**WHAT IS RADIATION?**
Radiation can be defined as the emission of energy in the form of waves or particles through space or through a material medium. The word radiation comes from the phenomenon of waves radiating, meaning traveling outward in all directions from a source. Radiation has always been present all around us. 

Radiation can be ionizing and non-ionizing, depending on its ability to knock electrons out of the orbit of atoms when travelling through a medium. The ionizing radiation can cause damage to matter, particularly living tissue. At high levels ionizing radiation is therefore dangerous, so it is necessary to control our exposure. While humans possess no senses that can detect or feel radiation, radiation is readily detected and measured with instruments, and exposure can easily be calculated and monitored.

Since one Sievert would represent a very large dose, in practice the milliSievert (mSv) is commonly used (1 milliSievert represents a thousandth of a Sievert).

**BACKGROUND RADIATION**
Background radiation is that ionizing radiation which is naturally and inevitably present in our environment. It originates from a variety of sources. Sources include radiation from space (cosmic radiation), radiation originating on Earth (terrestrial radiation), and intake of naturally-occurring radionuclides through ingestion and inhalation. A person living in Canada can expect to receive around 1.8 milli-sieverts of background radiation in one year, while the average person world-wide can expect to receive 2.4 mSv. [1]

**COSMIC RADIATION**
Earth is continually bombarded by radiation coming from outer space originating from the sun and other celestial events in the universe. Much of this radiation is absorbed in the atmosphere, but some will go through and will become absorbed by humans. The radiation dose a person receives from cosmic radiation varies and will depend on the location and altitude.
CONTINUED...

This radiation is much more intense in the upper atmosphere, around the 10 km altitude typical for airline flight paths, and hence is of particular concern for airline crews and frequent passengers. During their flights airline crews typically get an extra dose on the order of 2.2 mSv per year. [2]

TERRESTRIAL RADIATION
This is the radiation coming from the earth's crust due to the presence of naturally occurring radioactive substances such as uranium, potassium and thorium. From deposits in rocks and sediments, these radionuclides may migrate into soil, water and air. Some traces of these elements can also be found in building materials and so exposure to natural radiation can also occur indoors.

INGESTION
Some of the essential elements that make up the human body, mainly potassium and carbon, have radioactive isotopes that add significantly to our background radiation dose. Other radioactive elements are present in the food and drink that we consume daily. One example is bananas which are naturally radioactive due to Potassium-40, which is a radioactive isotope of potassium. Note that your should not avoid eating bananas because of this – for example, you would have to eat about 70,000 bananas to receive the same radiation dose as you would receive from one chest x-ray CT-scan.

CALCULATE YOUR RADIATION EXPOSURE
If you want to estimate your annual dose of radiation received from different sources you can use the following online calculator:
http://fedorukcentre.ca/resources/dosechart/index.php

RESOURCES
**WHAT IS RADIATION?**

Radiation is a generic term scientists use when describing the emission of energy. For example, the signal from a radio station *radiates* away from the antenna. When most people hear the word radiation, they are likely picturing *ionizing radiation*, such as that associated with x-ray imaging or nuclear power.

Ionizing radiation is often due to an atom having too much energy. Such an atom is said to be unstable. Unstable atoms can emit particles such as electrons, neutrons, or protons away from the nucleus to become stable. This process is referred to as radioactive decay.

It is referred to as ionizing radiation because these emitted particles have a lot of energy! When they pass through matter, they can separate electrons from an atomic nucleus. If the radiation passes through human tissue, this ionization can cause damage to cells, including DNA.

**HOW IS RADIATION MEASURED?**

The effect of radiation on humans is measured in a unit called a Sievert, and describes an amount of radiation dose. It is named after the scientist Rolf Sievert who contributed greatly to the study of the biological effects of radiation on humans. There is always radiation present in the environment. A typical Canadian can expect to receive between 2 to 4 milli-Sieverts of radiation dose per year. (1 milli-Sievert is 1/1000 of a Sievert).

Typical sources of typical background doses to Canadians are:
- 0.9 milli-Sieverts per year due to inhalation of radon gas in the home
- 0.3 milli-Sieverts per year due to ingestion of naturally occurring isotopes, such as Potassium in bananas
- 0.3 milli-Sieverts per year due to cosmic radiation from the sun
- 0.2 milli-Sieverts per year due to small amounts of naturally occurring radioactive materials such as uranium and thorium that are present in all soils and in composition of building materials such as granite or concrete.

Due to geological and geographic differences, people living in different regions within Canada may receive different annual radiation doses. For example, in Winnipeg where there is more radon present in buildings the annual dose may be about 4 milli-Sieverts, whereas in Vancouver it is closer to 1 milli-Sievert.
WHAT ARE THE RISKS?
There are two main types of biological effects where radiation is concerned: deterministic effects, and stochastic effects.

DETERMINISTIC EFFECTS
A deterministic effect is one that takes place over a short period, and after reaching a threshold dose of radiation there are known biological effects that are certain to occur. An example of a deterministic effect would be hearing loss after exposure to extremely loud environments. At normal conversational sound levels of about 50 dB, there is no risk to your hearing. After the sound level increases past 100 dB however, damage to hearing is certain to occur. The same is true of radiation exposures. Depending on which tissue or organ where the radiation dose is received and the type of radiation, a dose of about 1,000-2,000 milli-Sieverts is needed in a short period for deterministic effects to occur. Examples of deterministic effects of ionizing radiation include skin burns and production of cataract.

STOCHASTIC EFFECTS
A stochastic effect is one in which we can only attribute a certain probability of risk. An example of a stochastic health effect would be the risk of developing lung cancer after smoking. If a person smokes it cannot be said for certain that they will develop lung cancer, only that it increases the likelihood of developing lung cancer. The same is true with radiation exposures. Due to possible DNA damage, small quantities of radiation received over long periods of time may increase the likelihood of developing certain types of cancers. The current understanding of long term radiation exposures is that for a typical population of workers there is a 4% increase in cancer risk per 1000 milli-Sieverts of radiation dose received. Based on 2010 estimates, approximately 1 in 4 (25%) of Canadians will die from Cancer. Therefore, if a person were to receive a dose of 10 milli-Sieverts, this would increase the probability from 25% to 25.04%.

RISKS IN PERSPECTIVE
The regulatory framework in Canada currently sets the maximum legal dose a worker can receive. The dose limit is based on balancing workplace hazards and is set at, on average, 20 milli-Sieverts per year. This implies that if a person was working with nuclear substances and got the highest allowable dose every year, for 50 consecutive years during their career, their total lifetime dose would be 1,000 milli-Sieverts. This would represent an increased cancer risk of about 4%. In practice, it is incredibly rare to find a worker who exceeds this dose limit, and in fact workers are required to wear devices that monitor their exposure if they are likely to approach even 10% of the dose limit.

<table>
<thead>
<tr>
<th>PROFESSION</th>
<th>RISK OF DEATH PER YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finance</td>
<td>1 in 60,000</td>
</tr>
<tr>
<td>Service</td>
<td>1 in 40,000</td>
</tr>
<tr>
<td>Trade</td>
<td>1 in 20,000</td>
</tr>
<tr>
<td>2 mSv of radiation per year</td>
<td>1 in 12,000</td>
</tr>
<tr>
<td>Government (includes police and fire)</td>
<td>1 in 11,000</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>1 in 11,000</td>
</tr>
<tr>
<td>Transportation</td>
<td>1 in 4,000</td>
</tr>
<tr>
<td>Construction</td>
<td>1 in 3,000</td>
</tr>
<tr>
<td>20 mSv of radiation per year</td>
<td>1 in 1,200</td>
</tr>
<tr>
<td>Mining</td>
<td>1 in 1,100</td>
</tr>
<tr>
<td>Forestry</td>
<td>1 in 900</td>
</tr>
<tr>
<td>Fishing and Hunting</td>
<td>1 in 500</td>
</tr>
</tbody>
</table>


MORE INFORMATION
Radiation Calculator:
http://fedorukcentre.ca/resources/dosechart/index.php
WHAT IS RADIATION?
Radiation is a generic term that scientists use when describing the emission of energy. For example, the signal from a radio station radiates away from the antenna. Radiation can exist in many forms, including electromagnetic radiation (radio waves, microwaves, visible light and lasers, to name a few), sound (ultrasound for example), and particles (such as alpha particles emitted during the decay of radon gas). Radiation can also be categorized by its energy, as either ionizing radiation or non-ionizing radiation, depending on whether or not the radiation has sufficient energy to cause ionization when it interacts with matter (knocking an electron out of the orbit of an atom).

Radiation is regulated differently in Canada, depending on its type, its energy, and how it is generated.

FEDERAL REGULATIONS
The Nuclear Safety and Control Act and its associated Regulations, is in place to regulate the development, production, and use of nuclear energy, and the production, possession, and use of nuclear substances, prescribed equipment and prescribed information. The use of nuclear power, radiation exposure devices, radioactive material, and high-energy x-ray systems, are all regulated under this federal system, including the transportation of radioactive material. The Canadian Nuclear Safety Commission is responsible for regulating the use of nuclear energy, to protect Canadian's health, safety, security and environment. Their website is http://nuclearsafety.gc.ca/eng/ and they can be contacted in various ways, as listed in the following website: http://nuclearsafety.gc.ca/eng/contact-us/index.cfm

Also under federal jurisdiction is the Radiation Emitting Devices Act and its associated Regulations, which are in place to control the sale, lease, and importing of radiation emitting devices in Canada. The regulations set out the standards that must be met for various categories of radiating emitting
devices including but not limited to: television receivers and video monitors/display systems, dental, hospital, and analytical x-ray equipment, baggage inspection x-ray systems, microwave ovens, laser scanners, high energy mercury vapour discharge lamps, tanning equipment, and ultrasound devices. The Consumer and Clinical Radiation Protection Bureau of Health Canada is responsible for the administration of the Radiation Emitting Devices Act and Regulations. Their contact information is found on the following website: http://hc-sc.gc.ca/contact/ewh-semt/hecs-dgsecc/ccrp-prpcc-eng.php.

**PROVINCIAL AND TERRITORIAL REGULATIONS**

Individual provinces and territories are responsible for regulations around radiation use, for situations that are not under federal jurisdiction, including, for example, the use of x-rays (for both medical and analytical or industrial uses), the presence or use of Naturally Occurring Radioactive Material (NORM), use of lasers, and EMF or Electromagnetic Frequency radiation. Depending on the province or territory, the local regulations may be administered by the same or by different groups (e.g., in Ontario, the Ministry of Labour is responsible for industrial and workplace exposures while the Ministry of Health manages exposures due to the healthcare system). All provinces and territories, and the federal regulators, may participate in the Federal Provincial Territorial Radiation Protection Committee (FPTRPC), which is a group that was created to advance the development and harmonization of practices and standard for radiation protection. Information about the FPTRPC, and how to contact individual members of the various provinces and territories, can be found at the following website: http://hc-sc.gc.ca/ewh-semt/radiation/fpt-radprot
WHAT IS NUCLEAR MEDICINE IMAGING?
Nuclear medicine imaging uses small amounts of radioactive drugs and images how those drugs move through your body. This helps doctors see how your body is working. In contrast, x-rays or CT scans show how your body looks (i.e., anatomy) rather than how it works (i.e., function). Early diagnosis is often possible with Nuclear Medicine since changes in function often occur before changes in anatomy.

Unlike CT or x-ray devices, nuclear medicine imaging devices do not themselves give off any radiation. The nuclear medicine pharmaceuticals used give off “gamma rays” that allow one to track the progress of radioactive pharmaceuticals within the body. Note that radioactive material used disappears (decays) in a short time.

IS YOUR NUCLEAR MEDICINE TEST NECESSARY?
It is important as a patient to discuss with your doctor why you are receiving any test, no matter how small the risk. You should find out what your doctor expects to learn from the nuclear medicine procedure and how those results could affect your treatment in the future. If a procedure offers useful information that is likely to help your doctor decide on your treatment, the benefits of Nuclear Medicine Imaging will outweigh its small potential risk.

HOW MUCH RADIATION IS RECEIVED FROM NUCLEAR MEDICINE IMAGING?
The average effective dose from nuclear medicine imaging depends on the test being performed. In general, the amount of radiation from nuclear medicine procedures is similar to that from other radiologic procedures and from natural background radiation.

Table 1. Typical Patient Radiation Doses for Common Nuclear Medicine Procedures

<table>
<thead>
<tr>
<th>NUCLEAR MEDICINE PROCEDURE</th>
<th>TYPICAL RADIATION DOSE (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thyroid scan</td>
<td>0.14</td>
</tr>
<tr>
<td>Liver-spleen scan</td>
<td>1.0</td>
</tr>
<tr>
<td>Lung scan</td>
<td>2.0</td>
</tr>
<tr>
<td>Bone scan</td>
<td>4.2</td>
</tr>
<tr>
<td>Heart scan</td>
<td>11</td>
</tr>
<tr>
<td>PET/CT study</td>
<td>14</td>
</tr>
</tbody>
</table>

In comparison, all Canadians receive, on average, 2.4 mSv of exposure due to natural background radiation each year.

IS THERE A RISK ASSOCIATED WITH THE USE OF NUCLEAR MEDICINE?
Exposure to high levels of ionizing radiation can lead to serious adverse effects, including cancer. While there is no direct evidence that the low amount of radiation used in nuclear medicine leads to such effects, it is prudent to assume that every exposure to ionizing radiation carries some risk. However, when warranted, a nuclear medicine test gives your doctor important information that is worth the small possible risk.