Medical Imaging and Radiotherapy

In Canada, 48% of the radiation we will be exposed to in our lifetimes will come from medical procedures. Exposure to the sun and the naturally radioactive isotopes in the soil, air, food and water will account for 99% of the rest.

Every day, people undergo medical tests to diagnose diseases and injuries. Some of these tests involve exposure to ionizing radiation. The Canadian Nuclear Safety Commission (CNSC) regulates all nuclear substances in Canada, including the use of radioisotopes and linear accelerators in medicine.

Radiotherapy

External Beam Radiotherapy

Teletherapy

This is the most common form of radiotherapy used for the treatment of cancer. A high energy beam of X-rays or gamma rays is directed at the tumour. The beams are produced by medical linear accelerators or by devices containing one or more high-activity, sealed radiation sources. The total radiation dose is usually "fractionated" into multiple treatments, delivered over a period of several weeks.

Stereotactic Radiation Therapy

Also called radiosurgery, this procedure utilizes highly focused external beams of X-rays or gamma rays to destroy small target tissues (such as metastases or arteriovenous malformations) while preserving adjacent normal tissue, without the need for a surgical incision. The total dose is typically delivered in a single treatment.

Radionuclide Therapy

Brachytherapy - temporary implants

A device called a "brachytherapy remote afterloader" positions high-activity, sealed radiation sources at several locations near or within the tumour for a short period of time. The sources are then removed.

Brachytherapy - permanent implants

The tumour is implanted with 80 to 120 low-activity radioactive "seeds". These seeds remain within the patient and decay to background levels within about two years.

Systemic Radiation Therapy

Radioactive materials are ingested or injected into the patient. This is used to treat thyroid cancer, to relieve pain, or to treat cancers that have already spread throughout the body.

Nuclear Medicine Imaging

Imaging accounts for the use of 90% of all medical radioisotopes.

SPECT SCAN

Single-Photon Emission Computed Tomography

A patient is injected with (or inhales or consumes) a short-lived gamma-emitting radioisotope. A gamma-camera takes multiple pictures of the radioisotope's activity from multiple angles, creating a 3D model that tracks the movement and absorbtion of the radioisotope within the body.

PET SCAN

Positron Emission Tomography

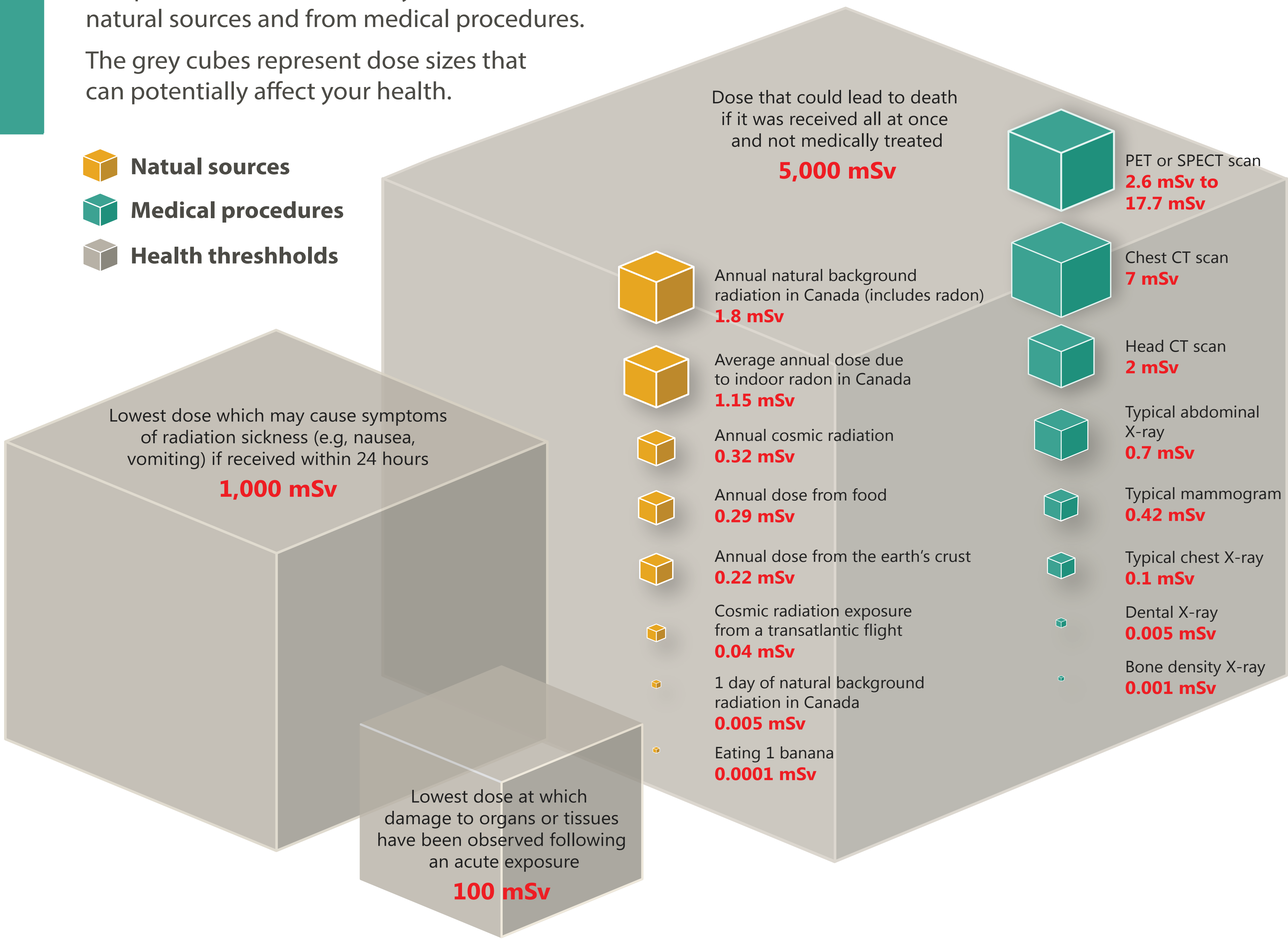
A patient is injected with (or inhales or consumes) a positron-emitting radioisotope. These positrons then combine with electrons to form two gamma rays which travel in opposite directions. A gamma camera tracks them to create a 3D model of the movement and absorption of the radioisotope within the body.

Radiation Doses

These green and yellow cubes represent the comparative radiation doses you receive from natural sources and from medical procedures.

The grey cubes represent dose sizes that can potentially affect your health.

- **Natual sources**
- **Medical procedures**
- **Health threshholds**



Measuring Radiation

Units

Becquerel (Bq)

Tells us: How many atoms are "decaying" per second?

This unit measures the radioactivity of a radioactive substance. The amount of radioactivity is determined by both the rate of decay or "half life" of the substance and the total quantity of the substance present.

Gray (Gy)

Tells us: How much radiation am I exposed to?

This unit is used to calculate **absorbed dose**. The calculation is affected by the amount of **time** you spent being exposed, how much **distance** there was between you and the source, and by what **shielding** there was was, if any.

Sievert (Sv)

Tells us: What effect will this exposure have on me?

This unit is used to calculate **equivalent dose** and **effective dose**. Equivalent dose takes into account the mass, charge, and energy of the particles involved. Effective dose then further adjusts this result by what body part was exposed. Some parts are more sensitive to radiation than others, so a weighted number for each body part is applied. Effective dose determines your increased risk of developing cancer in the future.

Exposure factors

Time

The more time you spend near a radioactive source, the more your body is exposed to the radiation emitted by that source. Minimizing the time spent near radioactive material reduces your dose.

Distance

As your distance from the source increases, the radiation it emits becomes more diffuse, just as the light from a lightbulb becomes dimmer the further you get from the bulb. Doubling your distance from a source reduces the dose to ¼ of what it would have been. This effect is known as the "inverse square law".

Shielding

Different materials may be needed to block different types of radiation. In addition, the more energy a particular radiation has, the greater the thickness of material required. Gamma rays are most effectively shielded by dense, heavy materials such as concrete or lead. High-energy beta particles can be effectively blocked by materials such as glass or plastic. Alpha particles only travel a few centimetres in air and can be completely blocked by a simple piece of paper.