Initial Radiation Safety Training at McMaster University

McMaster Health Physics

Part 1 – Radiation Safety

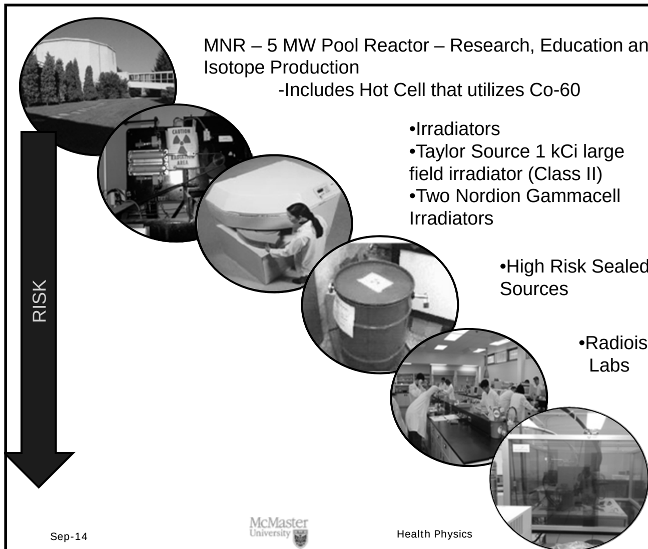
- Campus areas with special hazards
- Radioactive materials and radiation
- Dose and Exposure to radiation
- Effects of Radiation
- Regulatory Controls
- Hazard Awareness and Good Practices
- Emergencies, Incidents, and Upsets

Campus Areas with Special Hazards

Campus Areas with Radiation Hazards

- Nuclear Facilities
  - McMaster Nuclear Reactor
  - Accelerator Facilities
  - Taylor Radiobiology Source
- Radioisotope Labs
  - High Level Lab Facility
  - Campus Labs
- Irradiators
- X-Ray Facilities

MNR – 5 MW Pool Reactor – Research, Education and Isotope Production
-Includes Hot Cell that utilizes Co-60

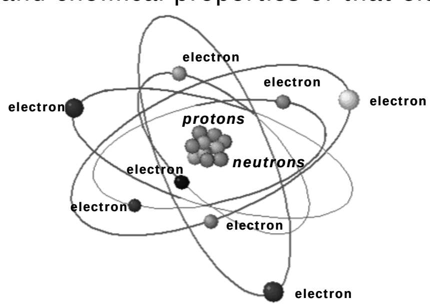


- •Irradiators
- •Taylor Source 1 kCi large field irradiator (Class II)
- •Two Nordion Gammacell Irradiators
- •High Risk Sealed Sources
- •Radioisotope Labs
- •X-Ray Facilities

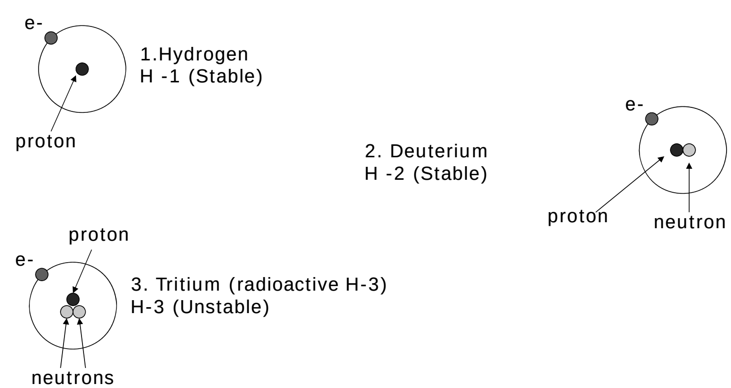
Radioactive Material and Radiation

The Atom

The smallest unit of an element which has all of the physical and chemical properties of that element.

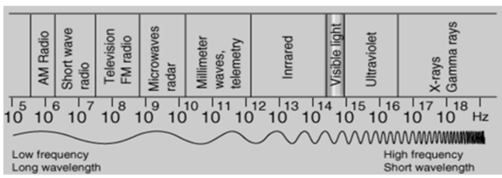


Isotopes of Hydrogen

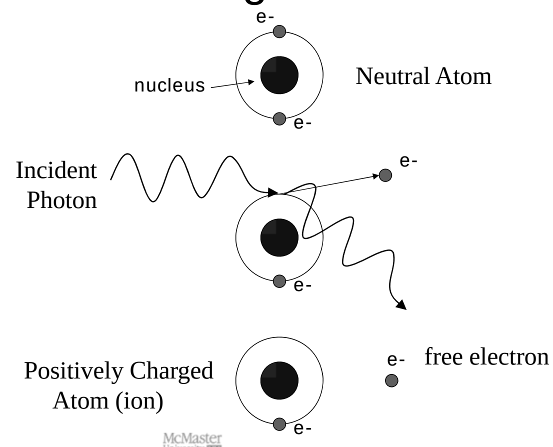


Radiation

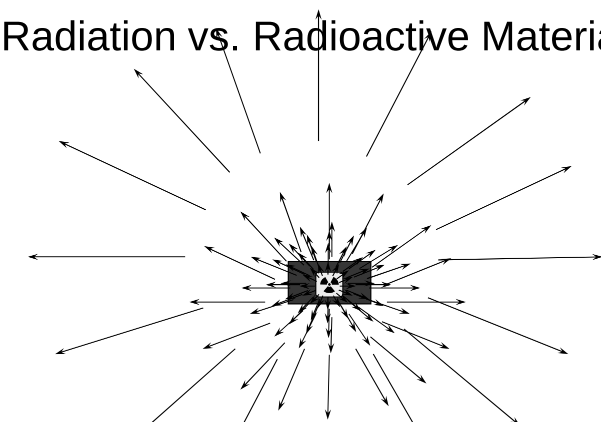
- **Radiation**: the emission or transmission of energy in the form of waves or particles.
- Radiation can refer to waves (or light particles called photons)
- Radiation can also refer to heavier particles emitted from a source



Ionizing Radiation



Radiation vs. Radioactive Material



Radioactive material EMITS radiation. Radiation can also be emitted by nuclear reactions.

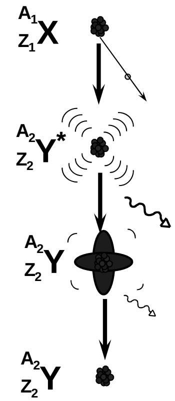
Radioactivity

- Certain isotopes have nuclei that that are energetically unstable.
- These nuclei undergo a spontaneous process of releasing energy to become more stable.
- The energy emitted by the nucleus is released in the form of particles or electromagnetic radiation.
- This conversion from one nuclear energy state to another is radioactive decay (disintegration).
- The rate at which these decays occurs is called **radioactivity**.

The Becquerel

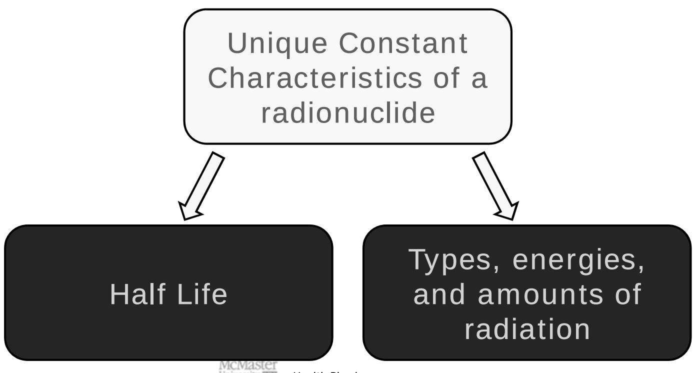
- **The becquerel (Bq):** one nuclear disintegration per second.
- It is a measure of the amount, or activity of a radioactive sample
- The becquerel replaces the old unit of radioactivity known as the curie (Ci).
- kilobecquerel (kBq = 10^3 Bq) megabecquerel (MBq = 10^6 Bq)
  gigabecquerel (GBq = 10^9 Bq) terabecquerel (TBq = 10^{12} Bq)
- 1 Ci = 37 x 10^9 Bq

Radioactive Decay - A Three Step Process



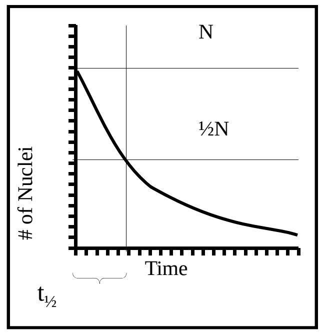
- Parent with unstable n/p ratio
  - Transformation within nucleus
    - fast moving particulate radiation emitted
    - alpha, beta, positron (or e.c.)
- Progeny nucleus in excited state
  - Nucleus de-excites
    - energy emitted
    - photons or conversion electrons
- Progeny in nuclear ground state, may be stable or radioactive
  - Re-arrangement of orbital electrons
    - may lead to X-Rays and auger electrons

Decay Phenomena



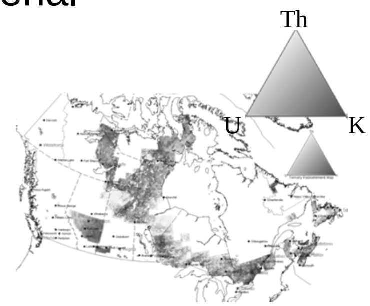
Half-Life

- A half-life is the length of time it takes for one half the original number of nuclei of a radioactive sample to undergo radioactive decay.
- The half-life is usually denoted with the symbol t½.



Naturally Occurring Radioactive Material

- Naturally
- Occurring
- Radioactive
- Material



Reference: NATGAM, Natural Resources Canada

Types of Ionizing Radiation

Gamma Rays and X-Rays

- Residual energy in a nucleus can be dissipated by emitting photons of electromagnetic radiation called gamma rays (γ-rays).
- Gamma rays are physically identical to X-rays
- Gamma rays result from nuclear changes and X-rays result from atomic (electronic) changes.
- High-Z materials are used to shield this radiation.
- Some notable gamma-emitters include ^{60}Co, ^{137}Cs, and ^{40}K.

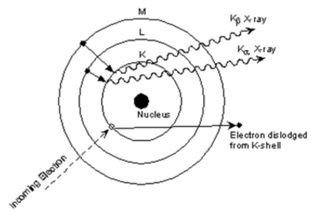
Bremsstrahlung Radiation

- When high energy beta radiation is absorbed in material, electromagnetic radiation known as 'Bremsstrahlung' radiation can be produced.
- Bremsstrahlung means 'braking' radiation
- Bremsstrahlung radiation is more penetrating than the original beta radiation.
- In high-Z metals, such as lead, the production of Bremsstrahlung radiation becomes more significant. Accordingly, beta particles are shielded with low-Z, non-metals, such as Plexiglas.

Characteristic X-rays

Characteristic X-ray Spectra

- Are produced at high voltage as a result of specific electronic transitions that take place within individual atoms of the target material.
- When accelerated electrons strike atoms in the target, they dislodge inner shell electrons resulting in outer shell electrons having to jump to a lower energy shell to replace the dislodged electrons. These electronic transitions result in the generation of X-rays



Alpha Radiation

- An alpha (α) particle is a He-4 nucleus, consisting of 2 protons and 2 neutrons.
- Alpha decay is the emission of an alpha particle from the nucleus
- Alpha radiation is easily shielded and is unable to penetrate the skin – an internal hazard only.
- Some notable alpha-emitters include ^{241}Am, ^{226}Ra, ^{222}Rn, ^{238}U, and ^{239}Pu.

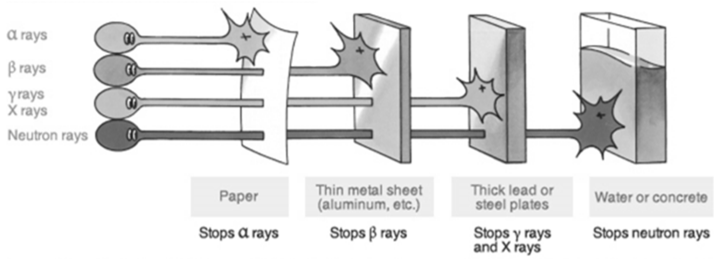
Beta Radiation

- A Beta particle are particles generated by the nucleus that have the same properties of either an electron or a positron, labeled β- or β+ respectively.
- Beta-decay (β decay): any of the processes by which the nucleus alters its atomic number (Z) but not its mass number (A).
- Beta particles are shielded with low-Z, non-metals, such as Plexiglas.
- Some notable beta-emitters include ^{3}H (β-), ^{14}C(β-), ^{35}S (β-), and ^{22}Na(β+).

Neutron Radiation

- In limited circumstances, neutrons can be emitted from a source, and interact with atoms in a material. At some energies, neutron radiation can be very damaging to tissue
- Prominent neutron sources include the reactor core, some accelerators, and select spontaneous fission sources such as Cf-252.
- Shielding is difficult, as the neutron is neutrally charged, interactions are less probable.
- Materials with high concentrations of Hydrogen like wax or concrete are used in neutron shielding.

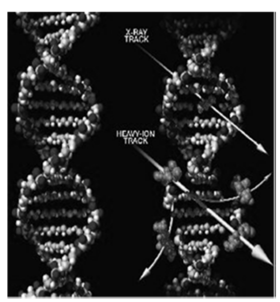
Relative Penetrating Ability



Dose and Exposure to Radiation

Ionizing Radiation Damage to DNA

- When radiation interacts with a molecule, energy is deposited.
- The molecule absorbs this energy, and if the increase in energy is enough to overcome the bonding forces holding the molecule together, the molecule will break up. When chemical bonds in DNA are broken in this way it is called a 'direct effect'.
- Ionizing radiation can also produce reactive chemicals that damage DNA



Dose Units

- Radiation Dose is a measure of the amount of ionizing radiation deposited in material.
  - Absorbed Dose
  - Equivalent Dose
  - Effective Dose
  - Detriment

FUNDAMENTAL DOSIMETRIC QUANTITIES

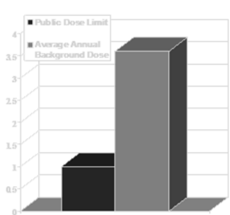
ABSORBED DOSE GY (RAD)	RADIATIONS INTERACT DIFFERENTLY → RADIATION WEIGHTING FACTOR W_R	EQUIVALENT DOSE Sv (rem)	DIFFERENT TISSUE AND ORGAN SENSITIVITIES → TISSUE WEIGHTING FACTOR W_T	EFFECTIVE DOSE Sv (rem)
SAME AMOUNT OF ENERGY DEPOSITED PER UNIT MASS		SAME BIOLOGICAL EFFECT (STOCHASTIC EFFECTS)		SAME OVERALL DETRIMENT (STOCHASTIC EFFECTS)

Units of Radiation Dose

- What we care about is the energy deposited per unit mass and the potential for harm in our bodies
- Units are the gray (Gy) and the sievert (Sv)
- Gy – just the energy deposited
- Sv – adjusted for potential to cause cancer (and genetic effects)
- For most situations, they are the same
- Usually talk about doses in terms of mSv

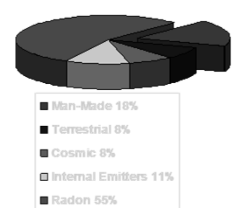
What's in a mSv?

- About 1/10th of a Whole Body CT scan
- 12 Chest X-Rays
- About 40 Toronto – Vancouver airline flights
- Moving to Colorado from Boston (annual dose)

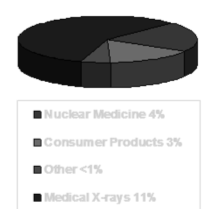


Sources of Radiation - General Population

Natural Sources



Man Made Sources



The average Canadian receives an annual dose of 3.6 mSv of exposure annually

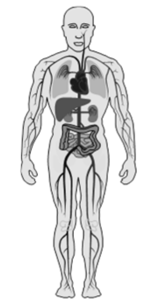
Other:	
Occupational	0.3%
Fallout	0.3%
Nuclear Power	0.1%
Miscellaneous	0.1%

Exposure to Radiation

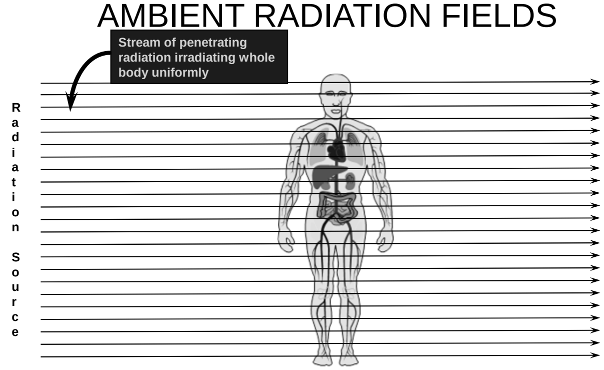
- People can be exposed to radiation in two ways.
- External exposures are exposures that occur from radioactive sources outside the body.
- Internal exposures are exposures that occur from radioactive sources inside the body.

External Exposure

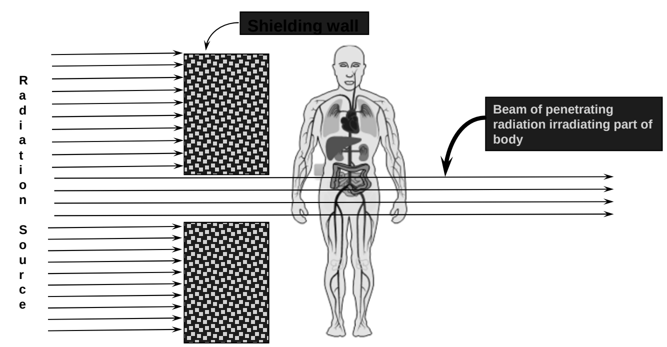
- \- Whole Body
- \- Skin
- \- Extremity
- \- Partial



UNIFORM WHOLE BODY EXPOSURE FROM AVERAGE OR AMBIENT RADIATION FIELDS

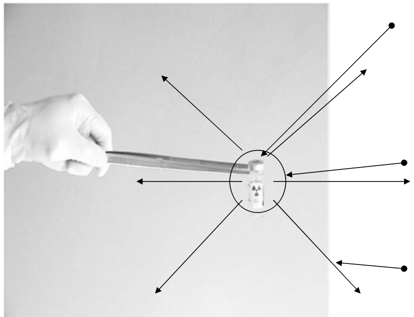


Partial Body Irradiation from an External Source



Ionizing Radiation from Radioactive Samples

The Hazard depends on the Activity, the types of radiation emitted, proximity to the source and the amount of shielding

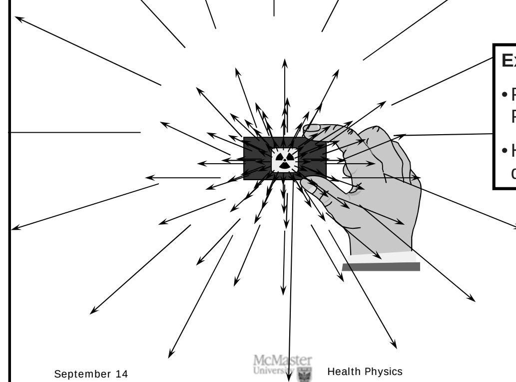


Radioactive sample or stock bottle

Radioactive decay takes place within the sample.

Radiation is emitted as a result.

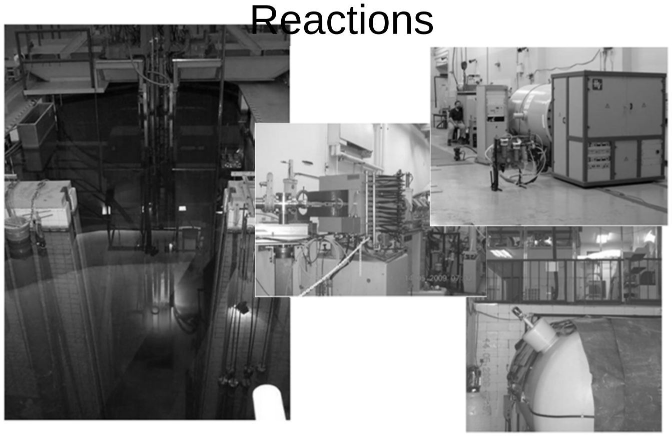
EXTREMITY EXPOSURE FROM NEAR CONTACT RADIATION FIELDS



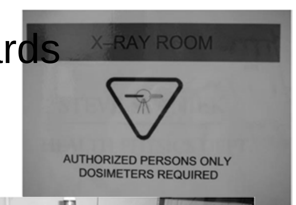
Exposure to

- Penetrating and Non-Penetrating radiation
- High intensity of radiation due to geometry

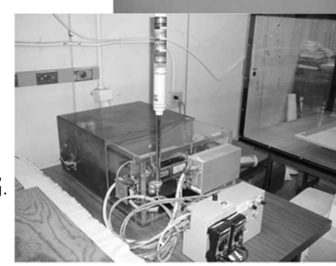
Ionizing Radiation from Nuclear Reactions



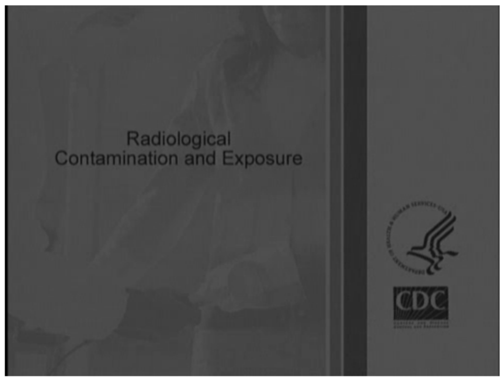
X-ray Hazards



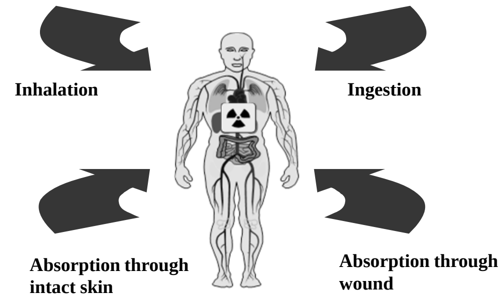
- Non-medical X-ray machines are used by the University to study the structure of materials, proteins, and animals.
- X-ray machines produce:
  - beams of x-rays
  - fields of scattered x-rays
- All rooms which contain X-ray machines have warning signs on doors.
- University policy requires that anyone entering an x-ray room wear an x-ray badge or dosimeter, when x-ray machines are operating.



Contamination Vs. Exposure



Internal Exposure Routes



Radioactive material inside the body is metabolized like the stable element – decays while in the body result in energy deposition (dose) until material is excreted or decays

Effects of Radiation

Deterministic Effects

- Radiation Injuries
- Acute exposures
- Threshold
- Severity of effect increases with dose
- Local - e.g. erythema, burns, cataracts...
- Whole body – e.g. ARS (LD50 ~ 4 Gy)

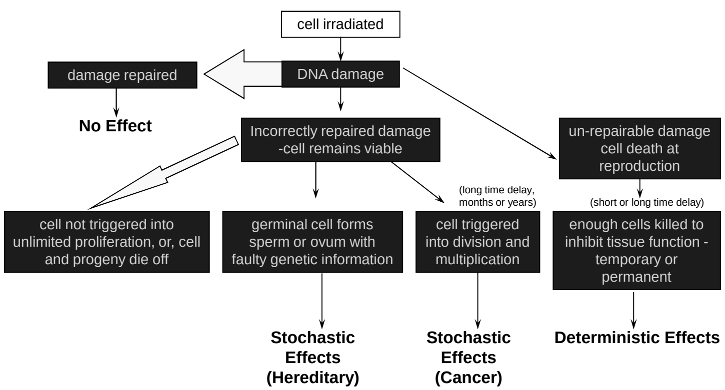
Stochastic Effects

- Cancer and genetic effects
- Chronic, long term exposures
- Assume no threshold
- Probability of effect increases with dose (not severity of effect)
- Genetic effects not observed in humans

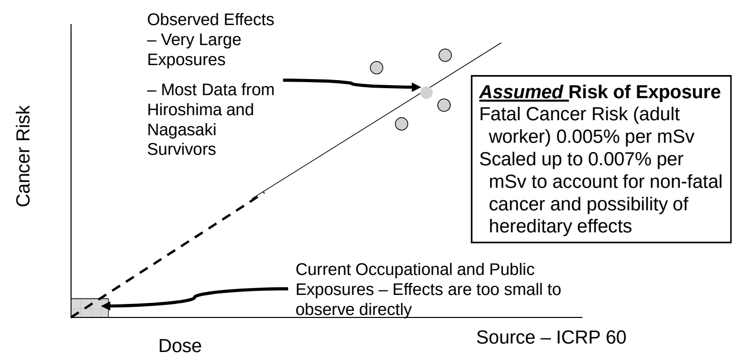
Summary of Effects

•Stochastic Effects	Deterministic Effects
•no threshold (statistical probability) •possibility of stochastic effect with any dose – probability increases with dose •severity of effect is not related to dose received	•threshold •no effect will be seen for doses below threshold •above threshold severity of effect depends on dose •effect is seen due to death of cells → enough cells to affect/impair this function of a tissue or organ
•cancer •genetic effects	•radiation burns •blood effects •cataracts (lens of eye) •Acute Radiation Syndromes

Harmful Effects - Categories



Linear No Threshold Model
Assume that Exposure = Risk



Source – ICRP 60

Cancer Risk

- Fatal Cancer Risk
- Adult Workers
  - 4.0 % per Sv
- Whole Population
  - 5.0 % per Sv

- Non-Fatal Cancer Risk
- Adult Workers
  - 0.8 % per Sv
- Whole Population
  - 1.0 % per SV

Example – 100 000 workers each given 10 mSv
expect (4/100)*(10E-3/1)*100 000 = 40 additional cancer fatalities

Baseline risk of fatal cancer in the whole population is about 25% or 25 000 in the example population

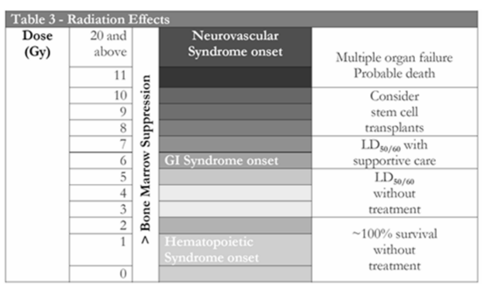
Risk in Perspective

Cause	Days	Cause	Days
Living in poverty	3500	Dangerous job-accidents	300
Being unmarried-male	3500	Motor vehicle accidents	207
Being unmarried-female	1600	Accidents in home	95
Smoking-male	2250	Average job-accidents	74
Smoking-female	800	Alcohol-average	130
Being 30% overweight	1300	Legal drug misuse	95
Being 20% overweight	900	Radon in homes	35
Cancer	980	**Radiation-1 mSv per year**	**10**
Diabetes	95	Coffee	6
Drowning	41	Smoke alarm in home	-10

Individual Action	Minutes of Life Lost	Individual Action	Minutes of Life Lost
Smoking a cigarette	10	Coast to coast drive	1000
Crossing a street	0.4	Coast to coast flight	100
Driving	0.4/Mile	**0.1 mSv radiation**	**40**
Not using a seat belt	0.1/Mile		

Deterministic Effects of Acute Whole Body Exposure

- No clinically detectable acute effects below ~0.25 Gy
- No deaths in a population below 1 Gy
- $LD_{50,60}$ about 3 to 5 Gy <u>without</u> medical intervention
- $LD_{50,60}$ about 6 to 7 Gy <u>with</u> medical intervention



From: Medical Aspects of Radiation Accidents

Nuclear Energy Worker Designation

- At McMaster University, anyone working with nuclear materials is designated as a Nuclear Energy Worker (NEW).
- Authorized workers are individuals who have completed Authorized Radioisotope Users Training and have been classified as Nuclear Energy Workers (NEWs).
- The most important aspect of being designated as an NEW is that there is a different set of dose limits for nuclear energy workers.

Regulatory Dose Limits – Non-NEWs

- Effective Dose
  - 1 mSv in one year
- Equivalent Dose
  - 50 mSv to the skin per year
  - 50 mSv to the extremities per year
  - 15 mSv to the lens of the eye per year
- Lower University limits apply depending on the facility and licence.

Regulatory Dose Limits – Routine Occupational Exposure of NEWs

- Effective Dose
  - 50 mSv in one year
  - 100 mSv in five years
- Equivalent Dose
  - 500 mSv to the skin per year
  - 500 mSv to the extremities per year
  - 150 mSv to the lens of the eye per year
- Lower University limits apply depending on the facility and licence.

Regulatory Dose Limits – Routine Occupational Exposure of Pregnant NEWs

- Effective Dose
  - 50 mSv in one year
  - 100 mSv in five years
  - 4 mSv for the balance of the pregnancy
- Equivalent Dose
  - 500 mSv to the skin per year
  - 500 mSv to the extremities per year
  - 150 mSv to the lens of the eye per year
- Lower University limits apply depending on the facility and licence.

Emergency Dose Limits For Workers

OBJECTIVE	EMERGENCY DOSE LIMIT	COMMENT
Urgent actions to prevent capital equipment loss or damage	50 mSv (5 rem)	Applies to any McMaster University employee and volunteers from outside agencies.
Urgent actions which will prevent or mitigate a serious radiological incident	250 mSv (25 rem)	Applies to any Nuclear Energy Worker and volunteers who are non-NEWs.
Rescue and Lifesaving	1 Sv (100 rem)	Any volunteer who has been briefed on potential consequences of exposure.

Radiation Protection Regulations:
•During the control of an emergency and the consequent immediate and urgent remedial work, the effective dose and the equivalent dose may exceed the applicable dose limits prescribed by sections 13 and 14, but the effective dose shall not exceed 500 mSv and the equivalent dose received by the skin shall not exceed 5 000 mSv.
•Does not apply in respect of pregnant NEWs
•May be exceeded by a person acting voluntarily to save or protect human life

Measurement and Evaluation of Dose

- Thermoluminescent Dosimeters
- Extremity Dosimeters
- Electronic Personal Dosimeters

Measuring Dose - TLD

- Monthly or Quarterly read-outs
- Measures gamma, x-ray, beta, and some models measure neutrons
- Reports generated by DSP
- Dose record updated with NDR
- HP reviews work and issues badges as needed

Regulatory and Administrative Controls

Government Regulators

- The Canadian Nuclear Safety Commission
- The Ministry of Health and Long-term Care (X-Ray)
- The Ministry of Labour (X-Ray)

Acts and Regulations

- Nuclear Safety and Control Act
- CNSC Regulations
- Licensing

McMaster University Controls

- HPAC
- NFCC
- HP Department
- Radiation Safety Programs
- Permits

McMaster University Health Physics **Health Physics Services Primary Contact Sheet** Revision: R7 Date:2012 Mar 5

Area	Radiation Surveyor	Health Physicist	Senior Health Physicist / RSO
Health Sciences Centre HHS Nuclear Medicine Life Sciences Building MDCL Building GSB Liquid Waste CAF ABB GSB JHE Psychology	Mahendra Joshi (23687)	Diana Moscu (23365)	Dave Tucker (24099)
Thrombosis and Atherosclerosis Research Institute	Mahendra Joshi (23687) (Bev Leslie)		
X-Ray Facilities	Mike Giuliano (24394)		
Nuclear Research Building HLLF	Glenn McClung (26885)		
McMaster University Cyclotron Facility and CPDC Cyclotron	Mike Giuliano (24394)		
McMaster Nuclear Reactor	Duane Lambert (27952) Mike Giuliano (24394)	Chris Malcolmson (27744)	
McMaster Accelerator Lab	Mike Giuliano (24394)		
Taylor Radiobiology Source Facility	Mike Giuliano (24394)		
Health Physics Annex	Duane Lambert (27952)		
Instrumentation	Mike Giuliano (24394)		

Services and Information

Training Bookings	Terri Parker (24226)	**Counting Services**	Glenn McClung (27952)
Dosimetry	Terri Parker (24226)	**Sample Shipments**	Glenn McClung (27952)
Calibrations	Mike Giuliano (24394)		

Compliance with Programs

- The Radiation Safety Program is submitted to the CNSC in support of the Licence application and becomes legally binding on the University and those working under the licence.
- The radiation safety program incorporates best practices in addition to legal requirements.
- Radiation safety programs at McMaster University have been designed for specific radiation hazards that may be encountered.
- Strict adherence to these programs is also essential for maintaining ALARA doses.

Hazard Awareness and Good Practices

The ALARA Principle

- This is the guiding principle of Radiation Protection. It states that radiation doses should be maintained:

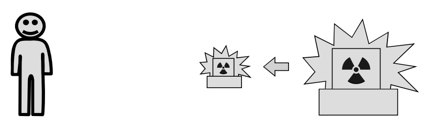
  A s
  L ow
  A s
  R easonably
  A chievable

With social and economic factors being taken into account.

Principles of Radiation Protection

- 1. Source Reduction

Reducing activity reduces dose.



- 2. Time

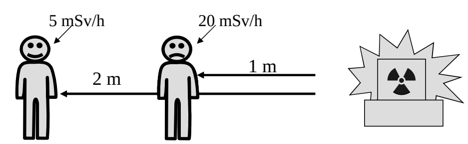
Reducing exposure time reduces dose.

Principles of Radiation Protection

- 3. Distance

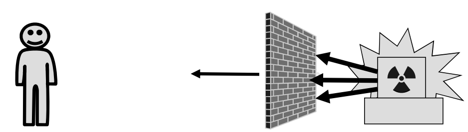
$\frac{1}{r^2}$ Reduction factor

(Approximation is only useful for point sources).



- 4. Shielding

Increased shielding reduces dose.



Planning and Requirements for Work Review

- All radiological work at McMaster University is to be carefully planned and executed.
- Each plan must incorporate steps to control and optimize exposures and contamination spread.
- Work that may result in exceeding any Administrative Control Level requires the prior approval of the NFCC and HPAC.

Contamination Hazards

- Radioactive contamination is the uncontrolled presence of radioactive material found in unwanted areas, out of containment. Contamination presents a radiological hazard because it demonstrates a loss of control of nuclear materials. There are different types of contamination that present unique possible hazards.
  - Loose Surface Contamination
  - Fixed Surface Contamination
  - Airborne Contamination
  - Liquid Contamination
  - External Personnel Contamination
  - Internal Personnel Contamination

Loose Surface Contamination

- Loose surface contamination is nuclear material found out of containment, deposited on a surface that is easily removed by simple decontamination methods.
- Loose contamination is easily spread, and may even be distributed to uncontrolled areas.
- This type of contamination should be cleaned as soon as practical to eliminate the potential hazards.

Fixed Surface Contamination

- Fixed contamination is nuclear material found out of containment, deposited on a surface that is not easily removed by simple decontamination methods.
- This type of contamination, while not easily spread, may present unnecessary increases to personnel dose if the source is large enough.
- An additional concern is that over time, the fixed contamination may become loose.

Airborne Contamination

- Airborne contamination is an undesirable presence of nuclear material in the air.
- This material may come in the form of particulate matter or gas.
- This type of contamination may present an internal radiation hazard if it is inhaled by personnel
- One of the main airborne contamination hazards at the McMaster Nuclear Reactor is airborne radioiodine, arising from the production of Iodine-125.

Liquid Contamination

- Liquid contamination is nuclear material found out of containment, deposited on a surface, and in liquid form.
- Often, this contamination results from a spill, and may also be easily spread like loose contamination.
- It should be cleaned up according to procedures as soon as practical.

External Personnel Contamination

- This contamination arises from nuclear materials deposited on the skin or clothes of personnel.
- The increased risk of this contamination is the close contact to the nuclear material.
- Skin contamination may diffuse through the skin and become a more harmful internal hazard.
- All instances of personnel contamination must be reported to Health Physics.

Internal Personnel Contamination

- This contamination arises from nuclear materials following one of the four main pathways into the body.
- Generally, there is an increased risk of an isotope being an internal hazard, rather than an external hazard.
- There is not usually an easy method of removing the isotope.
- The isotope is eliminated biologically or by radioactive decay.

Units of Contamination

Type of Contamination	Unit	Limiting Value
Internal Contamination	Becquerel (Bq)	Annual Limit on Intake (ALI)
Surface Contamination	Bq/cm^2	Derived Working Limit (DWL)
Airborne Contamination	Bq/m^3	Derived Air Concentration (DAC)

Control of Contamination

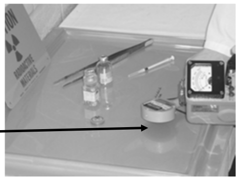
- The ability to demonstrate control of contamination is a key indication that a radiation safety program is successful.
- All radioactive work is to be approached with the philosophy that it is safer and cheaper to prevent contamination spread than it is to clean up contamination.
- While performing radiological work, personnel must check themselves and their work area frequently for contamination, where there is a risk of contamination spread.
- Personnel must also monitor themselves again upon completion of work involving potential for contamination spread.
- All instances of personnel contamination must be immediately reported to Health Physics.

Contamination Monitoring

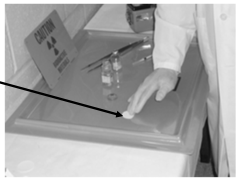
- Contamination monitoring is necessary in maintaining the control of nuclear materials at McMaster University.
- There are two main methods of contamination monitoring:
  - Direct Contamination Monitoring
  - Indirect Contamination Monitoring

Direct vs Indirect Monitoring

DIRECT method: detects both loose and fixed contamination

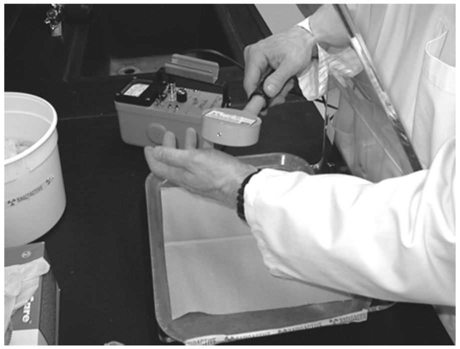


INDIRECT method: means taking a wipe sample, and detects only the loose or removable contamination



Operational Monitoring of Hands

- Monitor your hands thoroughly and often for any sign of contamination.
- Should contamination be found, decontaminate immediately.



Protective Equipment

- For work with open nuclear materials, personal protective equipment offers a barrier between the worker and the radioactive substances.
- Requirements for use of certain equipment will be established by Health Physics for routine tasks and determined for unique situations in the work planning phase of the task.
  - Gloves
  - Lab Coats
  - Shoe Covers (aka Booties)
  - Coveralls
  - Respirators and Air Supplied Hoods

Gloves

- Gloves are essential items for basic personnel protection.
- Hands are the most likely to become contaminated from handling open sources of radioactive material.
- Several gloves can be layered at the start of a procedure, and removed to expose a fresh clean glove as the task progresses.
- Gloves must be worn any time that open sources of radioactive material is handled, including contaminated objects.
- For more hazardous situations, 'heavy-duty' gloves used for specialized purposes.

Lab Coats

- In conjunction with gloves, lab coats offer a basic level of whole body protection against personnel contamination incidents.
- They protect not only the skin, but also clothes.
- Lab coats should be worn during the handling of radioactive materials.
- If lab coats become contaminated, they are easily cleaned, and failing that, inexpensive to replace.
- At the end of work, lab coats should be checked for contamination and cleaned if necessary.

Shoe Covers (aka Booties)

- When working in areas known to contain floor contamination, shoe covers (aka booties) are extremely useful in prevents contamination of personnel footwear.
- Booties should be donned prior to entering the area and removed (with gloves on) just before leaving the contamination area.
- For some areas booties made be routinely mandatory on entrance as required.
- The requirement for booties may be declared non routinely at the entrance to an area.

Coveralls

- Instead of lab coats, coveralls may be recommended for work with open radioactive materials or in contaminated
- Disposable coveralls offer protection for the whole body.
- When required, they are to be worn before entering the area, and like the booties, removed immediately before leaving the area.
- Non-disposable coveralls may be used as well, but are more expensive to replace

Respirators and Air Supplied Hoods

- In areas of airborne contamination, or potential for airborne contamination to arise, respirators must be worn.
- There are two main types of respirators that are for different applications.
  - air purifying respirators
  - air supplied respirators
- Each type of respirator has a protection factor that describes how effective it is at providing breathable air.
- Requirements for respirators will be established by Health Physics as the need arises.

General Approach to Protection

- All exposures should be justified
  - do more good than harm
- All exposures should be kept ALARA
  - minimize the chance of cancer and hereditary effects as low as reasonable
- All exposures should be under dose limits
  - Avoids the possibility of deterministic effects and limits overall accumulation of risk for the individual

General Approach to Safety

- Use time, distance and shielding to minimize external exposure around known or suspected sources
- Don't pick up items that are sources or are suspect
- Cordon and contain problems for further evaluation
- Use safety indicators – area monitors, exit monitors, survey meters

Emergencies, Incidents, and Upsets

Safe Backout

- When adverse conditions are encountered during work with radioactive material, the following practices should be used to ensure a safe backout.
  - if it is safe to do so, take immediate steps to stabilize the area or equipment to prevent further degradation of conditions
  - safely leave the area
  - alert Health Physics immediately
  - guard the area to prevent entry
  - if there is a need to leave, the area should be posted

Adverse Situations – When to Contact Health Physics

- In all situations when Health Physics is contacted, every effort will be made to ensure the safety of personnel is maintained. The goal of the Health Physics Department is to safely and quickly aid in the resolution of a potentially adverse situation.
  - Loss of Material
  - Spills Response
  - Release of Nuclear Substances
  - Suspected Exposures and Intakes
  - Personnel Contamination

What to Report to Health Physics

- If you are an NEW, you are required to report pregnancy as soon as it has been medically confirmed.
- Any suspected overexposure to radiation that is likely to exceed your regulatory or administrative control limits.
- Any personal contamination incidents, immediately.
- Any fire in a radiological work area.
- A major spill of radioactivity.
- Any theft or loss of (missing) radioactive material or breach/attempted breach of security provisions
- Any damage to or leakage from a radioactive parcel, or evidence of tampering.
- Any radiation hazard that you may feel has been overlooked or neglected.
- Any radiation detection instrument that is not working.
- An unexpected release of radioactive material to the environment.
- Loss of a personal dosimeter.
- Any radiation safety or nuclear security concern - anytime

Contacting Health Physics

- For more information, training and Health Physics assistance please contact our department at Extension 24226
- You may contact individual members of the Department using the contact sheet shown

Thank you