5TH GRADE SCIENCE - RADON LESSON PLAN

Introduction

Radon is a cancer-causing, naturally occurring radioactive gas that you cannot see, smell, or taste. Radon emanates from soil and bedrock, including granite, and can seep into homes primarily through cracks and seams in foundation floors and walls. It may also enter through well water.

Communities in southeastern and eastern New Hampshire have the highest percentage of homes with elevated radon levels. Rockingham, Carroll, and Strafford counties have several communities in which more than half of the homes tested had elevated radon. Exposure to radon gas is the second leading cause of lung cancer in the United States, with more than 21,000 deaths attributed annually to radon-related lung cancer. Radon is associated with approximately 100 lung cancer and related deaths in New Hampshire residents each year.

The mission of the New Hampshire Radon Program is to help all people in New Hampshire understand the health impacts of radon. To reach the younger population, the New Hampshire Division of Public Health Services and the New Hampshire Radon Program have developed curriculum with a primary focus on raising awareness among youth on the health effects and mitigation of radon.

This lesson plan is adapted from the Colorado Fifth Grade Science Radon Lesson Plan. Efforts have been made to adapt this lesson plan to fit within New Hampshire's Common Core State Standards and the Next Generation Science Standards performance expectations. Please see the following page for the specific academic standards met by this lesson plan.

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STANDARDS MET

Common Core State Standards for ENGLISH

Reading Standards for Literacy in Science and Technical Subjects

1. Cite specific textual evidence to support analysis of science and technical texts.
2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Common Core State Standards for MATHEMATICS

The Number System

- Understand the place value system
- Perform operations with multi-digit whole numbers and with decimals to hundredths
- Measurement and Data
- Convert like measurement units within a given measurement system
- Represent and interpret data

Next Generation SCIENCE Standards

DCI Arrangements of the Next Generation Science Standards

MS-LS1-1. Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.

MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.

HEALTH Education Curriculum Guidelines - Middle School Curriculum

Community and Environmental Health

1. Community and Environmental Health Services
    - 1.1 Identify home, school and community resources to promote health
    - 1.2 Identify how to access health agencies
    - 1.3 Identify Public Service Community Health Activities
2. Environmental Health and Resource Conservation

2.1. Recognize environmental health risks

2.2 Analyze the community for health problems

LESSON PLAN OBJECTIVES:

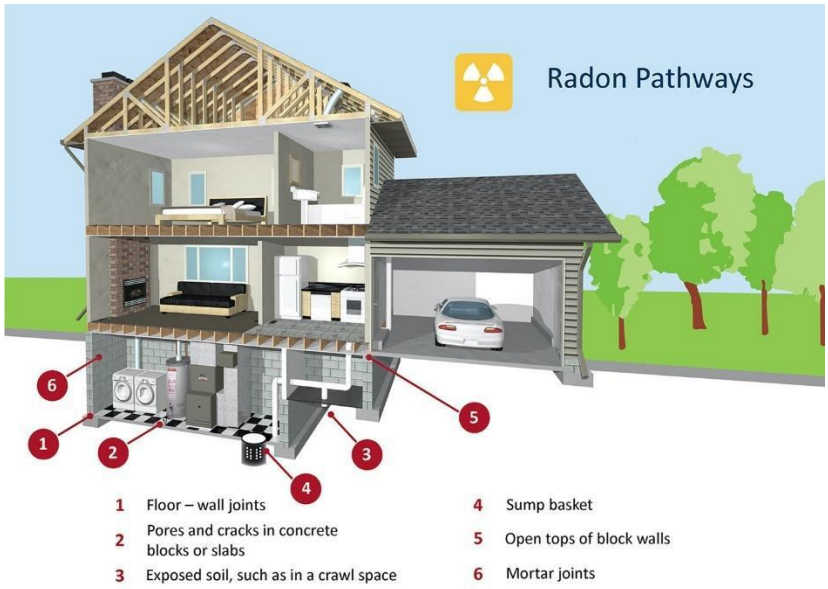
Students will be able to:

- Recall the properties of radon
- Explain how radon is formed and how it impacts health
- Describe how radon enters homes
- Identify forces and processes that result in increased or decreased radon levels
- Apply Bernoulli's Principle to predict radon test outcomes in different environmental conditions
- Identify ideal conditions for radon testing
- Create original messaging to advocate for radon testing

LESSON ASSETS:

- Lesson Plan
- Experiment
- Activities & Demonstrations
- PowerPoint
- Student Booklet
- Teacher Booklet

A minimum of 4-6 class periods recommended to facilitate lesson portions.



Note: In advance of implementation, ensure to coordinate collection and/or delivery of FREE radon test kits for the number of students applicable to the implementation of this lesson, from your local public health agency. NH residents can order free radon test kits through this order form.

For questions or more information, contact the New Hampshire Radon Program at (603) 271-1708 and radon@dhhs.nh.gov.

LEAD-UP DIALOGUE OPTION

- Introduction: Radiation is energy that moves from one place to another by waves or atomic particles. Light, sound, and heat are all examples. The Sun produces and sends out many types of radiation. Visible light is actually the only type of radiation you can see. (When it is broken down by a spectrum it produces red, orange, yellow, green and blue)
- Question: Can you feel UV Rays? (Yes, you can get sunburned)
- Question: Can you experience damage from it? (Yes, skin cancer. Radiation can damage cells that make up the human body)
- Question: What other forms of radiation can damage our cells?

PART 1: RADON IN YOUR LUNGS

RECOMMENDED TIME: 45 MINUTES

QUESTIONS:

- What are the properties of radon?
- How is radon formed?
- How does exposure to radon affect human health?

Materials: Projection/Smartboard, Radon PowerPoint, Student Radon Booklets (printed for each student), table, transparent tape, masking tape, paper hole punch pieces.

Slides 1-15: Introduce radon through presentation and student engagement with content of Radon PowerPoint and Student Radon Booklets.

Class Demonstration 1 – "Static Cling"

Procedures:

1. Place a semi-long piece of clear tape sticky side down on the table top.
2. Place punch pieces in a row on the table.
3. Quickly pull the tape off the table and hold each end.
4. Slowly lower the tape, sticky side up, above the pieces of paper until the tape almost touches the paper pieces, and then slowly raise the tape up.

Inferences:

What ideas do you have about why they were attracted to each other?
When the tape is pulled off the friction charges the tape by static electricity. The pieces of paper are oppositely charged now, so they cling together with "static cling."

How does this demonstration represent how radon decay products become attached to dust?
The clear tape represents dust; the punch pieces represent radon decay products. Radon decay products and dust are attracted to each other because they are oppositely charged.

Class Demonstration 2 – "Between a Rock and a Hard Place"

Demonstrate how radon decay products and dust become trapped in the lungs. The masking tape represents the lining of the lungs; the hole punch pieces represent radon decay products with dust.

Procedures:

- Arrange paper hole punch pieces in a small area on a table close to you.
- Set a semi-long piece of masking tape on one of its side edges with the sticky side facing you.
- Position tape so you are looking across a small pile of punch pieces with the tape in a semicircle.
- At eye level gently blow the paper pieces toward the tape.

Inferences:
How does this simulation demonstrate a health risk?

The radon decay products with dust adhere to the sticky mucus lining of the lungs. Once the radon decay products have been trapped on the lung lining, the sensitive cells of the lung can be exposed to alpha radiation that can cause lung cancer.

TEACHER'S NOTES AND DEBRIEFING:

Radon is an invisible, tasteless, odorless, and radioactive gas. Radioactive is a term to describe unstable atoms that spontaneously change into different atoms which results in radiation. Half-life is related to radioactivity intensity; the shorter the half-life, the greater the radioactive intensity. Radon has a half-life of 3.8 days. Because of a relatively short half-life, radon and its decay products give off a lot of radiation in a short period of time. Radiation where atoms are physically changed by making them electrically charged is known as ionizing radiation. All forms of ionizing radiation (Alpha, Beta, Gamma and X-ray) can result in cancer, but some are more damaging than others. Alpha particles are

not very penetrating but are extremely hazardous once inside the body. Radon gives off alpha particles which damage tissue more easily than beta or gamma radiation. Radon gas and its decay products account for over half of our ionizing radiation exposure, and that exposure to ionizing radiation can cause cancer.

Radon is present in soils and rocks because it is a decay product from uranium and radium. It is also in ground water because it can be dissolved, and in air because it is a gas. Since radon is a gas, it enters and exits the lungs easily during breathing. The real danger to our lungs is not the radon gas itself, but the radon decay products which are solid materials. The radioactive radon decay solids stick to dust particles in the air. Radon decay products and dust are attracted to each other because they are oppositely charged, similar to the "static cling" demonstration. When the tape is pulled off the table it becomes charged due to friction, and the oppositely charged paper pieces are attracted to the tape. The clear tape represents dust and the paper hole punch pieces represent the radon decay products.

Normal breathing brings the dust with the decay products attached into the lungs where they are trapped by the sticky, mucous-covered tissues that line the trachea, bronchial tubes and lungs. Once they have been trapped on the lung lining, they are in close proximity to the sensitive cells of the lung and can damage the tissue when the next radioactive decay takes place. In the demonstration "a rock and a hard place" the decay products are the paper hole punch pieces and the masking tape is the sticky lining of the lungs.

The body has some natural protection processes. Small hair-like structures called cilia will move the mucus and the decay products up through the larynx and out of the body. White blood cells will patrol the lungs and search out and capture intruding particles. Despite this protection, radon can still hurt you, especially when the amount of radon is large. Radon is second only to cigarette smoking in causing lung cancer.

PART 2: RADON IN THE HOME & BERNOULLI'S PRINCIPLE

RECOMMENDED TIME: 45 MINUTES

QUESTIONS:

- How does radon enter homes?
- What processes and forces impact radon levels?
- What is Bernoulli's Principle and how can you apply it to predict radon test outcomes?

Materials: Projection/Smartboard, Radon PowerPoint, Student Radon Booklets, penny for each student/student pair, sticky notes (3" x 3"; one per student or pair); 2+ empty soda cans (2 for demonstration or 2 cans for each small group).

Activity 1: "An Uninvited Guest"

DESP 3R's: teacher resource (no date). Unit 3: What is Radon? [Word document]

Procedures: (Recommended that students work in pairs)

- Place the penny on your desk.
- Place the sticky note face down about an inch behind the penny (with the sticky side edge closest to you and sticky side down).
- Challenge: Without touching the penny, the sticky note, or anything else can you or your partner move the penny onto the sticky note?

If stumped after 3-5 minutes, offer some clues. Once someone figures it out, allow them to demonstrate and explain in their own words what is happening. Allow students 1-2 minutes to practice.

Slides 17-27: Continue radon instruction through presentation and student engagement with content of radon PowerPoint and student radon booklets.

Activity 2: "Cheers, or No Cheers?"

Procedure: Students work in small groups of 4 (or provide as a demonstration)

- Place 2 soda cans approximately 0.5 inch apart.
- Predict what will happen if you blow between the two cans. Record.
- Try blowing between the cans.
- Record observations and inferences.

Prediction	Observation	Inferences

TEACHER'S NOTES AND DEBRIEFING:

DESP 3R's: teacher resource (no date). Unit 3: What is Radon? [Word document]

Bernoulli's Principle states that when airflow speed is lower, there is higher pressure, and when airflow speed is higher, there is lower pressure. The faster that air moves across the top surface of the penny, the lower the air pressure. Higher pressure under the penny from slower moving air, causes lift. With the Bernoulli Effect, air flows from a higher pressure to a lower pressure. This explains the lift of airplanes, shower curtains attacking bathers, and radon gas being pulled out of rocks and soil by simply heating the house.

Radon travels in small spaces in soil and rock under our homes. Then it gets drawn into a home through dirt floors, crawl spaces, cracks and pores in floors and walls. As pressure differences are created around a house, any radon present in the soil moves along the path of least resistance from high to low pressure.

A number of different factors influence the rate and amount of radon which enters buildings:

- High winds cause more radon to escape from the soil, both underneath and around buildings.
- Rain or melting snow can fill the spaces in the soil and acts as a cap in water-saturated soil, preventing radon from escaping from the underlying rock. However, the radon will move through dry spaces and into the house.
- Heating systems raise indoor air temperatures causing warm air to rise through the various floors of the building and reducing air pressure at the lower levels of the home resulting in the "stack effect".
- Building design factors that affect air flow (such as vents and chimneys) can also cause lower pressure in basements that will draw more radon into the home and activity.
- Activities within a building such as use of stove, water heater and dryer leads to lower pressure inside. Bathroom exhaust fans pull air out of the house leading to lower pressure inside.

In addition to radon escaping from soils and rocks, radon can also enter a house through the water system. Radon can escape from the water any time water is exposed to air. Radon levels of air in your home do not indicate the levels of radon in water; these must be tested separately.

Blowing between the cans produces faster moving air which creates a low pressure area between the cans. The higher pressure on the opposite side of the cans pushes them together.

PART 3A: RADON TESTING

RECOMMENDED TIME: 30 MINUTES

QUESTION:

How can we determine the radon levels in our homes?

Materials: Projection/Smartboard, Radon PowerPoint, Student Radon Booklets, radon test kit for each student.

Slides 28-37: Continue radon instruction through presentation and student engagement with content of Radon PowerPoint and Student Radon Booklets.

Review at-home activity instructions. Consider using one test kit in the classroom and demonstrating the setup of the draft shield and hanger.

Note: It is recommended to start the test on a Monday night, and then end the test on a Thursday night, and hand in to teacher on a Friday (or start on a Thursday/Friday and end on a Monday/Tuesday. Review the test kit instructions in advance and decide which portion will be labelled by the teacher afterwards and which portion you wish students to complete. It is recommended that the teacher determines one central email for the test results to be submitted. It is essential that students record their serial number or that the teacher keeps a reference sheet so that the test results can be matched to the right student. **It may be useful to start Part 4 during wait time between parts 3A3C.**

At-Home Activity: "The Only Way to Know"

"Begin Test" Procedures for Students: (Starting on a Monday evening)

1. Record the serial number of the test kit on the table below. (See page 6 in student booklet)
    a. Your Test Kit Serial # is required to access your test results.
    b. The Test Kit Serial # is on the plastic side of the Sampler.
    c. Write your Test Kit Serial # on the front of this Instruction Sheet and keep it for future reference.
2. Register your test kit at aelabs.com/register
3. Open the test kit instructions and carefully follow the instructions below for beginning the radon test.
    a. Follow Closed House Conditions:
        i. All exterior doors and windows are closed for 12 hours before starting your test, except for normal entry & exit.
        ii. Keep all exterior doors and windows closed for the entire testing period, except for normal entry and exit.
        iii. Use dehumidifiers, heating, & cooling systems normally.
        iv. Avoid using vent or exhaust fans during your test.
    b. Avoid Testing During Severe Weather:

i. Severe or unusual weather can temporarily change the building's radon levels. If unusual weather occurs during testing, visit aelabs.com/weather for guidance.

c. Where to Place the Radon Sampler:
   i. Place the Radon Sampler in a central room on the lowest level of the building suitable for occupancy, whether finished or unfinished.
   ii. Visit https://aelabs.com/pages/strategy?_pos=1&_sid=2c652c69f&[illegible]=r to learn more.
   iii. Place the Sampler paper side up on a flat surface.
   iv. Place the Sampler 2-7 feet above the floor.
   v. Place the Sampler at least 3 feet from exterior doors and windows and at least 1 foot away from walls.
   vi. Make sure the Sampler has at least 6 inches of space between it and any objects above or to the side of it.

d. DO NOT:
   i. Do not puncture, rip, tear, peel, or remove the paper side of your Radon Sampler.
   ii. Do not place the Sampler near heating or air conditioning vents, or in a place where it will be exposed to constantly moving air.
   iii. Do not place the Sampler where it will get wet.
   iv. Do not place the Sampler in rooms with high humidity (i.e. bathroom, kitchen, sump, or crawl space).
   v. Do not place the Sampler in crawl spaces or closets.
   vi. Do not place the Sampler in direct sunlight or within 1 foot of heat sources.

4. Planning the Test Start & Stop:
   a. For best results, expose your Sampler between 48 and 96 hours. Longer exposures do not increase accuracy.
   b. Samplers exposed less than 2 days (48 hours) or more than 7 days (168 hours) are invalid.
   c. All test dates & times are required for a result.
5. Starting the Test:
   a. Record the test start time & date online at aelabs.com/register.
   b. To start the test, remove the Radon Sampler from the plastic bag. The test begins immediately when the Radon Sampler is removed and exposed to air.
6. Stopping the Test:
   a. Record the test stop time & date online at aelabs.com/register.
   b. To stop the test, seal the Radon Sampler in the included Return Mailer. Include payment (if applicable).
   c. If you have more than one test kit, seal each Radon Sampler individually in its own Return Mailer.

HOME TEST				
Test Kit Serial #	**Prediction** (Test results Will be above, at or below 4pCi/L action level, and why)	**Environmental Observations** (external & internal variables over duration of test)	**Actual Test Results** (pCi/L)	**Inferences** (Variables that may impact reliability of test)

PART 3B: RADON TESTING CONTINUED *(4 DAYS LATER)*

Note: Remind students to complete the end of test procedures.

> ***Note:*** Use the provided paid postage envelope to mail in your kits on Fri afternoon. Early arrival assists with accuracy. Ensure each test kit is sealed and labeled properly with the separate locations. Results are typically available the same day the lab receives the test packet by mail.

At-Home Activity: "The Only Way to Know"
"End Test" Procedures: (Ending Thursday evening)

1. Refer to original test kit instructions and carefully follow steps 1-3 for ending the radon test.
2. Update observations in table (see page 6 in student booklet) during test duration such as indoor/outdoor temperature, draft, movement of people, proximity to weather factors (warmer indoor temperature), building design factors (vents, chimneys) and activities within buildings (ovens, exhaust fans) relative to heating or cooling vents, types.
3. Return a completely labeled and sealed test kit (with tag and draft shield removed) to your teacher on Friday's class or a designated drop-off location on Friday.

PART 3C: RADON TESTING CONTINUED

Note: Provide students the results.

Note: The test results will be mailed to the homeowner.

At-Home Activity: "The Only Way to Know"

Procedures:

1. Record test results.
2. Compare results to your prediction.
3. Review observations and record your inferences in the table whether there may be any variables that would impact the reliability of the test results. Note: Engage class in discussion of results in relation to prediction and indicate any inferences.

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TEACHER'S NOTES AND DEBRIEFING:

Houses in the same neighborhood are built differently, which can account for different pathways for radon to enter and different ventilation systems to expel radon. Houses with kids and dogs typically have more ventilation because doors are opened more often. Each location has individual rock and soil characteristics, even when next door to each other. Some sites may have greater concentrations of radon in rocks and soil because of the higher uranium and radium concentrations in them. Various building materials may have radioactive materials contained within them (cinder blocks, fireplace stones, etc).

Because radon gas is invisible, odorless, and tasteless, special devices are necessary to test for its presence. Charcoal detectors are the most affordable and easily accessible option for an initial test. They can be purchased at most hardware stores for $10-$20. Charcoal detectors have activated charcoal inside. The kit is opened to start the test and radon gas is trapped on the surface of the charcoal particles. The kit is then resealed after a 72-120 hour testing period, and immediately mailed to the laboratory for analysis.

Radon test devices should be placed in the lowest level of the house where it will not be disturbed, and where it will be at normal breathing level (3-5 ft. from the floor). Testing under the "worst possible case" situations will indicate the highest radon reading possible which offers some assurance of the worst case scenario. This includes limiting ventilation of the house or test area, keeping doors and windows closed, and testing when it is colder outside than it is inside (such as late fall, winter, early spring). Extreme high winds or the test period and extreme rain would also be examples of the worst case scenarios, but it also may cause an extreme spike in radon levels than normal high readings. In this case it may be recommended to repeat the test at another time.

Another testing device is the continuous radon monitor. It is reusable and produces immediate test results on a printout. It is expensive and is typically purchased by agencies involved in frequent radon testing activities. It will provide a "real time" reading as well as the average for an interval in time within a 24-48 hour period. This provides an interesting view of fluctuations in radon levels.

Radioactive concentrations are measured in picocuries per liter of air (pCi/L). The curie (Ci) unit, named for Marie Curie's discovery of radium, is the activity of 1 gram of pure radium 226. Pico is a scientific notation term which means $1*10^{-12}$. There is no safe radon level, but the Environmental Protection Agency (EPA) has set an allowable level of 4 pCi/L of air because present mitigation technology can typically reduce radon concentrations to below 4pCi/L.

PART 4: RADON POSTER CONTEST – OPTIONAL, AND TIMING OF LESSON IMPLEMENTATION IS IMPORTANT

Note: *The NH Radon Program, a program within the Division of Public Health Services (DPHS), is hosting a radon poster contest for New Hampshire students in grades 5-8! This contest is designed to raise awareness for radon testing and to inform people of the danger of radon in their homes. Contest winners will receive prize money on a GIFT CARD. The artwork from the winners and honorable mentions will be made into a calendar and provided to participating classes.*

Poster submissions are due November 3, 2023. Radon Poster Contest Rules and submission instructions can be found here:
www.dhhs.nh.gov/programs-services/environmental-health-and-you/radon/radon-teacher-resources

Question: What messaging and visual representation will be effective in making people stop, view/read and REMEMBER something important about radon?

Materials: Current Colorado Radon Poster Contest forms, Radon PowerPoint, Student Radon Booklets, 8.5 x 11 or 11x17 paper preferred, crayons, markers, paint, collage, pencil, and/or devices and programs for photographs or computer graphics

Slides 38-43: provides introduction to radon poster contest

- Review the Radon Poster Contest Requirements and Tips with students
- Identify amount of class time students will have and the art supplies that will be accessible from class
- Communicate deadline to submit poster to teacher
- Send artwork submission form home with students for parent and guardian signature

FOR QUESTIONS OR MORE INFORMATION, CONTACT THE NEW HAMPSHIRE RADON PROGRAM AT (603) 271-1708 AND RADON@DHHS.NH.GOV.

REFERENCES:

- Connecticut Department of Public Health, Mrs. Sullivan: radon lesson (no date). *Radon Lesson*. [PowerPoint presentation]
- DESP 3R's: teacher resource (no date). *Unit 3: What is Radon?* [Word document]
- Utah Department of Environmental Quality, Eleanor Divver: radiology lesson (no date). *Radiological Basics*. [PowerPoint presentation]
- Utah Department of Health: radon lesson (2018).
- Colorado Department of Public Health: infographic (2018). *Is Your Home Safe from Radon.* [PDF]