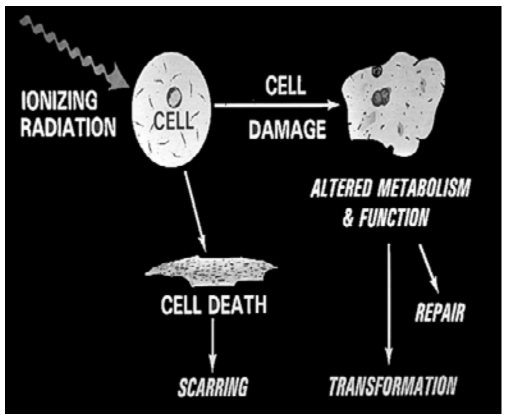
Radiation Exposure and Relative Risk

Radiation Safety Orientation | Open Source | Booklet 2 (June 1, 2018)

For more information, refer to the Radiation Safety Manual, 2017 RSP-6

What are the potential outcomes of exposure to ionizing radiation?



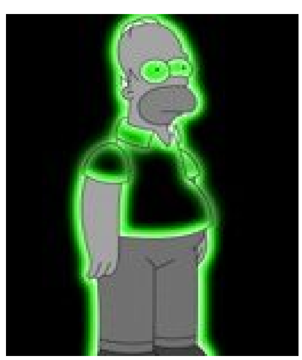
Damage to cells can lead to a transformed cell, to cell death or the cell is successfully repaired.

When too many cells die we will see cataracts developing, radiation burns, radiation illness or death. Dead cells do not cause cancer or negative genetic effects. Dead cells cause injury or scarring and if enough of the cells are killed, the result can be dangerous to health (cataracts, radiation illness).

When the cell is not repaired successfully, the transformation can lead to cancer or negative reproductive effects.

In addition, exposure to radiation is cumulative and damage is additive throughout your whole life. Considering the potential dangers, it is important to find perspective on the risk related to your planned work at the University. Let's get started by considering our own bodies!

Did you know that radioactive isotopes occur naturally in the human body!



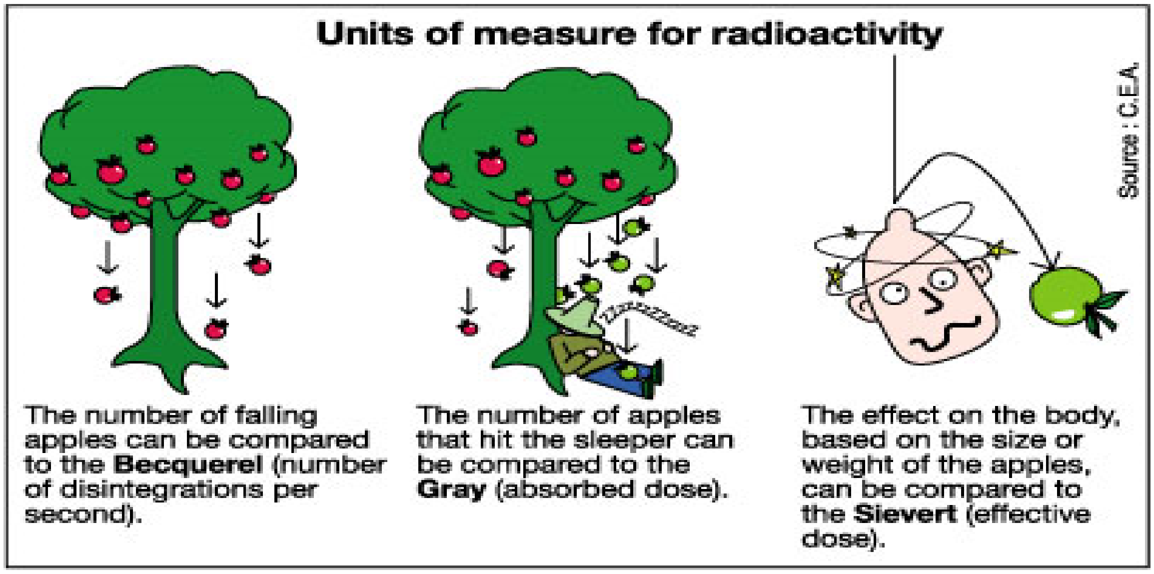
We are a source of exposure to ourselves.

Isotopes for a 70 kg adult	Amount of Radioactivity in Becquerel (Bq)
Carbon-14	3,700 [a]
Polonium-210	40 [b, d]
Potassium-40	4,000 [b]
Radium-266	1.1 [b]
Thorium	0.21 [b]
Tritium	23 [c]
Uranium	2.3 [a, b, d]

[a] ICRP, 1975, [b] Eisenbud and Gesell, 1997, [c] UNSCEAR, 2000, [d] ICRP, 1980

How does the amount of activity relate to the potential risk?

Let's start by considering how exposure to ionizing radiation is expressed:



What are the effects of over-exposure to Ionizing Radiation?

The effective dose is measured in Sieverts or millisieverts (mSv)

Acute effects	Dose Threshold to the whole body
Cataracts	100mSv
Burns	>100mSv
Radiation illness	>1000mSv
Death	>10 000mSv

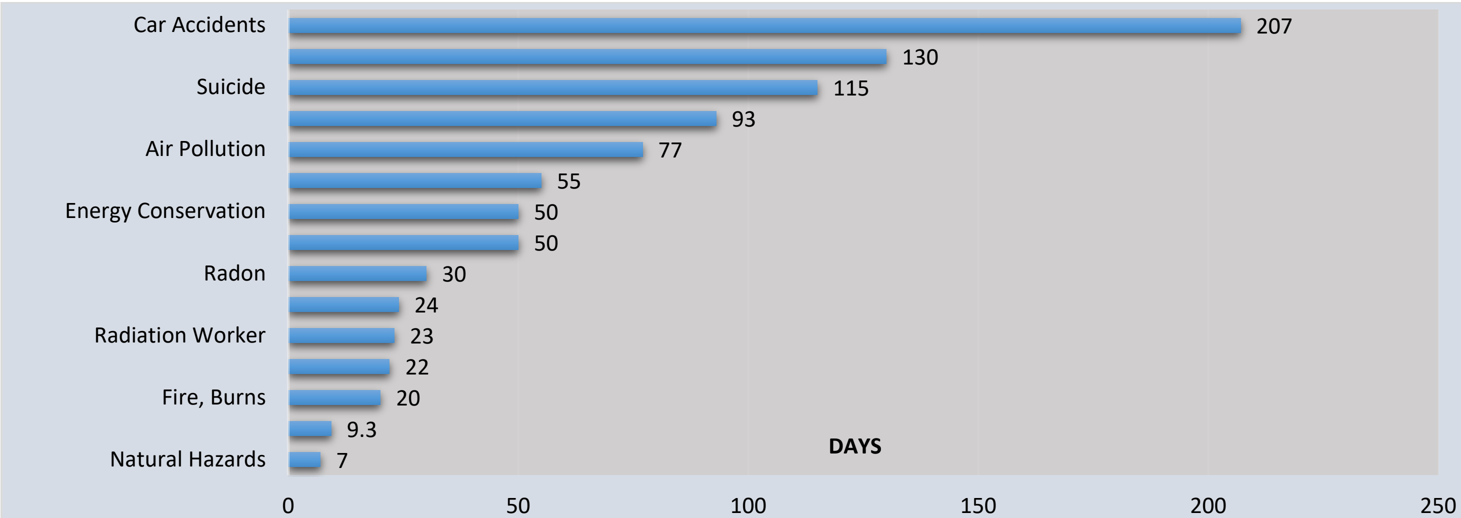
Let's put the effects in perspective

Annual radiation dose for a smoker (1 pack/day) is 30-80 mSv (from the fertilizer containing alpha-emitters Po-210 and Pb-210).

Radiation dose used clinically to kill cancer cells is 50,000-60,000 mSv (not whole body, site specific)

How can radiation risks be compared to other risks?

This graph shows you how many days these factors will shorten an average person's life.



Note: The Radiation worker – and you are not a Radiation worker unless………… you signed an "Acceptance of Nuclear Energy Worker Status Form".

When do I become a Radiation Worker or Nuclear Energy Worker (NEW)?

You only become a NEW if it is anticipated, based on the history or type of experiment, that your annual exposure will exceed the limit for a member of public. Nuclear Energy Workers work as radiopharmacy workers, cyclotron operators, nuclear power employees, industrial radiographers, nuclear medicine technicians or researchers working on certain research projects.

You will know if you have been designated a NEW because you will be required to sign an Acceptance of Nuclear Energy Worker Status Form.

Regulatory Dose Limits for Radiation Exposure

Classification of worker	Dose Limit
Member of the Public	1 mSv/yr, whole body (Effective Dose)
(You, me and all employees at the University of Manitoba (except NEWs)	15 mSv/yr, lens of eye (Equivalent Dose)
	50 mSv/yr, skin
	50 mSv/yr hands and feet
Nuclear Energy Workers (NEW)	Maximum is 50 mSv/yr, whole body with no more than 100 mSv averaged over 5 year periods
	150 mSv/yr, lens of eye (Equivalent Dose)
	500 mSv/yr, skin
	500 mSv/yr hands and feet
Restricted Access at the University	If exposure rate could be over 25 uSv/hr, only enter with lab personnel listed on the permit

The Average Background Radiation for Winnipeg is 4.1 mSv/yr (Effective Dose)

(Sources: Gratsky et al., 2004, UNSCEAR 2008, Geological Survey of Canada)

Your real personal exposure is the sum of exposure from background radiation, medical procedures and your occupational exposure.

Background + *Medical* + *Occupational*

Where does background radiation come from?

Recall the background radiation in Winnipeg. This contributes to an effective dose of 4.1 mSv per year to your personal exposure. Background radiation in Winnipeg comes from different sources

0.4 mSv from cosmic radiation

0.3 mSv from the food we eat

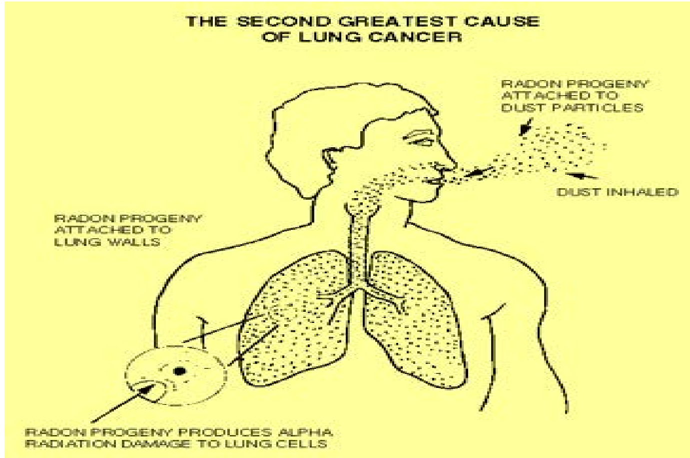
K-40 content Bq per 500 grams of certain foods	
Red meat	56
White potato	63
Carrot	63
Banana	65
Lima beans	86
Brazil nuts1	103

Source: Brodsky, 1978.
1Brazil nuts also naturally contain radium-226

0.2 mSv from terrestrial sources

0.1 mSv from consumer products

For the average Winnipegger most background radiation comes from radioactive gas Radon (3.1mSv)



What are the typical (adult organ) doses from various medical imaging procedures?

Study Type	Relevant Organ	Equivalent Dose (mSv)
Dental x-ray	Brain	0.01
Chest x-ray	Lung	0.1
Screening mammography	Breast	3
Adult abdominal CT	Stomach	10

(source: http://nuclearsafety.gc.ca/eng/resources/radiation/introduction-to-radiation/radiation-doses.cfm)

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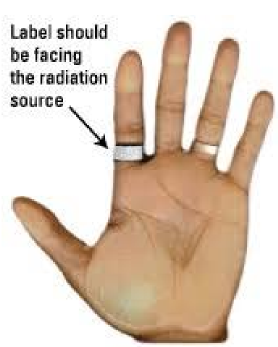
How is occupational dose measured at the University?

External Exposures

The University uses dosimeters from Health Canada's National Dosimetry Service. Dosimeters measure the amount of radiation to which you are externally exposed. Below are the commonly used dosimeters at the University.

InLight® (OSL) dosimeter or Optically Stimulated Luminescence technology.
It contains elements that absorb radiation and stores the energy in the form of excited electrons.



Ring dosimeter (extremity dose)
Thermo Luminescent technology

No longer in use at the University - If you find any of these badges in the lab that are no longer in use, please inform EHS (badges that are not returned, can result in late fees).

Internal Exposures

A Thyroid Bioassay method is used to determine an internal exposure from an uptake of I-124, I-125 or I-131 when in a 24 hour period the quantity used of I-124, I-125 or I-131:

- Exceeds 2 MBq in an open room,
- There is a spill of more than 2 MBq, or
- Whenever external contamination is detected on a worker.

Please refer to the Radiation Safety Manual, 2017 RSP-6 for more details!

Do you require a Dosimeter?

If you are working only with H-3, C-14, S-35 or Ca-45, you don't need a dosimeter (a dosimeter cannot measure the radiation from these radioisotopes).

The OSL (badge) dosimeter is required to be worn when working with P-32, I-125, Cr-51 and Tc-99m.

A ring dosimeter is also required to be worn if working with more than 50 MBq (1.35mCi) of P-32.

How should you take care of your Dosimeter?

These are the rules:

- Wear the dosimeter on your chest or waist with your name facing outward
- Wear ring dosimeters with the wider part facing the source of radiation
- Do not wear the badge when receiving an X-ray or during and after receiving medical procedures involving radioisotopes (example, bone scan, thyroid scan, stress test)
- Check the badge or ring for contamination often
- Do not share a dosimeter with another person
- Only wear at the University. Store it at the University so we can get it back at changeover time. If you need a dosimeter at another institution, you cannot use the one assigned from the University.
- Store badge away from radiation source (your source vial, radioactive waste etc.)

The results of your dosimeter readings will be mailed to the Radiation Safety Officer and you will be personally informed about a measured exposure at 0.2 mSv (that is equal to 2 chest X-rays).

What kinds of occupational exposures are measured at the University?

History indicates that they are extremely low. These are the highest exposures recorded at the University:

Year	Maximum individual exposure
2007	0
2008	0
2009	0
2010	0
2011	0
2012	0.22
2013	0
2014	0
2015	0.21
2016	0.33 (worn after a medical imaging procedure)

Are some radioisotopes safer than others?

Safety depends on several factors.

At the University, the commonly used radioisotopes can be separated into three basic groups:

Low energy beta emitters such as H-3, C-14, S-35 and Ca-45, all represent no external radiation hazard. As long as you keep them outside of your body, the radiation they emit cannot harm you. The radiation from these radioisotopes cannot penetrate the outer layer of (dead) skin. If you work with these radioisotopes, you need to practice contamination control strategies to keep these materials out of your body.

Mid-energy beta emitters and gamma emitters such as P-32, I-125, Cr-51 and Tc-99m may represent an external radiation hazard. Even when they are not inside your body, the radiation they emit may penetrate the skin (medical imaging uses gamma emitters). If you work with these radioisotopes, you need to take action to reduce your potential exposure and practice contamination control strategies.

Positron Emitters such as F-18 and I-124 may represent an external radiation hazard. Even when they are not inside your body, the radiation they emit may penetrate the skin (medical imaging uses gamma emitters). If you work with these radioisotopes, you need to take action to reduce your potential exposure and practice contamination control strategies.

How can you control your whole body exposure?

- Reduce the amount of radiation you work with (Activity in MBq or uCi)
- When possible, choose a Low energy beta emitter!
- Minimize contamination

If the work requires the use of Mid-energy beta emitters and gamma emitters, then add the following control measures:

- Minimize the exposure time
- Increase the distance (inverse square law)
- Use effective shielding

Also avoid or limit time in restricted areas when exposure rate is higher than 25uSv/h (access is restricted to these areas).

How can you control radioactive material from entering your body?

Just like other hazardous products, the route of entry is inhalation, injection, adsorption and ingestion. Preventing an internal exposure is key! Just like working with toxic materials, strategies to control contamination will help keep workers and the environment safe.

- Wear your Personal Protection Equipment
- Use the fume hood when appropriate
- Do not eat, drink or apply cosmetics in a radioisotope lab
- Avoid personal mannerism such as adjusting your glasses, brushing hair away…
- Contamination monitoring:
    - Required with in 7 days of each use
    - Use direct monitoring after manipulation
    - Monitor shipments when they arrive
    - Monitor if you think you may have a spill
    - Monitor for radioactive contamination often!

ALARA means keep your personal exposure to ionizing radiation As Low As Reasonably Achievable

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For more details, refer to the Radiation Safety Manual, RSP-3 and 6.

Remember, all personal contamination must be reported to the Radiation Safety Officer as soon as possible.