chapter 2
Other Forms of Diagnostic Technology

Prior Knowledge: The Bohr Model of the atom was introduced in Grade 9 science. As well, the four fundamental forces were introduced in Grade 11 physics. Students should recall the formula relating velocity, frequency and wavelength from Grade 11 physics ($v=\lambda f$), as well as the measurement units for frequency (Hertz). In this chapter, prior qualitative knowledge in magnetism is important.

Terms You Should Know: There is a list included here and at the end of the chapter highlighting important terms. Teachers could use this list as either a knowledge activation activity—have students create a concept map or definitions frame—or as a review of concepts.

Note that this list of terms is not intended to be a list for memorization or to provide lists of definitions. It is here to assist the teacher in the incorporation of new concepts and terminologies into the learning activities.

atomic number	barium
cobalt-60	colon
colonoscopy	Doppler Effect
electromagnetic field (EMF)	endoscope
enema	fibre-optic light
gadolinium	Hace 1 Gene
isotope	MRI (Magnetic Resonance Imaging)
magnetic field	mass number
radiofrequency coil	radium
transducer	ultrasound

Chapter Summary: This chapter introduces the concept of using non-radiation based technologies for diagnosis, including Magnetic Resonance Imaging (MRI) and Ultrasound. The chapter includes a brief description of Canada's role in isotope production, used in radiation-based technologies.

Blackline Masters/Enlarged Images: At the end of this set of answers and solutions to chapter 1's questions, there are enlarged images from the Student Resource guide, ready for either projection (display) or photocopying.

Page 19 | "Research & Extension Questions"

1. Why is gadolinium used as a contrast agent for MRI scans? Why wouldn't they use barium? Or cobalt?

   To find answers, students can use a search engine on the internet and type in phrases such as "gadolinium and contrast agent," "barium and contrast agent," etc.

   Gadolinium is a contrast agent injected intravenously. Gadolinium stays in blood vessels, which makes arteries, veins, and potential blood leakage highly visible in MRI scans. Gadolinium leaves the body through the kidneys, with a half life of 1-1.5 hours. While the MRI can be done without a contrast agent, gadolinium allows for greater detail and definition in the image produced. This makes diagnosis easier.

   The contrast agent barium is used in digestive tract analysis, but cannot be safely injected into the blood stream. Barium comes in the form of a dense liquid which coats the digestive tract to show any bumps or abnormalities on x-ray radiographs. Cobalt-60 is used in radiation treatment as it has a longer half life than gadolinium. Radioactive tracers such as cobalt-60 need to have short half-lives so that the radiation leaves the body quickly after the procedure is complete to allow the patient to return home safely.

A "Play on Words"

Form a group of three to four people. Create a drama that describes how one of the forms of diagnostic technology works. Your play must include the following:

1. Correct usage of the terminology in the previous chapters;
2. All group members must have an equal amount of time on stage;
3. Your play must have at least one portion which enacts what occurs at the atomic level when your chosen diagnostic technology is being used;
4. The following terms must be incorporated into the play: isotope, atomic mass, electromagnetic spectrum, gamma ray, and positron.

Your drama will be marked for scientific accuracy, clarity, creativity, and whether the four elements above have been incorporated and to what extent.

2. Discuss with a classmate what the list of general characteristics may be that would qualify an isotope as a "good" choice for use in diagnosis.

   Many answers are possible. Some possibilities: short half life; slim to no adverse side effects; provides clear images.

3. Could gadolinium be used in PET scans? Why (not)?

   Gadolinium is ferro-magnetic and useful as a contrast agent rather than a radioactive tracer which PET scans require. Isotopes of oxygen, nitrogen, carbon, and fluorine are used instead. These isotopes are used for their very short half lives and their ability to travel to and collect in areas where greater amounts of energy (glucose) are being used. Gadolinium cannot indicate brain activity as it remains in blood vessels. Gadolinium could be used in PET scans if the technician is attempting to analyze blood flow (or blood clotting) in the brain.

Page 25 | "Internet Activity: The Visible Human Project®"

Teachers may want to explore this website prior to students using it. Alternatively, a discovery approach with teacher and students exploring together can also be used. The three specific links provided at the end of this activity are good starting points for guided explorations.

Page 27 | "Activity: Concept Map"

Using the same vocabulary list as Activity III, create a concept map for RADIATION (like a spider-web that shows how the concepts are interconnected) to link the vocabulary together.

Many answers are possible.

"Activity I: A Play on Words"

Many answers are possible.

"Activity II: Compare and Contrast: CT and PET Scans"

How are CT and PET scans alike? How do CT and PET scans differ?

Many answers are possible. Some suggestions for similarities: both can use radiotracers; both are used to analyze internal organs/tissues. Some suggestions for differences: PET scans monitor brain activity (energy use), while CT scans can monitor other areas of the body too.

"Activity III: Sort and Predict"

Read the list of words below and sort them into four different categories, choosing the names of your categories carefully. When selecting categories, try to make the fourth category different than any other category of which your classmates would think. Be original!

Many answers are possible.

"Activity IV: CT and MRI Online Exploration"

Go to The Visible Human Project® online to perform a detailed exploration of an area of the body, or specific body part of interest to you. You can work with either a female or male "virtual subject." Your objective is to find out what the current state of research is with respect to your chosen area of focus: what function does this region have, how large are the structures involved, how do their tissue densities differ if you were to image the area. Come up with an interesting way to communicate your results to others

URL: http://www.nlm.nih.gov/research/visible/visible_human.html

There are many different areas that have been studied by the Visible Human Project. Teachers may want to divide the class into groups and have each group research one area. Students could present their findings using a "jigsaw" approach, or do presentations in front of the class. Note that page 25 of the Student Resource Booklet has examples of specific areas in the site students may explore.

activity 2

Compare and Contrast: CT and Pet Scans

Sometimes the essential vocabulary words of this module are very similar to each other. This encourages you to go beyond a simple definition of two words, and to describe how the two words are similar (compare) and how they are different (contrast). Create a larger version of the chart below and fill it in.

Compare: How are CT scans and PET scans different?

CT Scans	PET Scans

Contrast: How are CT sans and PET scans different?

CT Scans	PET Scans

Compare your chart to your classmates' charts: what's similar? What's different?

activity 3

Sort and Predict

Read the list of words below and sort them into four different categories, choosing the names of your categories carefully. When selecting categories, try to make the fourth category different than any other category of which your classmates would think. Be original!

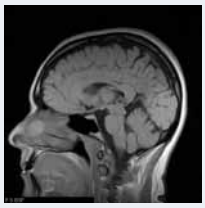
Barium
Radiograph
Distance
Contrast
Tissue
Electron
Hemorrhage
Gamma ray
Gadolinium
Density
Endoscope
Isotope
Tumour
Attenuation
Electromagnetic
Frequency
Wavelength
Colonoscopy
Alpha
Beta
Transmutation
Tomography
Radiotracer
Doppler Effect
Atomic number
Carbon-14

activity 4

CT and MRI Online Exploration

Go to The Visible Human Project® online to perform a detailed exploration of an area of the body, or specific body part of interest to you. You can work with either a female or male "virtual subject." Your objective is to find out what the current state of research is with respect to your chosen area of focus: what function does this region have, how large are the structures involved, how do their tissue densities differ if you were to image the area. Come up with an interesting way to communicate your results to others

URL: http://www.nlm.nih.gov/research/visible/visible_human.html



activity 5

Radiation Exposure

Supplies: broom, dustpan, red confetti, white confetti, and an area to do this activity where cleanup will be easy.

Background: Researchers estimate that if finely divided uranium oxide (or its equivalent) is ingested or inhaled, 95-99% of it leaves the body, with only 1-4% remaining to cause potential long-term radiation exposure effects. Researchers estimate that individuals working in nuclear research facilities will have up to four times the amount (16%) remain in their bodies for the long term, due to chronic exposure despite safety precautions and equipment.

PART A Setup: Mix 4 pieces of red and 96 pieces of white confetti in a bag. Have one classmate stand (carefully) on a chair slowly sprinkling confetti from the bag as the class walks underneath. Some confetti will fall on classmates; some will fall to the side.

Analysis: Locate where the four pieces of red confetti landed. How many landed on people? How many landed on the floor? CLEAN UP ALL THE CONFETTI!

PART B Setup: Mix 16 pieces of red and 84 pieces of white confetti in a bag. Follow the same procedure and analysis as before. By how much did the number of people exposed to radiation (red confetti) increase? Again, CLEAN UP ALL CONFETTI!

Final Analysis: How do your confetti statistics match with the background statistics? What kinds of precautions do workers in nuclear research facilities take to minimize their radiation exposure?

"Activity V: Radiation Exposure"

Final Analysis: How do your confetti statistics match with the background statistics? What kinds of precautions do workers in nuclear research facilities take to minimize their radiation exposure?

When students compare their confetti statistics with background statistics, they should be able to explain why they are similar (or different). Variables that were (not) controlled should be discussed. When answering the final question, students should refer to protective clothing as well as monitoring devices (such as pins that emit a warning sound when radiation levels are too high).