McGraw-Hill Ryerson

BC Science Connections 8

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UNIT 3

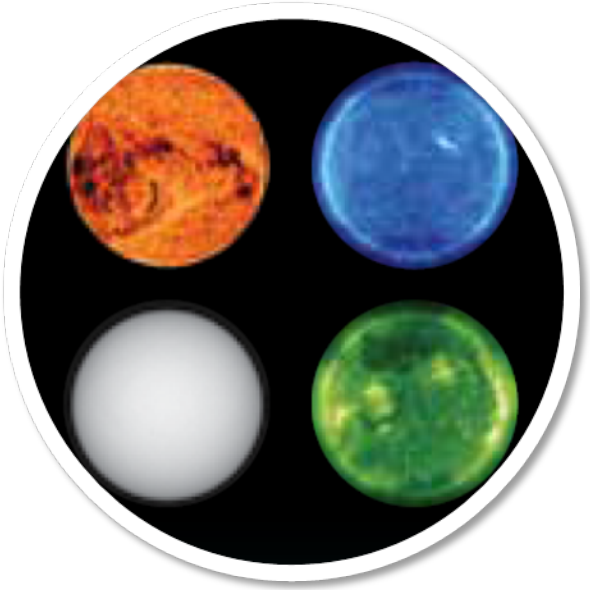
Energy can be transferred as both a particle and a wave

TOPIC 3.1

How does electromagnetic radiation shape your world?

Topic 3.1: How does electromagnetic radiation shape your world?

- Electromagnetic radiation is a form of energy.
  - Given off by different sources on Earth and in the universe (most comes from the Sun)
  - Some types of are harmful, and other types are essential to survival of life on Earth



Images of the Sun taken with telescopes that detect a different type of electromagnetic radiation. (Clockwise, from top left: infrared, x-ray, ultraviolet, optical)

Concept 1: Electromagnetic radiation is an important part of your world.

- Seven different types of electromagnetic radiation:
  - Radio wave
  - Microwave
  - Infrared
  - Visible light
  - Ultraviolet
  - X-ray
  - Gamma-ray

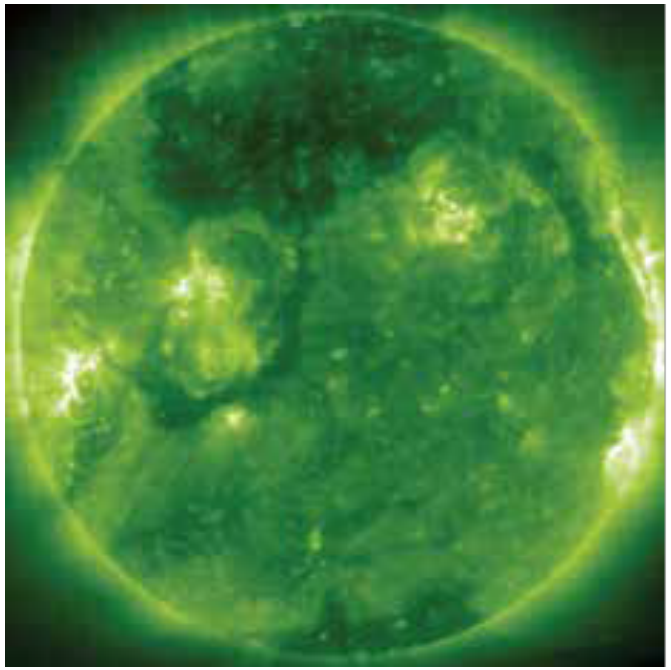


Image of the Sun taken with an ultraviolet telescope.

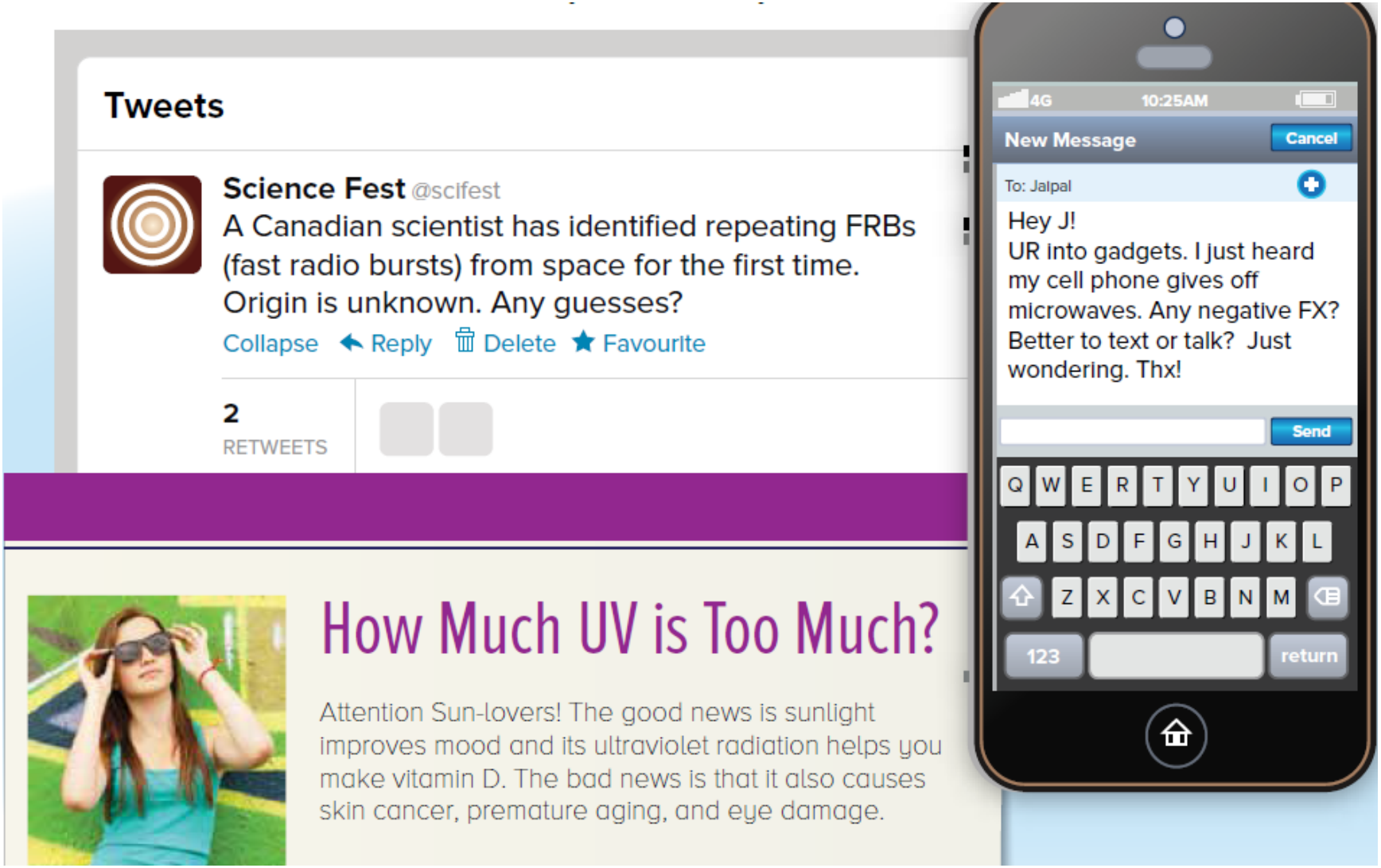
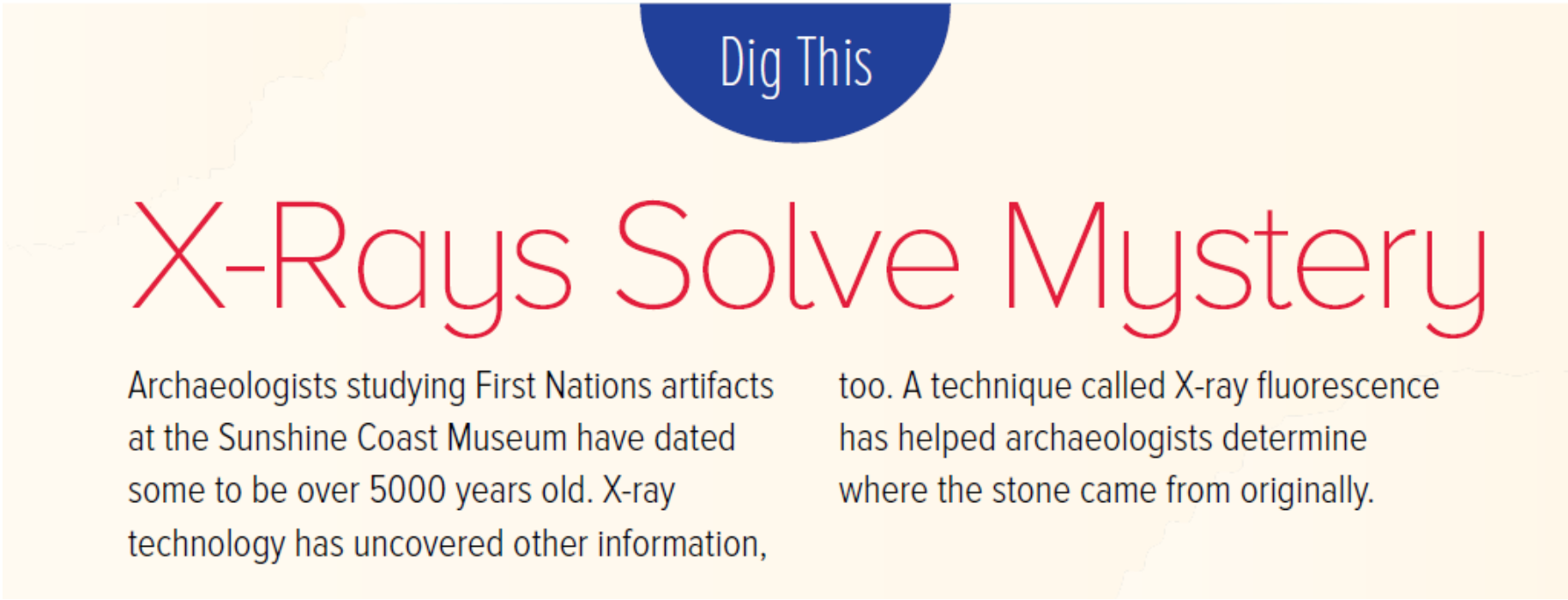


Figure 3.1: Electromagnetic radiation is often discussed online and covered by the news.



Dig This

X-Rays Solve Mystery

Archaeologists studying First Nations artifacts at the Sunshine Coast Museum have dated some to be over 5000 years old. X-ray technology has uncovered other information, too. A technique called X-ray fluorescence has helped archaeologists determine where the stone came from originally.

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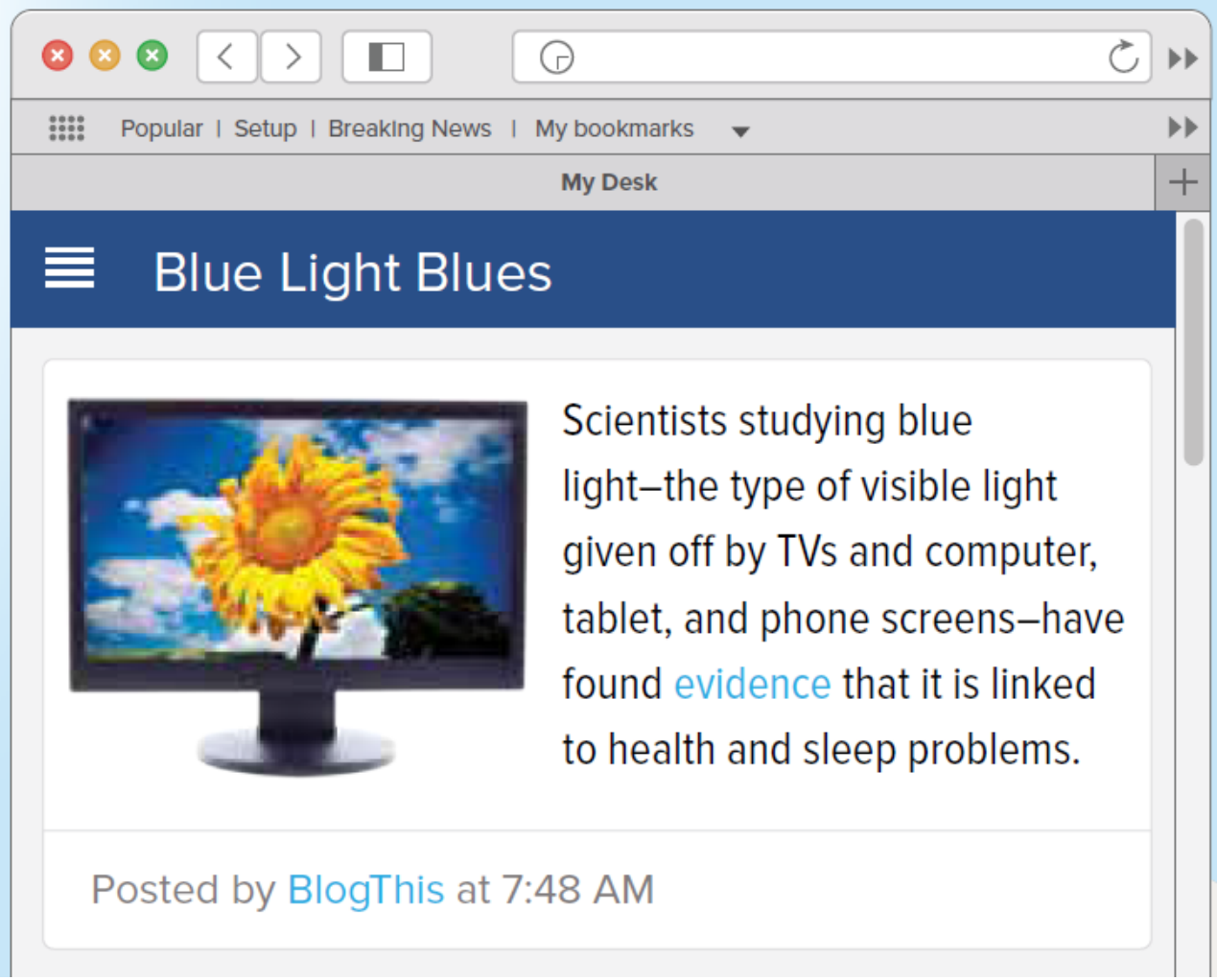

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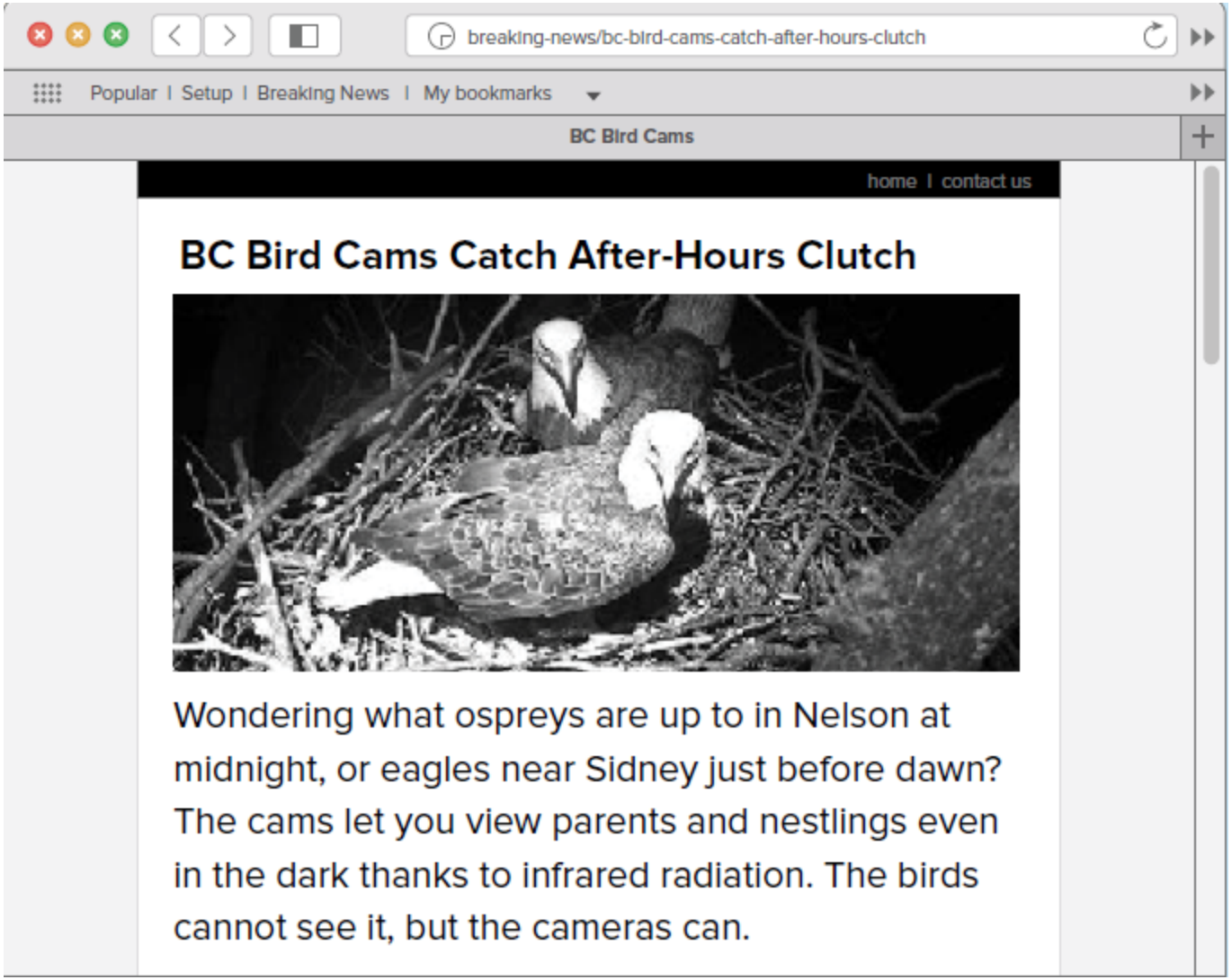

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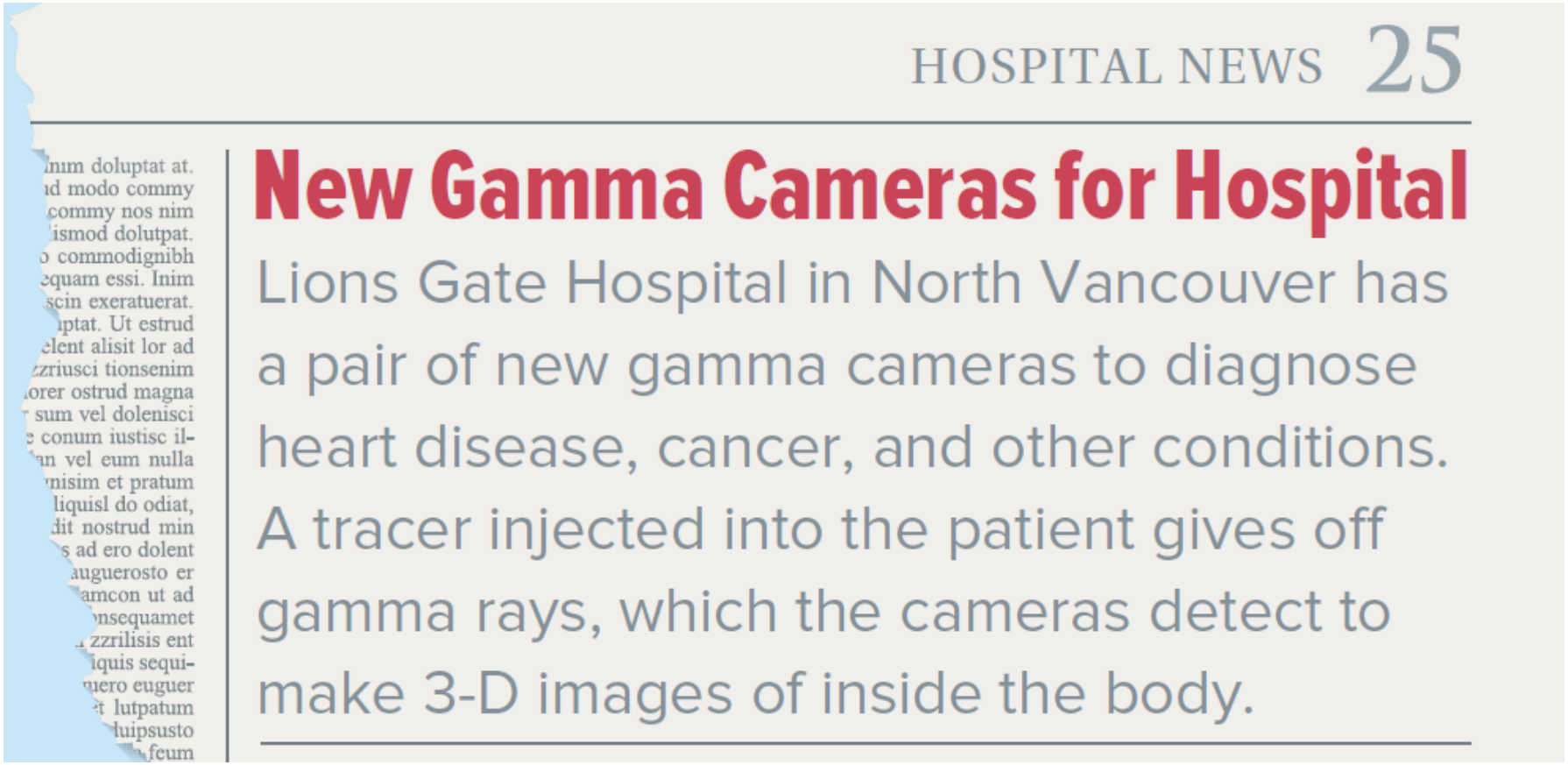

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New Gamma Cameras for Hospital

Lions Gate Hospital in North Vancouver has a pair of new gamma cameras to diagnose heart disease, cancer, and other conditions. A tracer injected into the patient gives off gamma rays, which the cameras detect to make 3-D images of inside the body.

Figure 3.1: Electromagnetic radiation is often discussed online and covered by the news.

Discussion Questions

- Why do you think sunglasses have special lenses that filter out ultraviolet light?

- Why might you want to limit the amount of time you spend in front of an electronic screen at night?

Concept 2: Sources of electromagnetic radiation are all around you.

- Many different sources of electromagnetic radiation:
  - Some sources are artificial (cell phones, light bulbs)
  - Some sources are living organisms (humans)

The Sun is a source of all types of electromagnetic radiation.

The Sun: A Source of All Types of Electromagnetic Radiation

The Sun: gives off all types of electromagnetic radiation.

- Energy carried by radiation is produced by nuclear fusion
  - Hydrogen nuclei collide and combine to form helium
  - Fusion of 1 g of hydrogen atoms: reaction releases 65 billion kJ of energy (50 000 pieces of pizza!)
  - 500 trillion grams of hydrogen fuse in the Sun every second

The large amount of energy released by the Sun supports life on Earth.

Chemical Reactions in Living Organisms: A Source of Visible Light

Chemical reactions give off visible light.

- Some reactions occur in living organisms
  - Female anglerfish have a lure that gives off visible light to attract prey
  - Bacteria in the lure produce the light

Female anglerfish have a lure that gives off visible light

Heated Materials: A Source of Visible Light and Infrared Radiation

All objects, including you, give off infrared radiation.

- As objects get hotter: give off more infrared radiation (sensed as heat)
- If objects are very hot: give off visible light and infrared radiation

Light bulbs give off infrared radiation and visible light. When the bulb is turned on, the wire inside gets very hot and gives off light.

Telecommunications: A Source of Microwaves and Radio Waves

- Cell phones are a source of microwaves.
  - Microwaves carry information from the cell phone to nearby cell phone tower
  - Cell phone towers create microwaves that carry the information to another cell phone

Cell phone towers create microwaves that carry information from cell phone to cell phone.

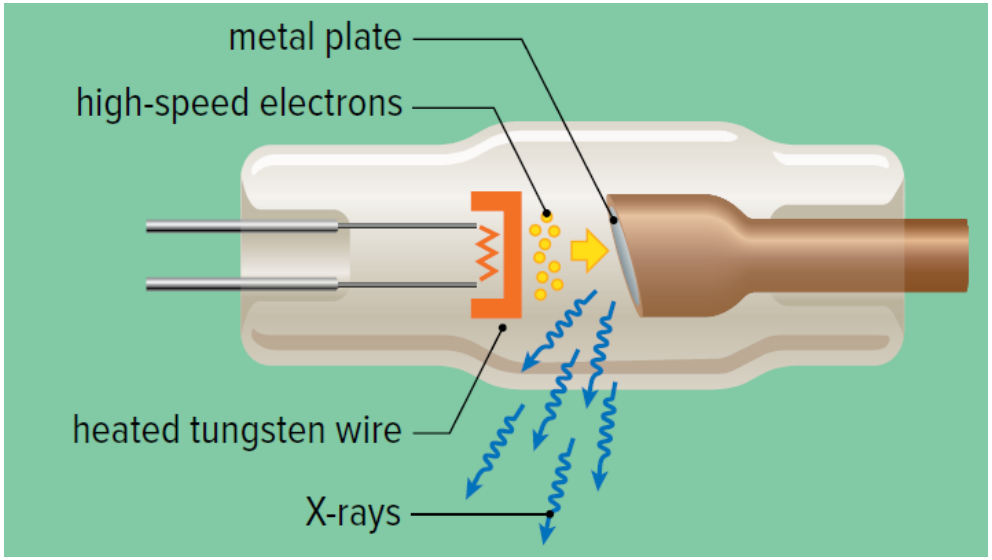
Telecommunications: A Source of Microwaves and Radio Waves

- Communication systems (fire, police, emergency systems) and radio stations generation radio waves
  - Send signals to radio receivers that convert them into sound

X-ray Tubes: A Source of X-rays

X-rays are produced are produced in an x-ray tube.

- High-speed electrons are released from a heated tungsten wire
- Electrons collide with metal surface that stops them
- The sudden change in speed of the electrons generates x-rays

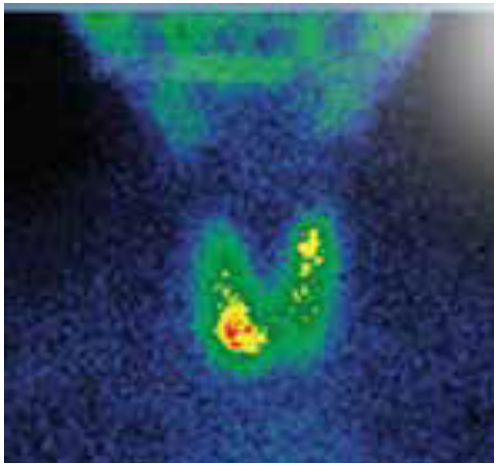


X-rays are produced in x-ray tubes. X-rays can be used to create images of teeth and bones.

Radioisotopes: A Source of Gamma Rays

Gamma rays are produced by unstable nuclei of certain atoms.

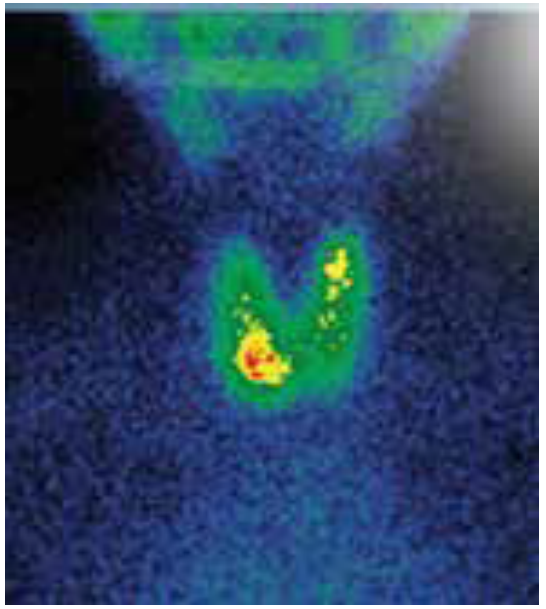
- Atoms with unstable nuclei are called radioisotopes.
  - Radioisotopes have too much energy
  - To become stable, they give off energy in different forms, including gamma rays



A gamma camera image of a thyroid gland injected with radioactive iodine. The brighter area has taken up more iodine, so the camera detects more gamma rays.

Radioisotopes: A Source of Gamma Rays

- Iodine-131 is a radioisotope that gives off gamma rays
  - Used to treat thyroid cancer
  - When a patient swallows it, it will go to the thyroid gland to kill the cancer cells



A gamma camera image of a thyroid gland injected with radioactive iodine

Discussion Questions

- What type or types of electromagnetic radiation are given of by the following sources?
  a) a halogen light bulb
  b) the Sun
  c) iodine-131
  d) you

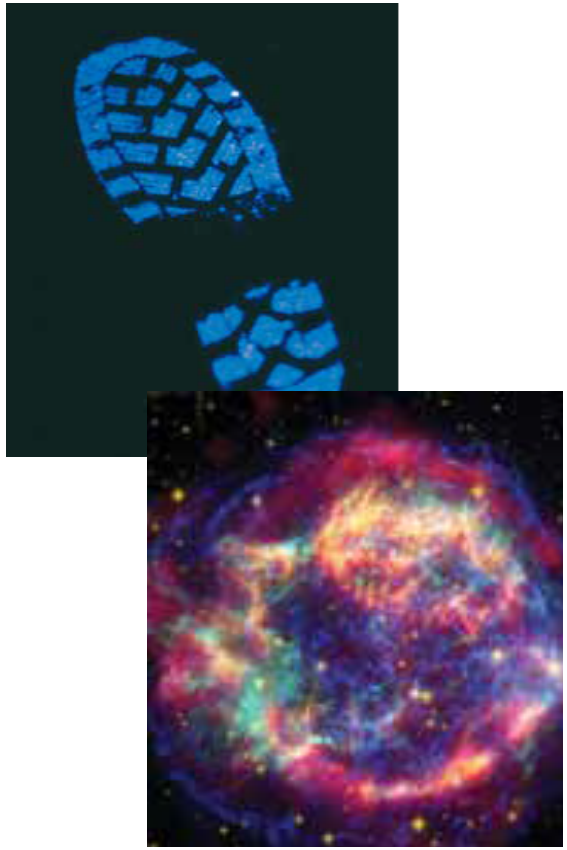
Discussion Questions

- Identify three sources of electromagnetic radiation that you interacted with this week.

- A type of starfish uses electromagnetic radiation to warn predators that it does not taste good. What type of electromagnetic radiation is most likely given off by the starfish?

Concept 3: Electromagnetic radiation enhances how we sense our world.

- You are an electromagnetic radiation detector.
  - Skin: special cells sense infrared radiation, and send a message to your brain that is interpreted as heat
  - Eyes: sense visible light to see brightness, objects, and colour
- Electromagnetic radiation and technology lets us "see" in a new way



Solving Crimes

Electromagnetic radiation helps uncover evidence.

- Luminol:
  - Used to find blood
  - Undergoes a reaction with iron in blood to give off visible light

Figure 2.3: Luminol is sprayed at a crime scene to test for blood.

Solving Crimes

- Infrared photography:
  - Senses temperature differences
  - Used to find hidden evidence (weapons) within walls

- X-ray, infrared, ultraviolet radiation:
  - Used to uncover art forgeries by identifying varnishes, pigments, brushstrokes

Figure 2.3: Luminol is sprayed at a crime scene to test for blood.

Diagnosing Disease

Electromagnetic radiation is used to identify medical problems.

- Magnetic resonance imaging (MRI)
  - Radio waves and magnets work together
  - Signals are used to create an image of tissues

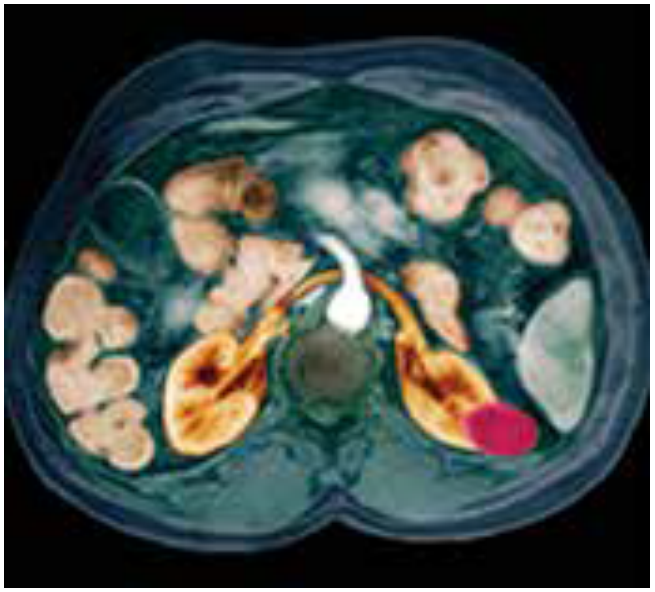


Figure 2.4: This MRI image shows a cross-section of a human abdomen. It has been coloured to help show the different organs.

Diagnosing Disease

- X-ray imaging:
  - Used to diagnose broken bones and cavities in teeth
  - X-rays are absorbed by bones and teeth, but pass through most other body tissues

X-ray of bones

Diagnosing Disease

- Blue light cancer detection:
  - B.C. Cancer Agency developed a device that shines blue light into the mouth to detect cancer
  - Under blue light or ultraviolet radiation:
    - Normal tongue will glow
    - Cancerous tissue will look dark

BC Cancer Agency
CARE + RESEARCH

Seeing Earth from Space

Satellites use different types of electromagnetic radiation to gather information about Earth (remote sensing).

- Weather satellites:
  - Use visible light and infrared radiation from Earth to monitor weather conditions
  - Can detect movement of clouds and amount of moisture in atmosphere

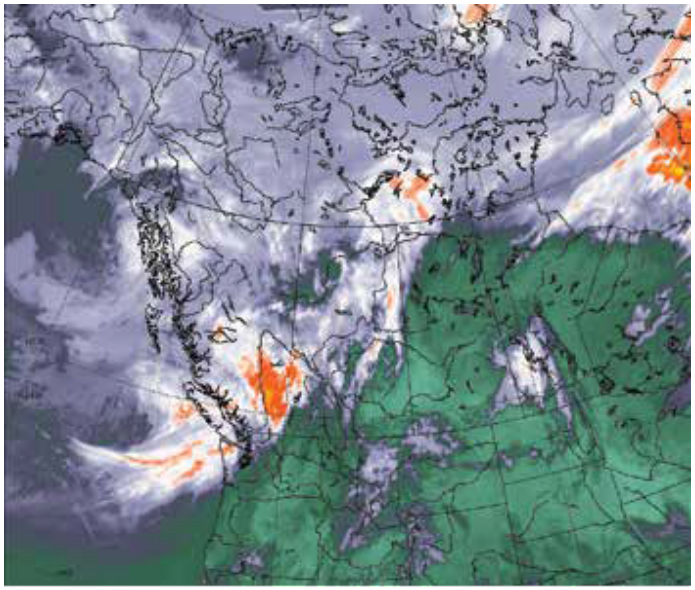


Figure 3.5: Satellite image of Earth

Seeing Earth from Space

- LANDSAT satellite:
  - Measures visible light and infrared radiation from Earth's land surface to map it
  - Helps with monitoring and observing land use (examples: loss of rainforests, finding near-shore shipwrecks)

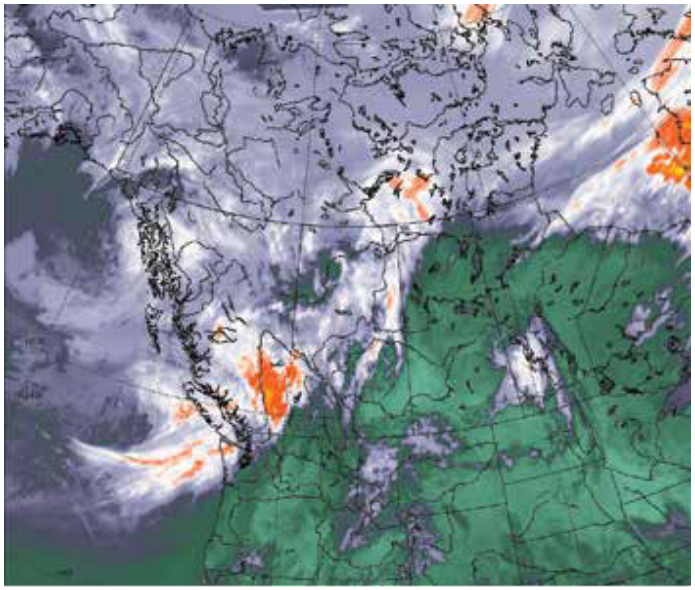


Figure 3.5: Satellite image of Earth

Viewing the Universe

Electromagnetic radiation is being used to study the universe.

- Hubble Space Telescope:
  - Uses mirrors to collect and focus visible light
  - Other instruments on the telescope sense ultraviolet and infrared radiation

Figure 3.6: This image of a supernova (exploding star) combines data from telescopes sensing different kinds of electromagnetic radiation.

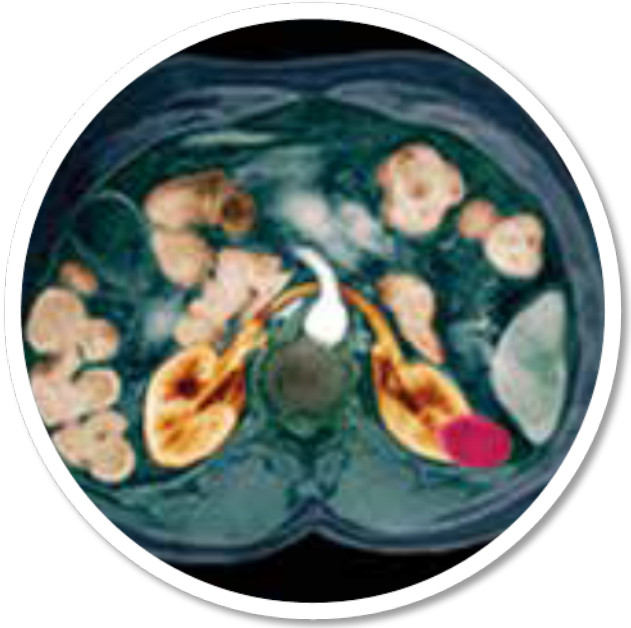
Viewing the Universe

- Very Large Array radio telescope:
  - Largest radio telescope on Earth
  - 27 receivers work together to sense radio wave radiation from space

Figure 3.6: This image of a supernova (exploding star) combines data from telescopes sensing different kinds of electromagnetic radiation.

Discussion Questions

- Describe how you are an electromagnetic radiation detector.



Summary: How does electromagnetic radiation shape your world?

- Electromagnetic radiation is an important part of your world.
- Sources of electromagnetic radiation are all around you.
- Electromagnetic radiation enhances how we sense our world.