
2. Allow the photos to develop for a week
3. Develop the film according to your teacher's instructions
4. Observe the resulting image that is developed
5. Attach developed film to this sheet and label

Questions

1. What caused the image to develop on the sheet of film?

   The gamma radiation from the lantern mantle.

2. How did you use shielding principles to identify what kind of radiation each source emits?

   By using lead or aluminum foil or other objects, you can determine what kind of radiation that goes through.

3. For sun paper activity, why does placing an object on the sun paper and putting sun screen on skin compare to protecting an area from the Sun's radiation.

   Both physically block the cosmic radiation from the sun.

Enrichment Question

1. How did scientists use this concept in medicine?
   a. Compare the early usage of 1900's medicine to today's application.

   Have student research about the uses of x-ray Radium and Radon and today's medical uses.

Making Atoms Visible

Autoradiographs

Student Data Collection Sheet

Name: ______________________________

Date: ______________________________

Objectives

- To visually demonstrate the concepts of ionizing radiation.

Directions

1. Place a key, coin, or other metal object onto the face of the film sheet. Place a Coleman lantern mantle, fiesta-ware plate, or a radium-dial clock completely over the object
2. Allow the photos to develop for a week
3. Develop the film according to your teacher's instructions
4. Observe the resulting image that is developed
5. Attach developed film to this sheet and label

Questions

1. What caused the image to develop on the sheet of film?
2. How did you use shielding principles to identify what kind of radiation each source emits?
3. For sun paper activity, how does placing an object on the sun paper and putting sun screen on skin compare to protecting an area from the Sun's radiation?

Enrichment Question

1. How did scientists use this concept in medicine?
   a. Compare the early usage of 1900's medicine to today's application.