Science - - PHYSICAL SCIENCE GRADE 9

Unit 3: CHEMISTRY – PART II (3 WEEKS)

SYNOPSIS: Students will learn the basic concepts of nuclear energy including its numerous uses in everyday lives. Students will study both types of nuclear energy and form opinions about their usefulness. Finally, students take a position on the potential of a nuclear power plant in Youngstown.

STANDARDS

I. The Study of Matter

E. Reactions of Matter

1. Chemical reactions are about changes in the electrons.
   a. balancing equations and writing balanced equations requires being given either formulas of reactants and products or a word description of the reaction
2. Nuclear reactions are about changes in the nucleus and involve much larger energies than chemical reactions.
   a. the nuclear force binds protons with neutrons, and the electrical force repulses the protons
   b. the nuclear force is extremely weak at distances, but over the short distance in the nucleus, it is greater than the electrical force
3. An unstable nucleus (i.e., if forces are unbalanced) emits radiation through radioactive decay.
   a. the products of radioactive decay are fast-moving particles, energy, or a new nucleus; the identity of the element changes
   b. radioisotopes have medical applications (e.g., used to kill undesired cells); when introduced into the body, they show the flow of materials in biological processes
   c. for radioisotopes, the half-life is the time required for the isotope to lose half of its radioactivity; half-life values are unique and constant, and are used in radioactive dating.
4. Fission and fusion involve the splitting and combining the nucleus to release large quantities of energy.
   a. fission is splitting a large nucleus into smaller nuclei, releasing large quantities of energy
   b. fusion is joining smaller nuclei into a larger nucleus, releasing large quantities of energy
   c. fission and fusion are responsible for the formation of all elements in the universe beyond helium and the energy of the sun and stars..

LITERACY STANDARDS: READING (RST) and WRITING (WHST)

RST.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. [Given a picture, equation, translate into words and vice versa] (IE1a, b, c)

RST.6 Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.

RST.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

WHST.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (IE2a, b)

VOCABULARY

Reactants	Radioisotopes	Detectable	Coefficient
Products	Half-Life	Repulses	Subscript
Nuclear Reactions	Radioactive Dating	Distance	Spontaneous
Unstable Nucleus	Fission	Emits	
Radiation	Fusion	Medical applications	
Radioactive Decay	Conservation of Matter	Biological processes	

VOCABULARY: Post words in room and leave up for the unit. Create a word wall where students know to look for new words.

Address roots and affixes of new words
Use a diagram to show meaning of new words

Relate the new word to a similar and/or familiar word
In the course of teaching, define the word in the context of where if falls in the unit rather than in isolation
Throughout the teaching of the unit, use the word in conversation/discussion
Require students to use the word(s) in: discussion, investigations, and in 2-and 4-point response questions
Use new words in Rubric for the Authentic Assessments

MOTIVATION	TEACHER NOTES
1. Give students the standards and have them read through with the teacher, describing what they know and what is new for them. Have a student write the words chosen on the board or post on wall chart so students have as reference. 2. Teacher poses problem with rust on an iron fence; bike chains, other examples of where rust occurs so students associate a chemical reaction with real-life circumstances. Digestion is another example that could be used. 3. Do the Hands-on Activity: Observing a Chemical Reaction (page 168-169 in text) 4. Demonstrate Conservation of Matter by using a pen, finding the mass, and then disassemble the pen and then find the mass to show that they are the same. Make sure students are using metric measurements (do not have them do conversions! They should work in metric only). 5. Students establish both academic and personal goals for this unit 6. Teacher previews the Authentic Assessments for the end of the Unit	

TEACHING-LEARNING	TEACHER NOTES
1. Teacher refers to pen demonstration with the **Law of Conservation of Matter** to introduce balancing a chemical equation. From here, show students how they need to know what is the make-up of the pen to understand how something changes **- -** chemical reactions are about changes in the electrons. Since we cannot do things like the pen, we need to introduce (pen produces → spring + ink cartridge + upper tube + lower tube + metal band + clicker) **reactants** and **product.** Use Text, page 172 to show sodium as reactant plus chlorine as a reactant produces sodium chloride as the product. There are several examples here, so use what is needed for students to grasp the content. **(IE1a) (RST.7)** 2. Next introduce **Balancing Equations** as a way to prove that what you start with is what you end with. Tie back to previous unit. Use text page 172-173 to show equations with reactants and product as well as with symbols. Introduce the terms **coefficient and subscripts**. ($2Na + Cl_2 \rightarrow 2NaCl$). Relate to what students have done in Algebra class, and show them how this is a bit different. There is no equal sign in the chemical equation, but it still has to balance. Have students practice balancing equations, and explain what they do and why. Also, at the bottom of page 173, there are equations that need to be corrected. Use video http://phet.colorado.edu/en/simulation/balancing-chemical-equations Students complete Balancing Equations Worksheet **(IE1a)** 3. Introduction to **Nuclear Reactions**: (NOTE: this is not a "hands-on" section, but rather students view video, etc. to gain experiences with the concepts). Show clips from the *Iron Man Series* where he creates a device to protect himself; there are a couple of scenes that could be used for ideas about energy source. Explain the strength of nuclear force and relate it to the force of gravity. Show examples in history (e.g., Chernobyl, 3-Mile Island, Japan, using nuclear energy, medicine, industry and quality control, agriculture). Connect to the structure of the atom; (see page 238 in text**)** protons and neutrons, and what holds them together. Talk about advantages and disadvantages of nuclear power. What would happen when you add a proton or a neutron **(isotopes**) to an atom? **Radioisotopes** are isotopes that are radioactive and spontaneously	

TEACHING-LEARNING	TEACHER NOTES
decay and this make them good to be used in medicine, agriculture, etc. **(IE2a,b)(IE3b,c)** **(RST.6; RST.7; RST.8)** http://sciencenetlinks.com/lessons/isotopes-of-pennies/ (**attached to unit pages 3-5**) http://sciencenetlinks.com/lessons/radioactive-decay-a-sweet-simulation-of-a-half-life/ (**attached to unit pages 6-8**) http://sciencenetlinks.com/lessons/frosty-the-snowman-meets-his-demise/ (**attached to unit pages 9-10)** **ADDITIONAL ARTICLES:** **The Case of the Melting Ice, attached pages 11-12** **The Story of Carbon Dating, attached page 13** **May Everyday Products We Use Are Radioactive, pages 14-16** **Natural Exposure to Gamma Rays in Background Radiation Linked to childhood Leukemia, attached on pages 17-19** 4. **Fission**: Teacher uses video clip to illustrate nuclear reactions (note: you can sign up for an account on teachersdomain.org; you can access site up to 7 times without setting up an account) at teachersdomain.org and/ or **Teacher Tube** has Nuclear Fission Chain where a group of high school students in Cleveland re-created Nuclear Fission Chain Reaction with the mouse traps and ping pong balls. Discuss with students that Fission involves splitting an atom and that it produces huge amounts of energy in the form of heat, which can be used in several situations. **(IE3a, IE4a)** http://www.teachersdomain.org/resource/nvhe.sci.chemistry.fission/ 5. **Fusion**: Teacher discusses concept of fusion by modeling examples of fused items (use hands separate and then together with fingers clasped, find art work showing examples of fusion, welding, using super glue etc.) **(IE4b)** 6. Complete hands on activity on page 239 in text. Students should work in pairs. Teacher uses follow-up discussion to help students understand the basic concepts of fusion. **(IE3c) (RST.7)** 7. **Half-life** Using pages 240-241 in text adapt the procedure and conclusions to the use of M&M's or Skittles. Follow with class discussion. **(IE3c)**	

TRADITIONAL ASSESSMENT	TEACHER NOTES
1. Multiple-Choice **Unit Test**	

TEACHER CLASSROOM ASSESSMENT	TEACHER NOTES
1. Teacher Classroom Assessments	

AUTHENTIC ASSESSMENT	TEACHER NOTES
1. Students evaluate progress on their goals 2. A proposal to build a nuclear power plant in Youngstown for the purpose of generating electricity has been discussed by city leaders. Look up articles citing the advantages of nuclear power and another article citing the disadvantages of nuclear power. Finally write a paper stating your position on building a nuclear power plant in Youngstown for the purpose of generating electricity. **(RST.6, RST.7, RST.8, WHST.4)**	

T-L #3

Isotopes of Pennies


Photo Credit: Science NetLinks

PLANNING AHEAD

Before the lesson, prepare the canisters in the following manner:

1. Put a piece of tape on the sides of the canisters and write a code letter on the top of each canister. Be sure to keep a record of the code letters on a separate sheet of paper.
2. Weigh the canisters with their tops. Record the mass on the tape on the side.
3. Place a penny sample in the canister. Record the number of old and new pennies next to the appropriate code letters on your separate sheet of paper.
4. Seal the canisters with a small amount of Superglue.

Note: These sealed canisters may be kept from year to year.

INTRODUCTION

You will do a lab that will deal with isotopes, mass number, and atomic mass.

Before you begin your work in the lab, try to explain these terms in your own words. After you have finished the lab, you will have a chance to revise your explanations based on what you have learned in the activity.

Isotope

____
____
____
____
____

Mass number

____
____
____
____
____

Atomic mass

____
____
____
____
____

In 1982, the United States government changed the way it minted pennies. Before 1982, pennies were made of 95% copper and 5% tin. Now they are made of zinc coated with copper. Because they weigh different amounts (have different masses), we can call them isotopes of pennies.

• What do the two kinds of pennies represent in this exercise?
• How do the pennies differ? How do isotopes differ?
• What do the pennies have in common? What do isotopes have in common?

Part A:

1. Obtain a sample of ten pennies.
2. Weigh several pre-1982 (old) pennies and record their average mass. ______g
3. Weigh several post-1982 (new) pennies and record their average mass. ______g
4. Calculate how much three old pennies plus seven new pennies should weigh. ______g
5. Divide your answer for number 4 to find the weighted average mass of the pennies in the sample containing three old plus seven new pennies. ______g
6. Now weigh your sample of three old and seven new pennies. Record the mass. ______g
7. Divide your answer for number six by ten to find the average mass of a penny in your sample. ______g
8. Compare your answer for number five to your answer for number seven. Is the weighted average mass closer to the mass of an old penny or a new penny? Why?
9. How is this weighted average mass related to atomic mass?

Part B

1. Obtain a sample containing six old pennies and four new pennies.
2. Using the mass of an old penny and a new penny from part A above, calculate a weighted average mass for this sample of pennies. You need to find the mass of all ten pennies and divide by ten to find the weighted average mass. ______g
3. Now weigh your sample of pennies. Record the mass. ______g
4. Divide the mass of your sample of ten pennies by ten to find the actual average mass of a penny in this sample. ______g
5. Compare your answer from number two to your answer for number four. Is the weighted average mass closer to the mass of an old penny or a new penny? Why?

Part C: The Mystery Sample

1. Return your sample of ten pennies from part B to your teacher. Get a canister of pennies.
2. Don’t open it. Record its identifying number or letter:______
3. Record the mass of the empty film canister, which is on the label of the canister. ______g
4. Weigh the sealed film canister containing ten mixed pennies. ______g
5. Return the canister to your teacher.

Calculations:

1. Calculate the number of old and new pennies in your canister:
2. Since the total number of pennies is ten, we can say that there are x old pennies plus 10 – x new pennies. The total mass of the pennies (canister with pennies minus the mass of the canister) is useful here.
3. X times the average mass of an old penny plus (10 – x) times the average mass of a new penny equals the total mass of the pennies in the canister. Set up an equation and solve for x. Then you will know how many old pennies are in your canister. Subtract that number from ten to find the number of new pennies that are in your canister.

Show your math here:
• How many old pennies do you have? ______
• How many new pennies do you have? ______
• What percentage of old and new pennies do you have?

Radioactive Decay: A Sweet Simulation of Half-Life

Photo Credit: Science NetLinks

INTRODUCTION

In this simulation, you will use small pieces of candy marked on one side. They will be your "nuclei." You also need a paper towel on which to place your "nuclei."

Procedure:

1. Count your nuclei (candy). Write that number in the data table under the heading "Number of Radioactive Nuclei." In the column marked "Prediction for Next Toss" write the number of radioactive nuclei you think you will have with your next toss. (Radioactive nuclei will be those candies with the marked side down.)

2. Place your "nuclei" in a paper cup, cover and shake the cup. Pour the "nuclei" onto your paper towel. Separate the "nuclei" into two piles, one with the marked side up and the other with the marked side down. Count the number of "nuclei" in each pile. On your data table, record the number of "radioactive nuclei" candies with the marked side down. Predict how many radioactive "nuclei" you will have after the next toss.

3. Return only the radioactive "nuclei" to your paper cup. (You decide what to do with the "decayed nuclei," or those with the marked side up.)

4. Continue this process until there are no radioactive "nuclei" left. Add more rows to your data table, if needed.

Toss	Number of radioactive nuclei	Prediction for Next Toss
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

Analysis:

1. **Using the pooled data**, prepare a graph by plotting the number of radioactive “nuclei” on the y-axis and the number of tosses, which we will call half-lives, on the x-axis.

2. How good is our assumption that half of our radioactive “nuclei” decay in each half-life? Explain.

3. If you started with a sample of 600 radioactive nuclei, how many would remain undecayed after three half-lives?

4. If 175 undecayed nuclei remained from a sample of 2800 nuclei, how many half-lives have passed?

5. Why did we pool the class data? How does this relate to radioactive nuclei?

6. How many half-lives would it take for 6.02 x 10 23 nuclei to decay to 6.25% (0.376 x 1023) of the original number of nuclei?

7. Is there any way to predict when a specific piece of candy will land marked side up or “decayed?” If you could follow the fate of an individual atom in a sample of radioactive material, could you predict when it would decay? Explain.

8. Strontium-90 has a half-life of 28.8 years. If you start with a 10-gram sample of strontium-90, how much will be left after 115.2 years? Justify your answer.

9. What do we mean by half-life? With what kinds of materials do we use this term?

FROSTY THE SNOWMAN

MATERIALS

For each pair of students, you will need:

- Ring stand
- Iron ring
- Funnel
- 100 mL graduated cylinder
- Graph paper
- Clock
- Ice

PLANNING AHEAD

For the laboratory portion of this lesson, you will have to set up the ring stands, rings, funnels, and graduated cylinders. Fill the funnels with ice before the students arrive in the classroom. You can continue to fill the funnels as different classes arrive. Empty the graduated cylinders between classes if the volume is more than about 25 ml.

MOTIVATION

Begin by having students read the article The Story of Carbon Dating. The article briefly describes radio carbon dating.

To introduce the activity, ask students:

- How do you think archaeologists, when studying ancient pottery shards, determine how old their discoveries are?
- Have you ever heard of a technique called carbon dating, used to determine the ages of these archaeological samples?

DEVELOPMENT

- Say to students:

  "Carbon-14 undergoes beta decay with a half-life of 5720 years. The element carbon is an essential element in all living matter. Carbon-14 is produced constantly as our atmosphere is bombarded by cosmic rays. It is incorporated into the carbon cycle, so that all living things, including you, contain radioactive carbon-14.

  Living things have about 15 disintegrations per minute per gram of carbon. Because living things constantly interchange carbon atoms, the amount of carbon-14 remains constant, but when organisms die, no new carbon-14 enters the organism. However, the carbon-14 that was in the organism at death continues to disintegrate.

  By measuring how much carbon is left in a sample as well as its radioactivity, we can calculate when the organism died. It's a way of working backwards to solve a puzzle.

  In this activity, you will work backwards to solve a puzzle, much like scientists work backwards to find the time that an organism died."

PROCEDURE

Give each student a copy of The Case of the Melting Ice student sheet. You may group them in any size group, but working in pairs is optimal for this exercise. The lab stations should have been set up already as described in the Planning Ahead section above. Students should complete the Analysis section of the lab sheet, which will be used as part of their assessment.

Advise students to read through the case first so that they understand what they should do. Written below is the case as it appears on The Case of the Melting Ice student sheet.

The Case of the Melting Ice

INTRODUCTION

Frosty the Snowman lies melting in the funnels at your lab station. There were no eyewitnesses, but there are several suspects. All the suspects have holes in their alibis. You need to determine the exact time at which Frosty was put into the funnels to melt away, leaving no trace.

On a separate sheet of paper, immediately record the volume of Frosty's melted remains (water) in your graduated cylinder and note the time on the clock. Make a data table and at regular intervals (you decide how long) record the time on the clock and the volume of water in the graduated cylinder. Stop after about 30 minutes, unless Frosty has completely melted earlier.

Analysis:

1. What are the units for the **rate** at which Frosty melted?
____

2. Think about making a graph from your data. To determine which axis you will use for volume and which axis for time, recall that slope is rise (y-axis) over run (x-axis). Look at which units you decided to use for the rate of melting.
   Y-axis______________________________________
   X-axis______________________________________

3. What volume will you start with at the origin of your graph? Why did you choose that number?
____

4. Estimate when you think Frosty met his demise. Explain how you got your **estimate**.
____

5. Using your answers to questions 1 through 4, set up your graph and graph your data.

6. **Using your graph**, find the exact time Frosty started to melt. How close is this time to the time you estimated in question 4? ____

7. Describe the shape of your graph.
____

8. What does your graph tell you about the rate at which Frosty melted and the rate of radioactive decay?
____

9. Write the equation for the beta decay of carbon-14.

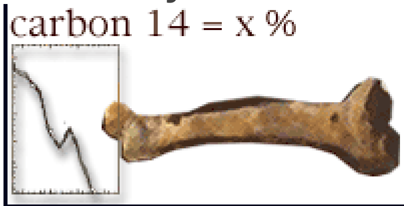
____

10. Speculate: Do you think any isotopes but carbon-14 could be used for radio dating? Why do you think that?

____

You can check your answer at this site: Radiometric Dating
http://facstaff.gpc.edu/~pgore/geology/historical_lecture/radio.htm.

The Story of Carbon Dating



Radio carbon dating determines the age of ancient objects by means of measuring the amount of carbon-14 there is left in an object. A man called Willard F Libby pioneered it at the University of Chicago in the 50's. In 1960, he won the Nobel Prize for Chemistry. This is now the most widely used method of age estimation in the field of archaeology.

How it works

Certain chemical elements have more than one type of atom. Different atoms of the same element are called isotopes. Carbon has three main isotopes. They are carbon-12, carbon-13 and carbon-14. Carbon-12 makes up 99% of an atom, carbon-13 makes up 1% and carbon-14 - makes up 1 part per million. Carbon-14 is radioactive and it is this radioactivity which is used to measure age.

Radioactive atoms decay into stable atoms by a simple mathematical process. Half of the available atoms will change in a given period of time, known as the half-life. For instance, if 1000 atoms in the year 2000 had a half-life of ten years, then in 2010 there would be 500 left. In 2020, there would be 250 left, and in 2030 there would be 125 left.

By counting how many carbon-14 atoms in any object with carbon in it, we can work out how old the object is - or how long ago it died. So we only have to know two things, the half-life of carbon-14 and how many carbon-14 atoms the object had before it died. The half-life of carbon-14 is 5,730 years. However knowing how many carbon-14 atoms something had before it died can only be guessed at. The assumption is that the proportion of carbon-14 in any living organism is constant. It can be deduced then that today's readings would be the same as those many years ago. When a particular fossil was alive, it had the same amount of carbon-14 as the same living organism today.

The fact that carbon-14 has a half-life of 5,730 years helps archaeologists date artefacts. Dates derived from carbon samples can be carried back to about 50,000 years. Potassium or uranium isotopes which have much longer half-lives, are used to date very ancient geological events that have to be measured in millions or billions of years.

Posted June 27, 2009 at 9:01 p.m.

Many Everyday Products We Use Are Radioactive by Isaac Wolf (Scripps Howard News Service)

Thousands of everyday products and materials containing radioactive metals are surfacing across the United States and around the world.

Common kitchen cheese graters, reclining chairs and tableware manufactured with contaminated metals have been identified, some after having been in circulation for as long as a decade. So have fencing wire and posts, shovel blades, elevator buttons and airline parts.

A Scripps Howard News Service investigation has found that — because of haphazard screening and an absence of oversight — no one knows how many tainted goods are in circulation.

But thousands of consumer goods and millions of pounds of unfinished metal and its by-products have been found to contain low levels of radiation, and experts think the true amount could be as much as 10 times higher.

Government records, obtained through state and federal Freedom of Information Act requests, illustrate the problem.

In 2006 in Texas, for example, a recycling facility inadvertently created 500,000 pounds of radioactive steel by-products after melting metal contaminated with Cesium-137, according to U.S. Nuclear Regulatory Commission records. In Florida in 2001, another recycler unintentionally did the same, and wound up with 1.4 million pounds of radioactive material. And in 1998, 430,000 pounds of steel laced with Cobalt-60 made it to the U.S. heartland from Brazil.

But an accounting of the magnitude of the problem is unknown because U.S. and most state governments do not require scrap yards, recyclers and other businesses to screen metal goods and materials for radiation or report it when found. And no federal agency is responsible for oversight.

“Nobody’s going to know — nobody — how much has been melted into consumer goods,” said Ray Turner, an international expert on radiation with Fort Mitchell, Ky.-based River Metals Recycling. “It’s your worst nightmare.”

It is also one that has only barely begun to register as a potential threat to health and safety.

What is known now is that — despite the shared belief of officials in six state and federal agencies that tainted metal is potentially dangerous, should be prevented from coming in unnecessary contact with people and the environment, and should be barred from entering the United States — there is no one in charge of making sure that happens.

In fact, the Scripps investigation found:

> Reports are mounting that manufacturers and dealers from China, India, former Soviet bloc nations and some African countries are exporting contaminated material and goods, taking advantage of the fact that the United States has no regulations

specifying what level of radioactive contamination is too much in raw materials and finished goods. Compounding the problem is the inability of U.S. agents to fully screen every one of the 24 million cargo containers arriving in the United States each year.

U.S. metal recyclers and scrap yards are not required by any state or federal law to check for radiation in the castoff material they collect or report it when they find some.

No federal agency is responsible for determining how much tainted material exists in how many consumer and other goods. No one is in charge of reporting, tracking or analyzing cases once they occur. In fact, the recent discovery of a radioactive cheese grater triggered a bureaucratic game of hot potato, with no agency taking responsibility.

A U.S. government program to collect the worst of the castoff radioactive items has a two-year waiting list and a 9,000-item backlog.

Experts say you needn't empty your home of metal implements for fear of radiation. The peril from most individual items is generally not considered great.

In fact, everyone is exposed every day to the "background" radiation found in nature. For instance, some ceramic pots emanate low levels of radiation that occurs in clay. Granite countertops often contain measurable, but individually insignificant, amounts of naturally occurring uranium.

Other exposures come from small and contained amounts of radiation used in smoke detectors and medical devices.

The potential danger comes, however, from the cumulative effect of proximity to radiation, particularly over time and in relation to other contaminants. The precise degree of that danger has not yet been definitively determined for low-level radiation, such as that contained in commonplace goods and materials.

One scientific school of thought, which has been losing favor in recent years, holds that low levels of radiation mean low-level threats. An opposite camp contends that exposure to any level of radiation carries health risks.

According to a 2006 report by a National Academy of Sciences panel, there is a direct relationship between radiation and an increased risk of cancer. Prolonged exposure can also lead to birth defects and cataracts, studies have shown.

Because the amount of tainted metals in circulation is unknown, the cumulative overall health effect — now and over time — is impossible to calculate. Whatever it is, there is little debate that unnecessary exposure to radiation is best avoided.

"There is no threshold of exposure below which low levels of ionizing radiation can be demonstrated to be harmless or beneficial," said Richard Monson, chairman of the Committee to

Assess Health Risks from Exposure to Low Levels of Ionizing Radiation, at the release of the National Academy report.

The Scripps investigation used the federal Freedom of Information Act to gain access to a Nuclear Regulatory Commission database, the only official assemblage of reports of radiologically contaminated items that have turned up in scrap yards, trash dumps and manufactured goods since 1990.

But neither state nor federal environmental officials — nor many in the scrap-metal industry — consider the NRC accounts an accurate reflection of the problem's true dimensions.

"Typically, these go unreported," said Carolyn Mac Kenzie, a U.S. Department of Energy physicist who is a world expert in radioactive metals. "Whatever number you come up with would not reflect reality."

What is known is that the NRC's national Nuclear Material Events Database has documented 18,740 cases involving radioactive material in consumer products, metal intended for their manufacture and other inadvertent exposures to the public, the vast majority since 1990.

A recent example emerged last summer, when a Flint, Mich., scrap plant discovered a beat-up kitchen cheese grater that was radioactive. The China-made grater bearing the well-known EKCO brand name was laced with the isotope Cobalt-60. Tests showed the gadget to be giving off the equivalent of a chest X-ray over 36 hours of use, according to NRC documents.

Estimated to have been in circulation for as long as a decade, the grater likely was four to five times more radioactive when it was new. EKCO's parent company, World Kitchen, of Rosemont, Ill., described the incident as isolated and found no need to issue a recall, spokesman Bryan Glancy said.

It was not the only cheese grater found. NRC documents show that another Cobalt-60-tainted grater had turned up in Jacksonville, Fla., in 2006. The reports do not indicate what brand it was.

Cobalt-60 also tainted a 430,000-pound shipment of metal from Brazil in 1998. Part of that load found its way to Michigan and then Indiana, where it was used to make brackets for 1,000 La-Z-Boy recliners.

The contamination was detected by a radiation monitor when scrap leftover from the brackets job was shipped to a steel recycler. The Cobalt-60 tainted Reclina-Rocker chairs, which would have given off a chest X-ray's worth of radiation every 1,000 hours, were still in warehouses when the contamination was discovered, and never made it to stores or living rooms, according to Rex Bowser, director of the Indoor Air and Radiological Health Emergency Response Program of the Indiana State Department of Health.

T-L #3

Natural Exposure to Gamma Rays in Background Radiation Linked to Childhood Leukemia

ScienceDaily (June 18, 2012) — New findings demonstrate that there are small effects of radiation even at very low doses.

A small but statistically significant link between risk of childhood leukemia and the gamma rays we are all exposed to from our natural environment has been detected in an Oxford University-led study.

Exposure to gamma rays from natural sources in the environment isn't something that can readily be altered, but the study adds to our understanding of the small cancer risks associated with other low doses of radiation, such as from medical X-rays and CT scans.

Guidelines on exposure to low doses of radiation have largely been based on estimated risks from models using data from Japanese survivors of the atomic bombs, where radiation exposures were brief and very much higher. As a result, there have been some long-standing uncertainties about the extrapolation of these risks to low radiation doses.

The researchers conclude that the size of the increased risk of childhood leukemia with natural gamma-ray exposure is consistent with these models and supports their continued use in radiation protection.

The results of the study contradict the idea that there are no adverse radiation effects, or might even be beneficial effects, at these very low doses and dose rates.

The Oxford University researchers, along with colleagues from the US National Cancer Institute, The University of Manchester and the Health Protection Agency, have published their findings in the journal *Leukemia.*

The case-control study, based on tens of thousands of records from a UK national cancer registry, is the largest such study ever conducted on links between childhood cancers and natural background radiation levels.

It has needed a study of this very large size to be able to reliably identify the small effect of background radiation on childhood leukemia. Previous studies have lacked the size and statistical power to be able to detect any link.

'We found a statistically significant correlation between natural gamma-rays and childhood leukemia,' says lead researcher Dr Gerald Kendall of the Childhood Cancer Research Group at Oxford University. 'What is new in our findings is the direct demonstration that there are radiation effects at these very low doses and dose-rates.'

The researchers believe that the association between natural gamma-rays and childhood leukemia is likely to be causal.

Gamma rays in background radiation come largely from naturally occurring radioactive isotopes of uranium, thorium and potassium in the environment. In the UK, children have an annual radiation dose of roughly 0.7 mSv (millisievert) to bone marrow from natural gamma-rays.

Background radiation accounts for only a minority of childhood leukemias. The cause of most cases is unknown.

While there is some variation in natural gamma-ray exposure around the UK, the radiation doses are small and there is very little that can be done to mediate or prevent any cancer risk. In this respect it is different from naturally occurring radon gas: radon exposure can be controlled but gamma exposure where you live is inevitable.

'In terms of preventing childhood cancers caused by natural gamma-rays, there's not a lot you can do,' explains Dr Kendall.

'We have estimated that about 15% of the 500 or so cases of childhood leukemia which occur annually in the UK are due to natural background radiation.

'Natural gamma-rays account for about half the dose reaching children's bone marrow from all sources. So they account for approaching 40 childhood leukemias a year.

'That means even if the entire UK population were to move to mid-Wales, fewer than 15 childhood leukemias per year would be prevented.'

The three counties with the lowest mean gamma-ray dose rates are Powys in mid-Wales, Dorset and Wiltshire at 70 nGy/hr (nanograys per hour).

The three counties with the highest are South Yorkshire, Cornwall and the Isles of Scilly, and the Scottish Borders at 120 nGy/hr.

The researchers used records from the National Registry of Childhood Tumours to investigate associations with natural background radiation.

The National Registry of Childhood Tumours has an essentially complete record of UK cases of childhood cancers, allowing the researchers to compare the radiation exposures for almost 27,500 cases diagnosed between 1980 and 2006 (including over 9,000 childhood leukemias) with a set of almost 37,000 matched control children without cancer.

Cumulative radiation exposures from birth to cancer diagnosis were estimated for where the mother was living at the time of the child's birth.

The team found that there was a 12% increase in the risk of childhood leukemia for every millisievert of natural gamma-ray dose to the bone marrow. While this finding was statistically significant, even with a study of this size there is still some uncertainty around the size of the effect. The relative risk increase is likely to lie within a range from 3% to 22% per millisievert.

There were no statistically significant associations between other childhood cancers and natural gamma-rays, or between any cancers and levels of radon in the natural background radiation.

Dr Kendall adds: 'The findings are relevant to understanding the risks from low radiation exposures such as medical X-rays and CT scans; planning for the disposal of nuclear waste; and the risks from the exposures received by people living near Chernobyl or Fukushima.

'The risk estimates used by those involved in radiation protection for such situations have tended to rely on models that extrapolate risk from data on Japanese survivors of the atomic bombs where radiation exposures were very high. Our findings are consistent with these models.'

Professor Richard Wakeford of The University of Manchester, a co-author of the study, said: 'Radiation protection measures assume that even low doses of radiation pose some, albeit small, risk of cancer. Naturally occurring gamma-rays provide an ever-present, very low-level source of exposure to radiation, but this very large epidemiological study suggests that even at these very low levels there is a very small risk to health. However, the results are what would be expected from previous scientific evidence, and indicate that the current assumptions underlying radiation protection are about right.'

A separate paper finding an increase in risk of leukemia linked to radiation exposure from CT scans in childhood was published in *The Lancet* on 7 June.

Dr Kendall of Oxford University believes the increase in risk that the authors found to be associated with the radiation dose received from a CT scan is 'certainly compatible' with the findings of this study.

Dr Mark Little of the Radiation Epidemiology Branch at the National Cancer Institute in the USA was a co-author on both studies. Dr Little says: 'CT scans will remain very valuable for medical imaging and diagnosis, especially when serious health conditions are suspected. There should be no need to change current practice in the UK: CT scans should continue to be used when medically justified, although radiation doses should be kept as low as possible, and alternative procedures which not involve radiation exposure should be considered if appropriate.'