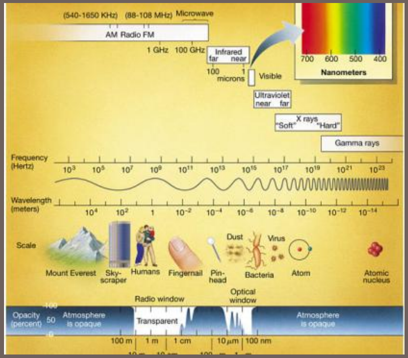

Everyday Radiation and Fukushima

Joe Mildenberger | Health Physicist | TRIUMF

Radiation Protection Group

Nov. 19/26, 2011

Outline

- Physics and math
- Radiation basics
- Radiation sources
- Radiation effects
- Radiation risks
- Locally detected radiation from Fukushima
- Summary and conclusions
- Questions?

Physics and math: Is it really necessary?

- What is science? Too difficult to answer!
- What do scientists do?
  - Ask questions!
  - Attempt to understand how the world works
  - Construct models and make measurements
  - Compare measurements with models
  - Select models which best explain measurements
- A high-precision “language” is desirable
- There *will* be numbers: it’s unavoidable for our purposes!

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Radiation basics

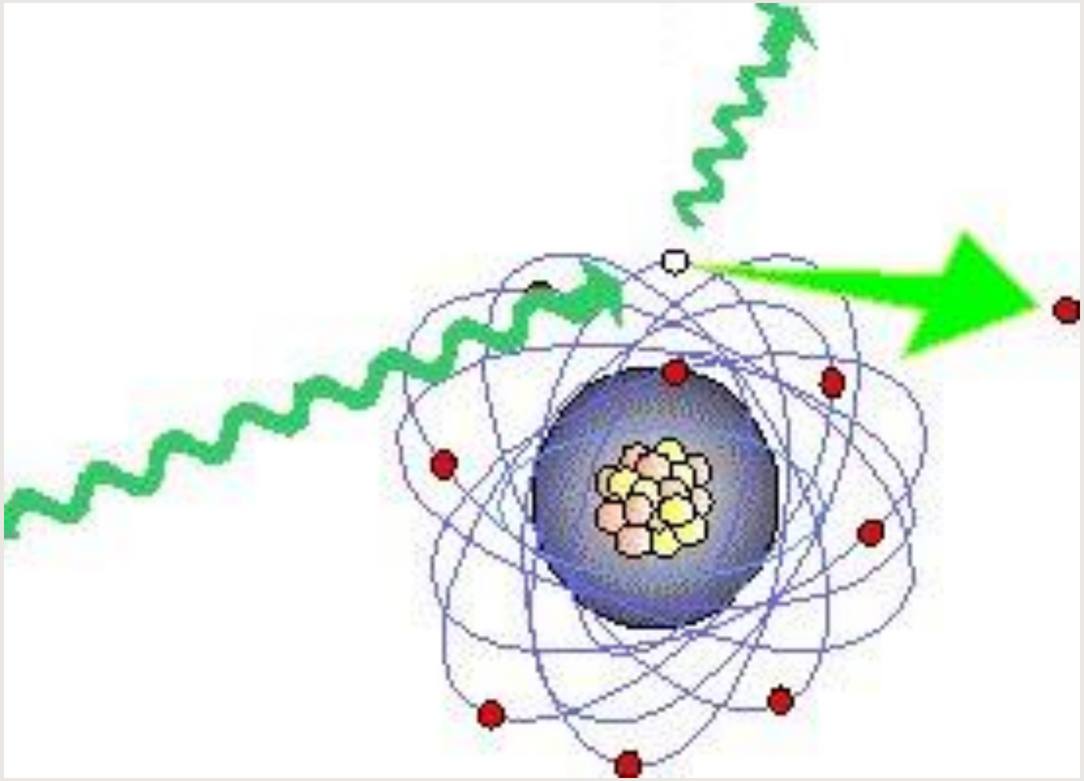
- What is Radiation?

"Energy emitted or transmitted in the form of rays or waves (esp. electromagnetic waves), or subatomic particles" (OED)

- Types of radiation:
  - Electromagnetic: massless, chargeless particles (photons)
  - β^-, β^+: light, stable, charged particles from nuclear decay
  - α: heavy, stable, charged particles from nuclear decay
  - Neutrons: heavy, short-lived chargeless particles
  - π, K, μ: massive, short-lived particles (cosmic rays)

Brief diversion: ionizing radiation

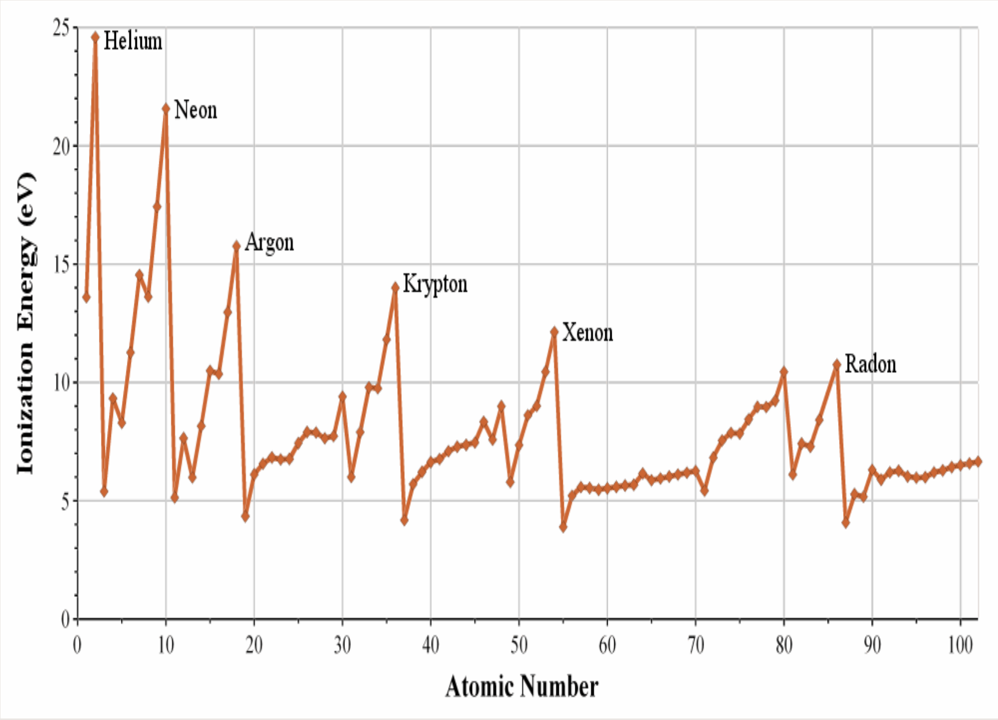
- Energetic enough to knock out atomic electrons
  - ➔Can also break chemical bonds, e.g. DNA

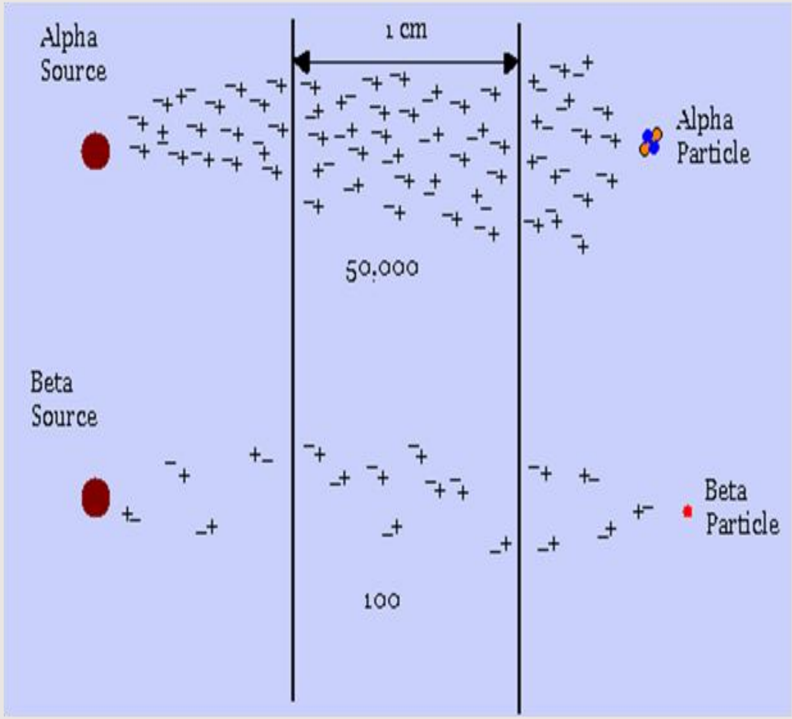


Ionizing radiation

- Typical ionization energies

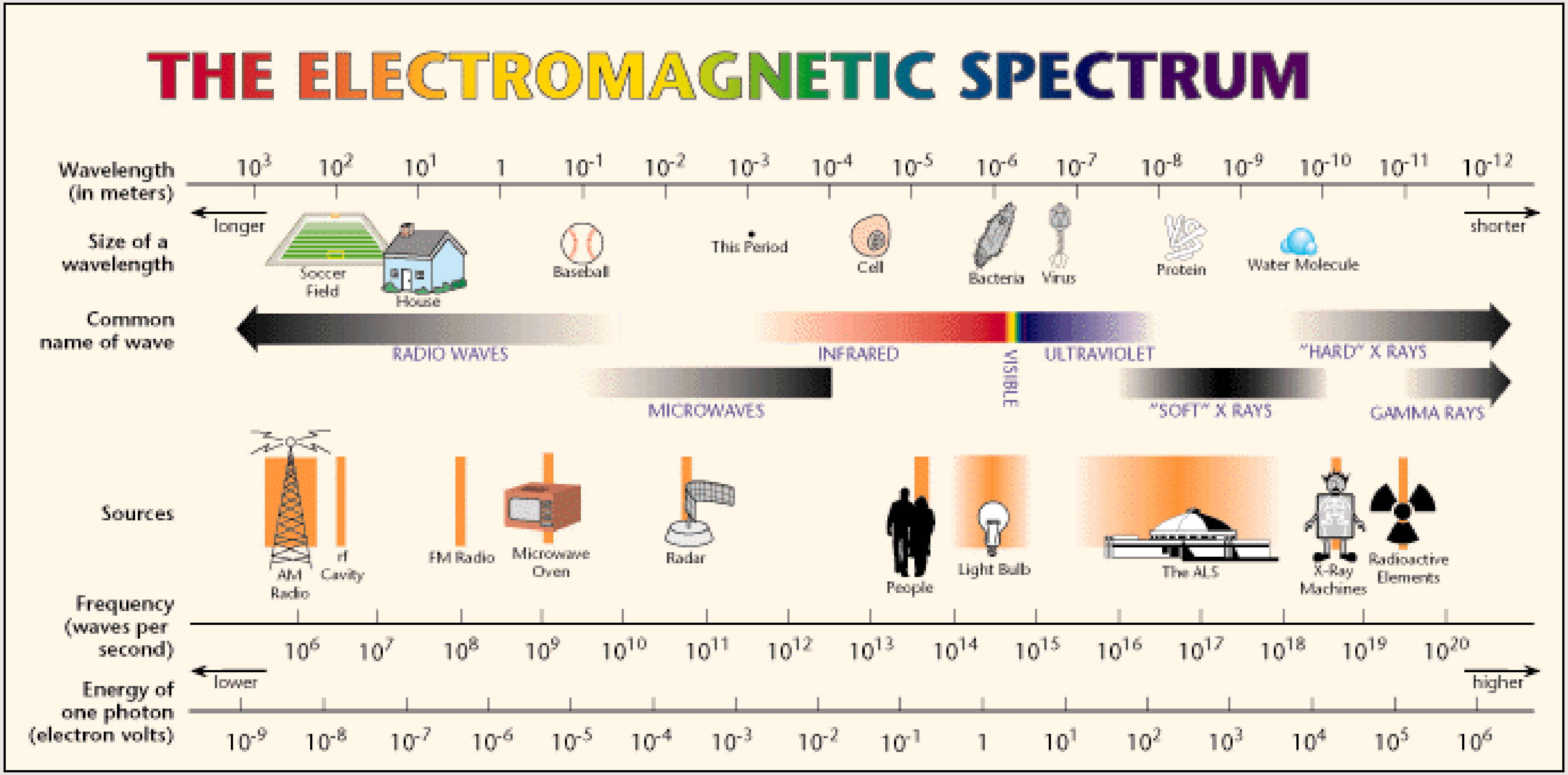
  E_{ionize} ~ 34 eV for tissue (cf. $E_{battery}$ = 1.5 eV)





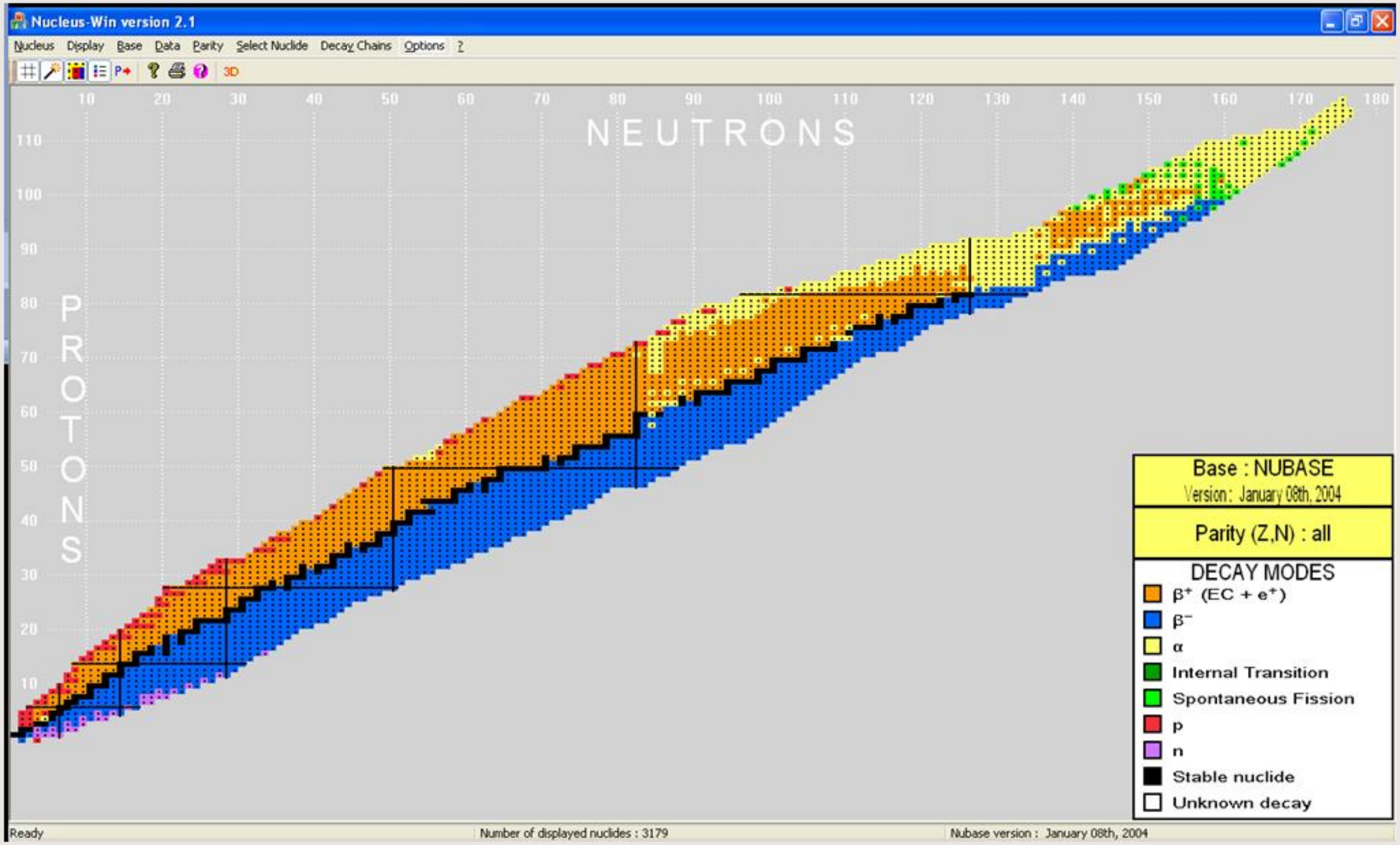
Radiation basics (cont.)

- Electromagnetic radiation:

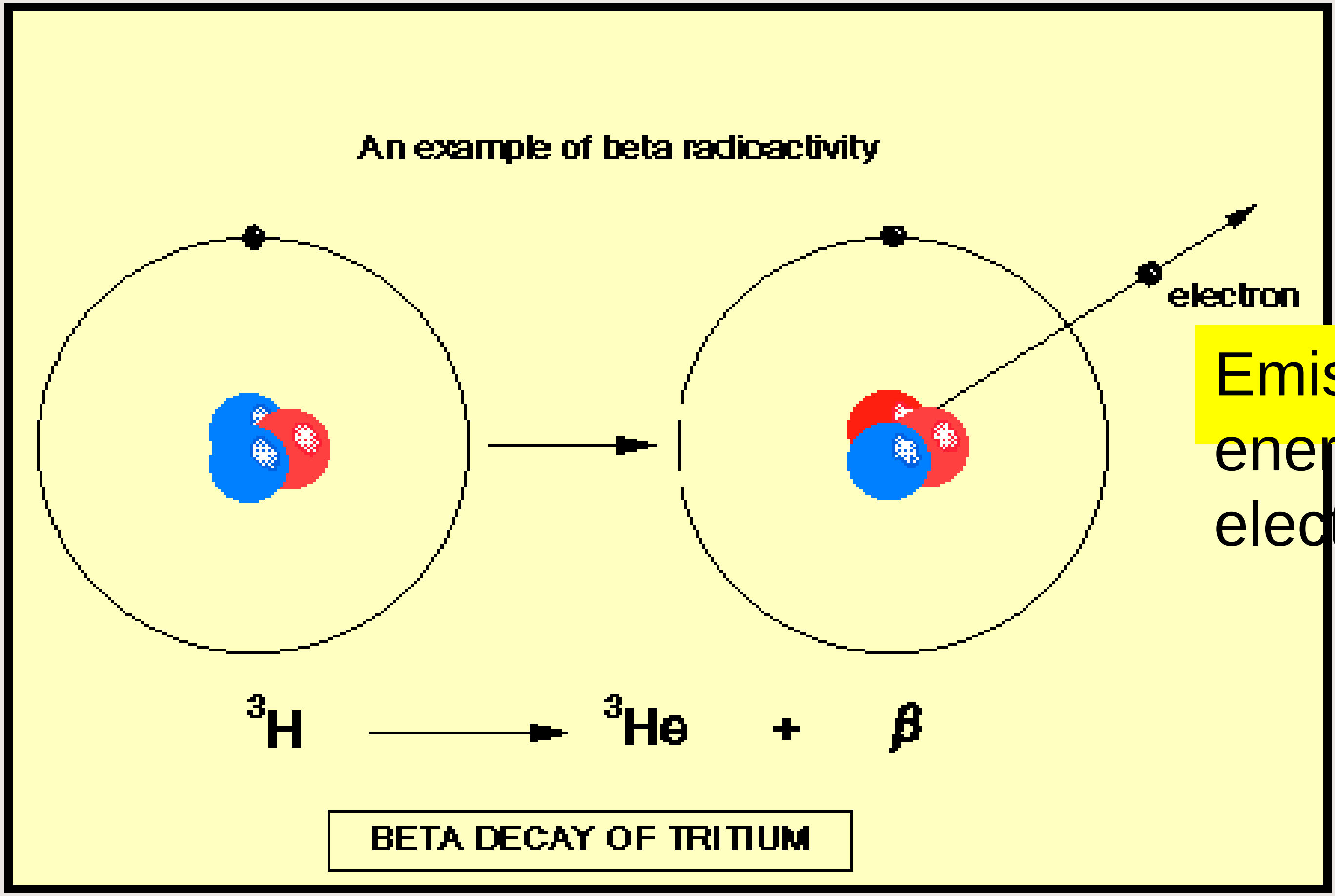


Radiation basics (cont.)

- Nuclear decay

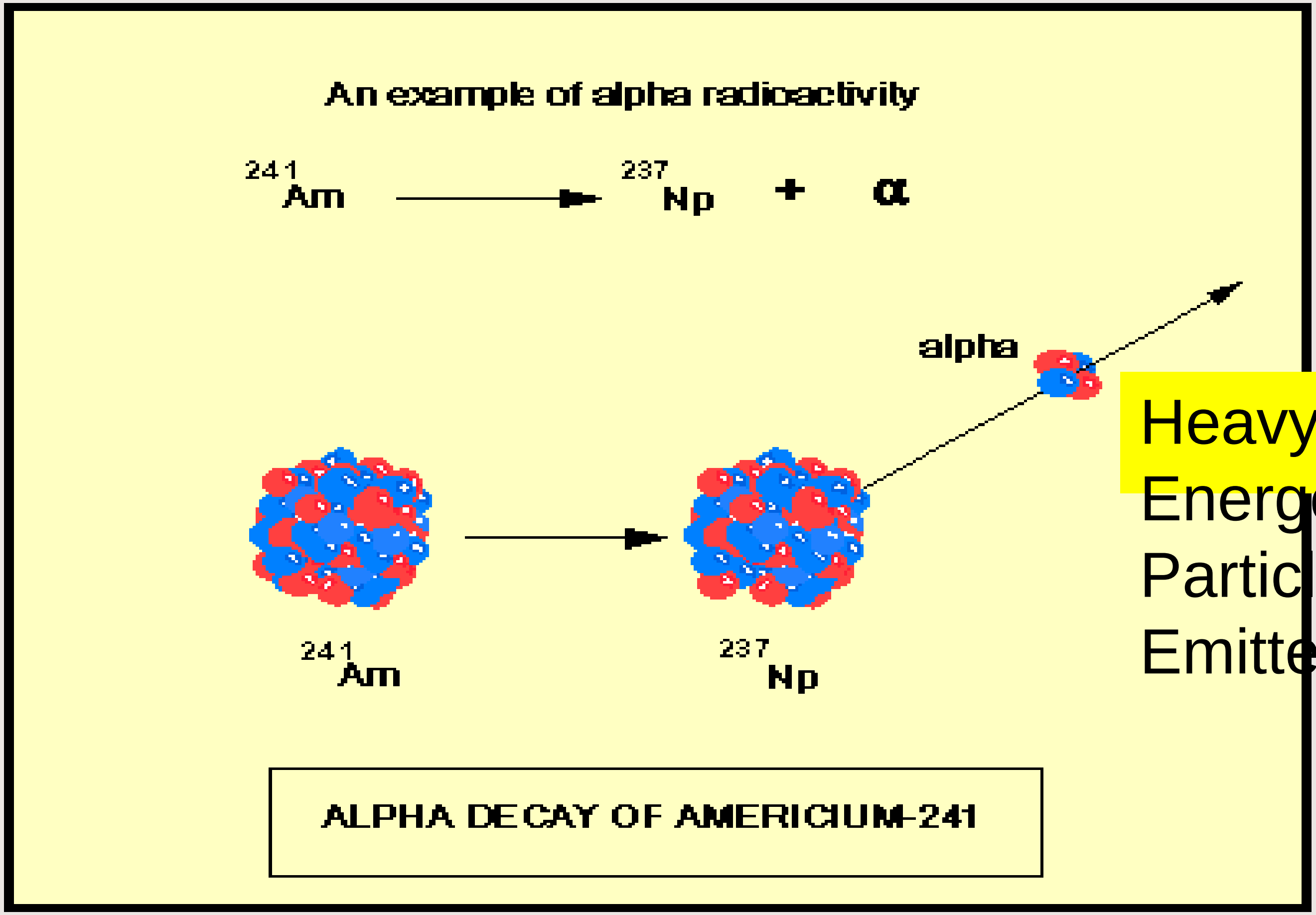


Beta Decay (neutron-rich)



Emission of energetic electron

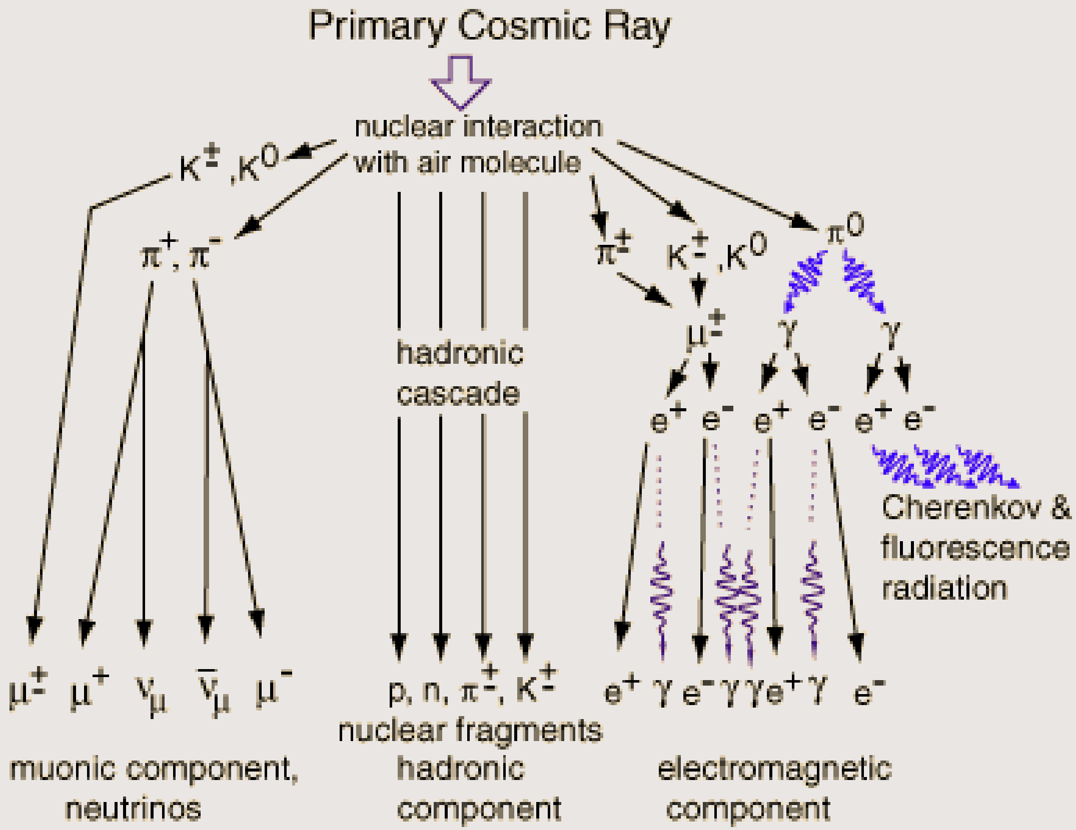
Alpha Decay



Heavy
Energetic
Particle
Emitted

Radiation basics (cont.)

- Cosmic radiation
  - ~89% protons; ~10% He nuclei (α particles); γ's too!



Units for measuring radiation

- Radioactivty, the “rate of decay”: Bq (#decays/s)
- “Absorbed dose”: Gray (Gy): (Joule/kilogram)
- “Effective dose”:Sievert (Sv): Gy x W_R
- Big Unit! Annual dose ~ mSv; x-ray ~ 20 μSv
- W_R : describes different interaction mechanisms
  ➔measures *risk* of exposure

Type of Radiation	Radiation weighting factor W_R
Photons	1
Electrons, muons	1
Neutrons	5-20
Protons	5
Alpha; heavy nuclei	20

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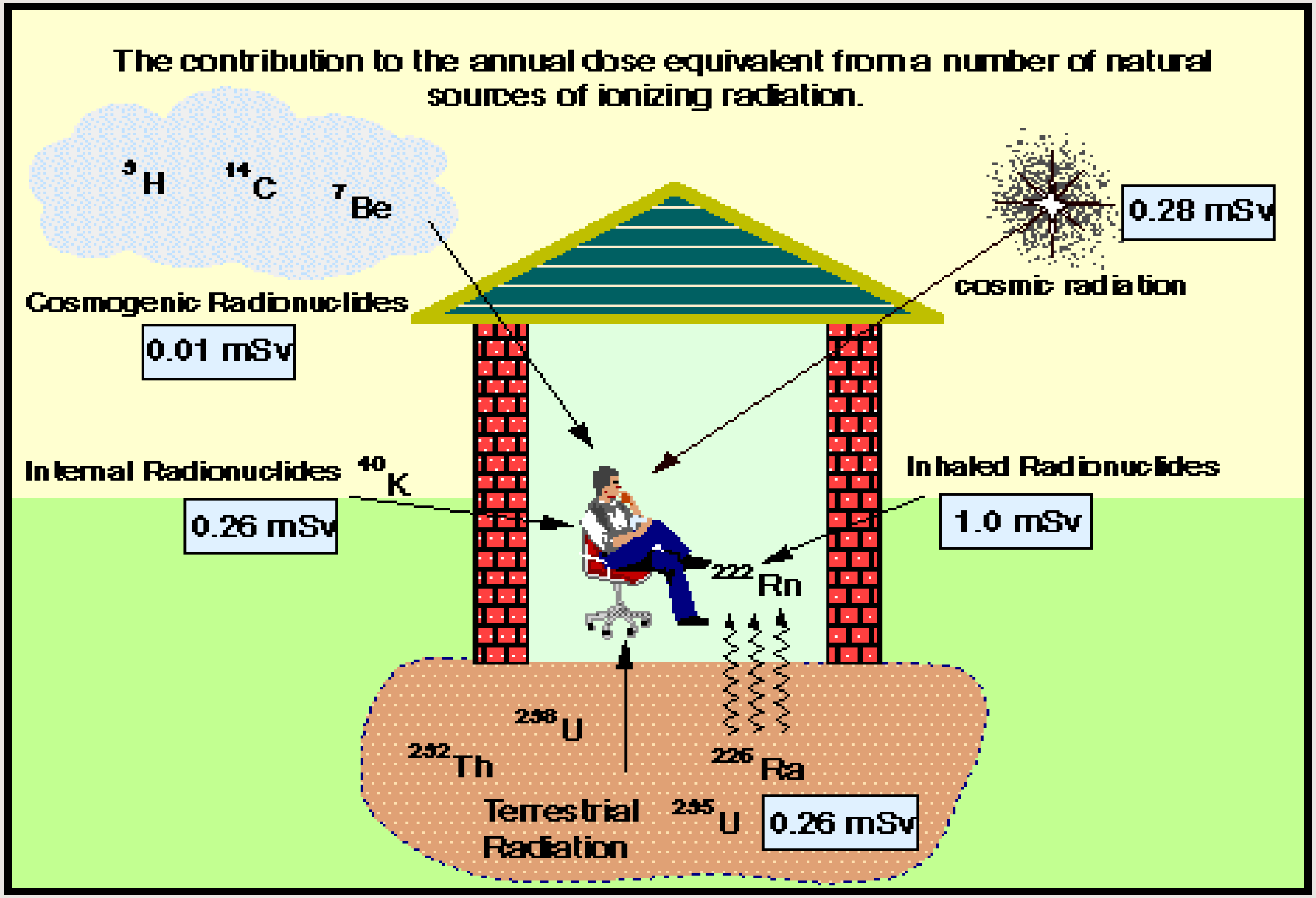
Sources of radiation

- Natural



Typical radioactivity levels in food

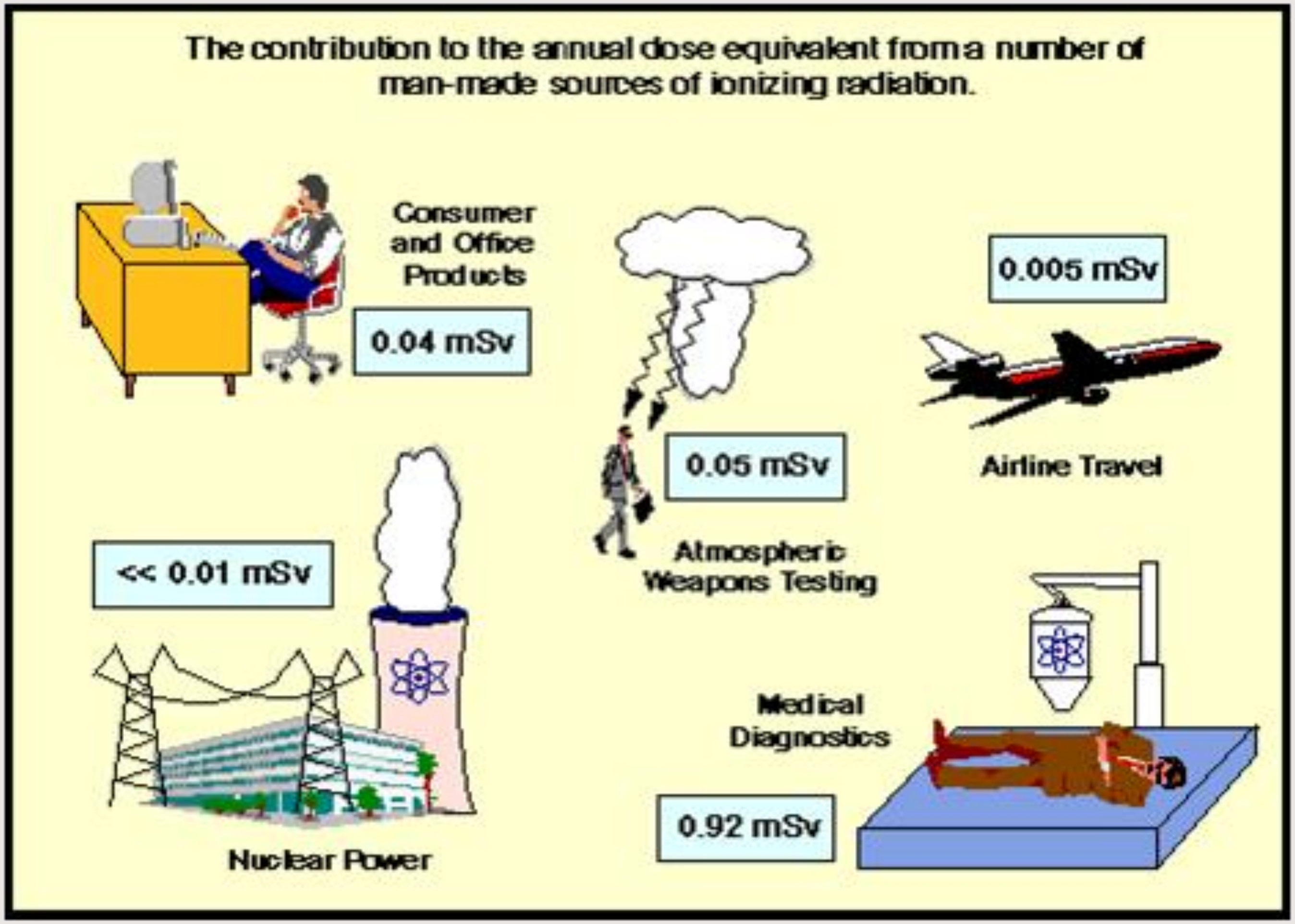
- Milk: 50 Bq/litre K-40
- Bananas: 15 Bq K-40 per banana
- Brazil nuts:
  - 200-400 Bq/kg K-40
  - 40-260 Bq/kg Ra-226
- Carrots, potatoes: ~125 Bq/kg K-40
- Red meat: ~100 Bq/kg K-40
- Lima beans: ~170 Bq/kg K-40
- Total internal dose: 0.3-0.4 mSv/year

Background doses in BC (BCCDC)

Natural Background Radiation In British Columbia Annual Effective Dose Values for Various Locations in B.C.					
British Columbia Location	***RADON EXPOSURE in mSv ****	***COSMIC RADIATION in mSv***	***TERRESTRIAL RADIATION in mSv*****	***INTERNAL RADIATION EXPOSURE in mSv ******	***TOTAL BACKGROUND RADIATION in mSv***
Atlin	2.78	0.380	0.281	0.35	3.79
Barriere	5.11	0.330	0.63	0.35	6.42
Castlegar	3.61	0.339	0.753	0.35	5.05
Clearwater	6.72	0.333	0.473	0.35	7.88
Cranbrook	0.50	0.435	0.461	0.35	1.75
Fort Nelson**	1.28	0.337	0.28	0.35	2.25
Fort St, John	1.33	0.385	0.28	0.35	2.35
Kamloops	0.83	0.329	0.405	0.35	1.92
Kelowna	2.22	0.323	0.631	0.35	3.53
Nelson	3.16	0.365	0.796	0.35	4.68
Penticton	3.61	0.325	0.692	0.35	4.98
Prince George	3.72	0.364	0.397	0.35	4.84
Q.C.I.**	0.39	0.263	0.257	0.35	1.26
Quesnel	1.39	0.349	0.394	0.35	2.49
Stewart	0.78	0.263	0.446	0.35	1.84
Terrace	1.17	0.275	0.377	0.35	2.17
Trail	2.28	0.336	0.938	0.35	3.91
Valemont	2.11	0.403	0.529	0.35	3.40
Vancouver	0.28	0.263	0.291	0.35	1.19
Vernon	1.94	0.330	0.63	0.35	3.26
Victoria	0.61	0.263	0.257	0.35	1.49
Whistler	0.83	0.294	0.367	0.35	1.85

Radiation doses (cont.)

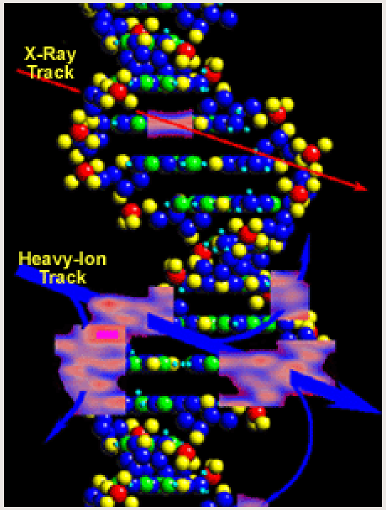
- Human produced



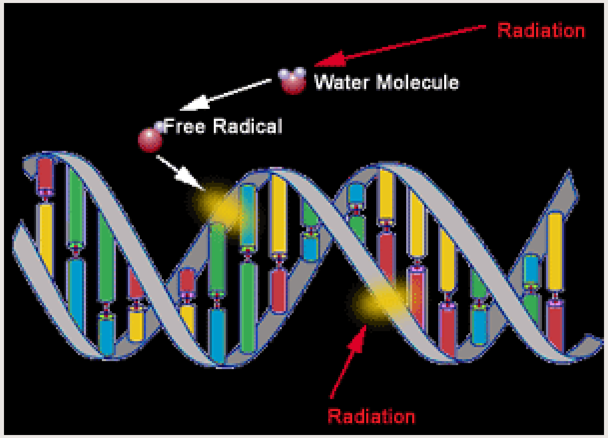
Typical doses from medical diagnostics

- Information from Health Physics Society
- X-rays
  - Dental x-ray: 0.005-0.01 mSv
  - Chest x-ray: 0.02-0.06 mSv
  - Spinal x-ray: 0.03-0.07 mSv
  - CT scans: 2-11 mSv
- Medical radionuclides (e.g. Tc-99m; I-123)
  - Thyroid: 0.04-0.600 mSv
  - Bone scan: 4.6 mSv
  - Heart/blood flow: 6-17 mSv

Radiation damage mechanisms



- Direct action
  - Ionizing radiation directly strikes DNA molecule
  - Instantaneous; breaks DNA strand
- Indirect action
  - Ionizing radiation strikes water and creates free radicals
  - Long-lived free radicals can diffuse to distant sites
  - Responsible for 75% of biological effects



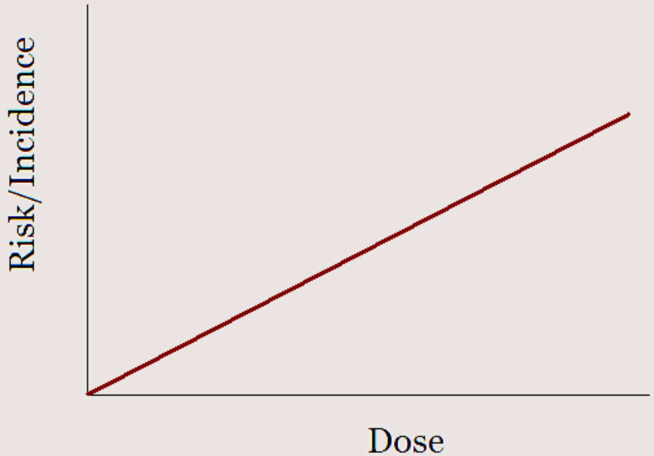
Cell radiation damage protection

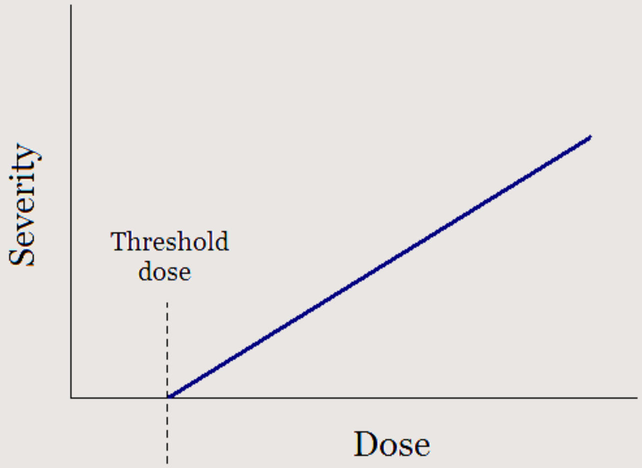
- Cells have free radical scavengers
- Cells have DNA repair mechanisms (10^{13} DNA breaks are repaired *daily)*
- Cells have mechanisms which remove defective cells from tissue (apoptosis)
- Cells contain surplus DNA which does not impact cellular function

High radiation exposures are needed to observe *permanent* changes at the cellular level.

Stochasticity and determinism

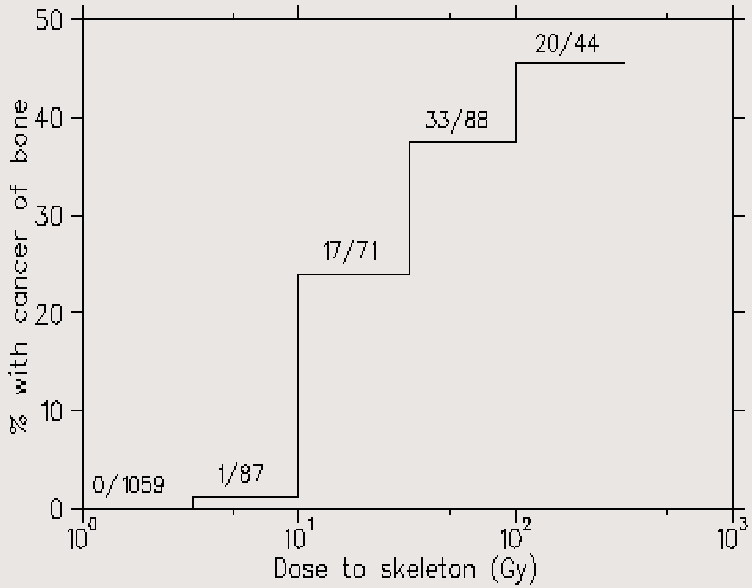
- Stochastic: “Governed by laws of statistics”
  - Can predict how many, but not who
  - Incidence proportional to dose; no threshold
- Deterministic:
  - Severity of effects proportional to dose
  - Usually a threshold for effects

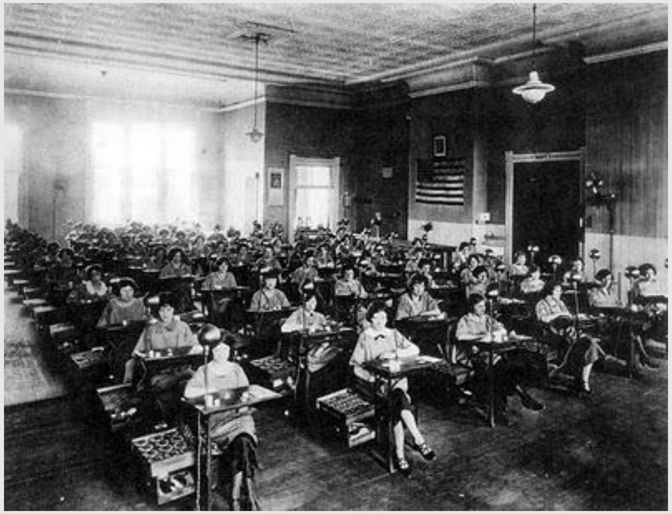




Radiation induced cancer

- Radium clock dial painters:
  - Instructed to lick brushes to obtain a fine point
  - Many developed bone cancer within 8 - 40 years

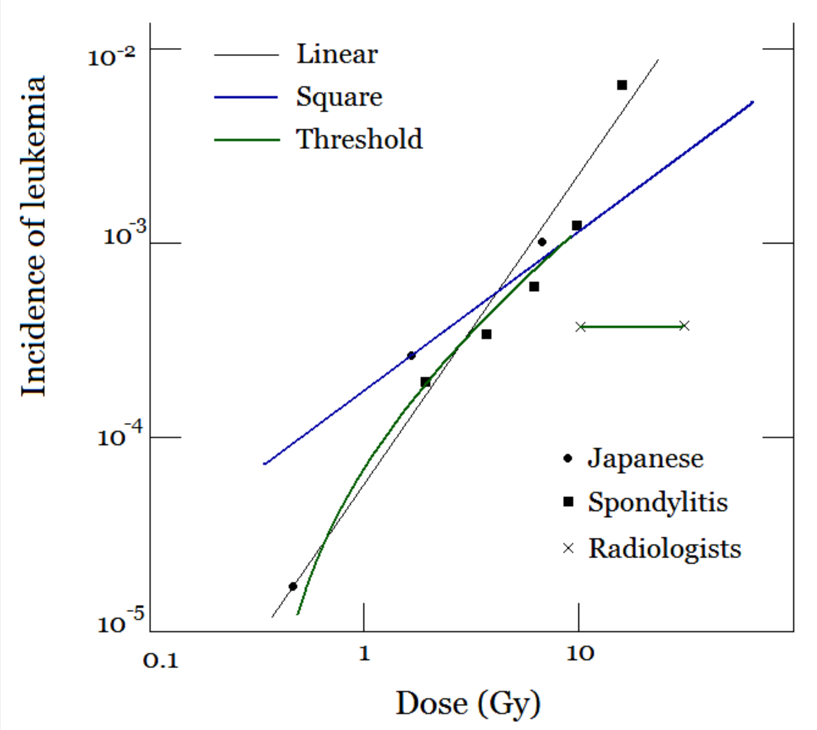




Risk of cancer increases with radiation dose.

Effects of chronic, low doses

- Statistics very small, so extrapolations must be made from effects based on larger doses



Populations	Sample Size
Atomic Bombings *(Hiroshima & Nagasaki)*	91 000
Nuclear Weapons Testing *(observers, inhabitants near test site)*	510 250
Medical Therapeutic Exposure *(ankylosing spondylitis, cervical cancer patients)*	236 000
Occupational Exposure *(nuclear workers, radium dial painters)*	90 000

Radiation risks

- Acute risk:
  - Immediate harmful effects
- Chronic risk:
  - Harmful effects after prolonged exposure
  - Chronic risk is *always* present since exposure to *any* radiation carries with it the risk of cancer at a later date (4%/Sv).

Loss of Life Expectancy is used to compare different types of risk.

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Radiation risks (cont.)

- Loss of life expectancy: start with "lifetime risk"

Ex. You drive to and from work daily for a total of 1 hour.

The hourly risk of a fatal car accident is 2×10^{-6}.

Over a lifetime (200 times/year x 45 years) the total risk will be:

$$\text{Total Risk} = 2 \times 10^{-6} \times 1 \times 200 \times 45$$

$$= 0.018$$

= **1.8%** Lifetime risk of fatal car accident

Lifetime risk is used to calculate loss of life expectancy

Radiation risks (cont.)

- Loss of life expectancy

Ex. (cont'd)

A fatal accident at 40 years of age results in 30 years of life lost to the individual (assuming lifespan of 70 years).

Loss of Life Expectancy = (Lifetime risk) x (# of lost days)

= 0.018 x 30 x 365

= **179 days**

179 days represents an average loss of life expectancy for all individuals who drive one hour to work for 200 days a year.

Radiation risks (cont.)

- Loss of life expectancy for TRIUMF staff exposed to 2 mSv annual dose for 45 years:

Lifetime dose = 0.002 Sv/year x 45 years = 0.09 Sv

Lifetime risk = 4%/Sv x 0.09 Sv = **0.36%**

Cancer induced at age 40; has latency period of 15 years. Thus only 15 years lost.

Loss of Life Expectancy = 0.0036 x 15 x 365
= **19.7 days**

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Radiation v. other risks

Loss of Life Expectancy (various causes)	
Cause	**Days of Life Lost**
Being unmarried (male)	3500
Cigarette smoking	2250
Being unmarried (female)	1600
Being 30% overweight	1300
Less than 8th grade education	850
Motor vehicle accidents	207
Accidents in home	95
Average job-accidents	74
Job with radiation exposure (2 mSv/year)	16
Background radiation	8
Diet drinks	2
Smoke alarm in home	-10
Air bags in car	-50

Radiation v. other risks

Average Annual Risk of Death in Canada from Fatal Accidents at Work and from Radiation Exposure	
Occupation	**Risk of Death per Year**
Finance	1 in 60,000
Service	1 in 40,000
Trade	1 in 20,000
2 mSv radiation per year	1 in 12,000
Government (includes police and firefighters)	1 in 11,000
Manufacturing	1 in 11,000
Transportation	1 in 4,000
Construction	1 in 3,000
20 mSv radiation per year	1 in 1,200
Mining	1 in 900
Fishing and Hunting	1 in 500

Average Annual Risk of Death in Canada from Fatal Accidents or from Radiation Exposure	
Hazard	**Risk of Death Per Year**
Accidents on the road	1 in 5,000
Accidents in the home	1 in 11,000
Accidents at work	1 in 24,000
1 mSv yearly limit for public	1 in 20,000
0.05 mSv yearly limit from nuclear facilities	1 in 400,000
0.001 mSv yearly average from nuclear facilities	1 in 20,000,000

Regulatory limit for public

Regulatory limit for Nuclear Energy Worker

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Local effects from Fukushima

- Earthquake and tsunami, March 11, 2011
- Earthquake magnitude 9.0; tsunami up to 15m
- >13000 deaths; > 12000 drowning ; 65% > 60y
- Fukushima Daiichi nuclear power station:
  - Loss of cooling from tsunami damage
  - Backup power unavailable
  - Reactor cores overheated and melted down
  - Stored fuel (not in reactors) also overheated from loss of cooling water
  - Releases (est.): I-131: ~10^{17} Bq ; Cs-137: ~10^{16} Bq (~10% of Chernobyl releases)

Local measurements

- Rainwater; seaweed (SFU)
- Local reservoirs (Metro Vancouver)
- Rainwater; milk (TRIUMF)
- Milk (CFIA)
- Airborne I-131 (CTBTO)

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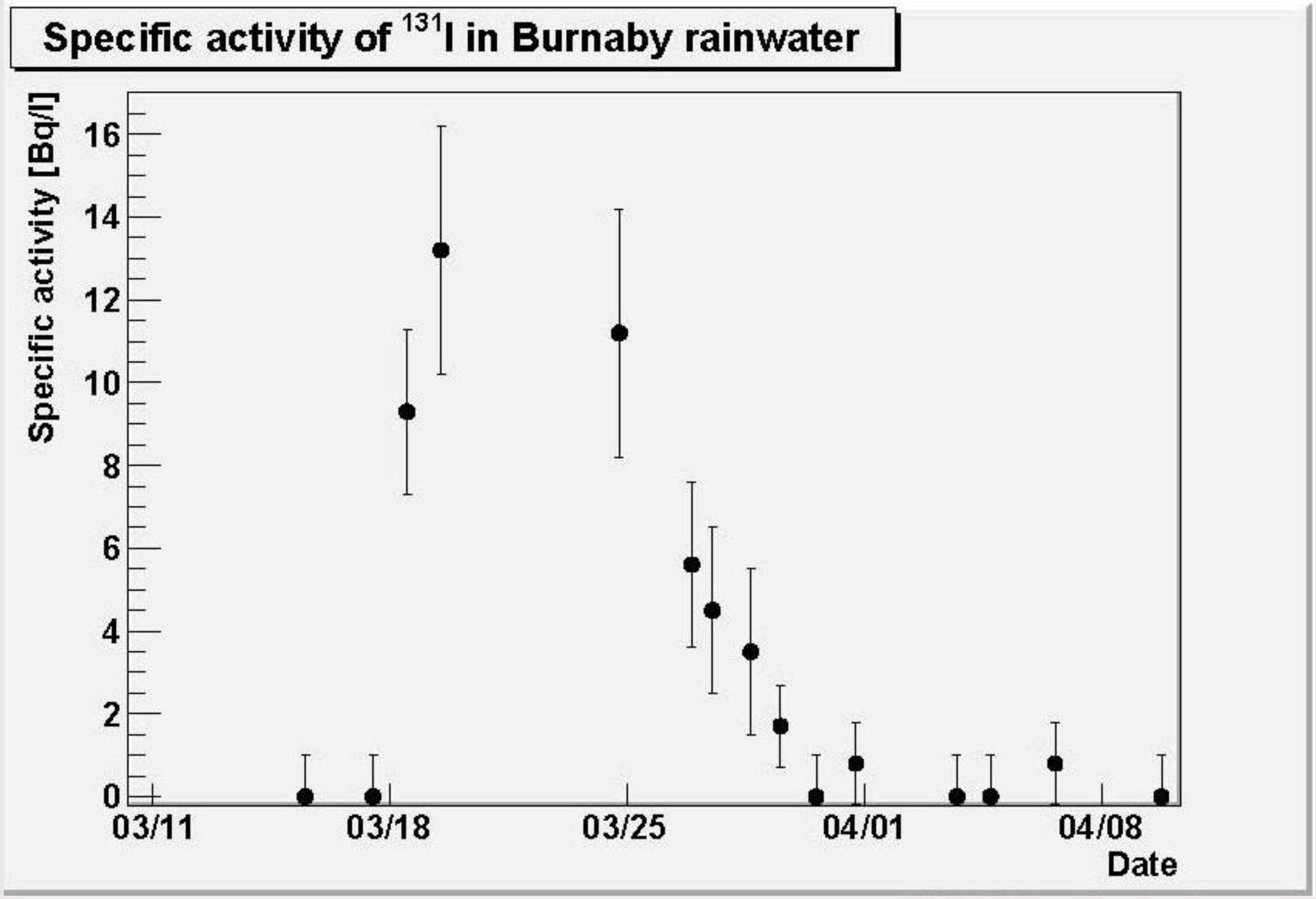
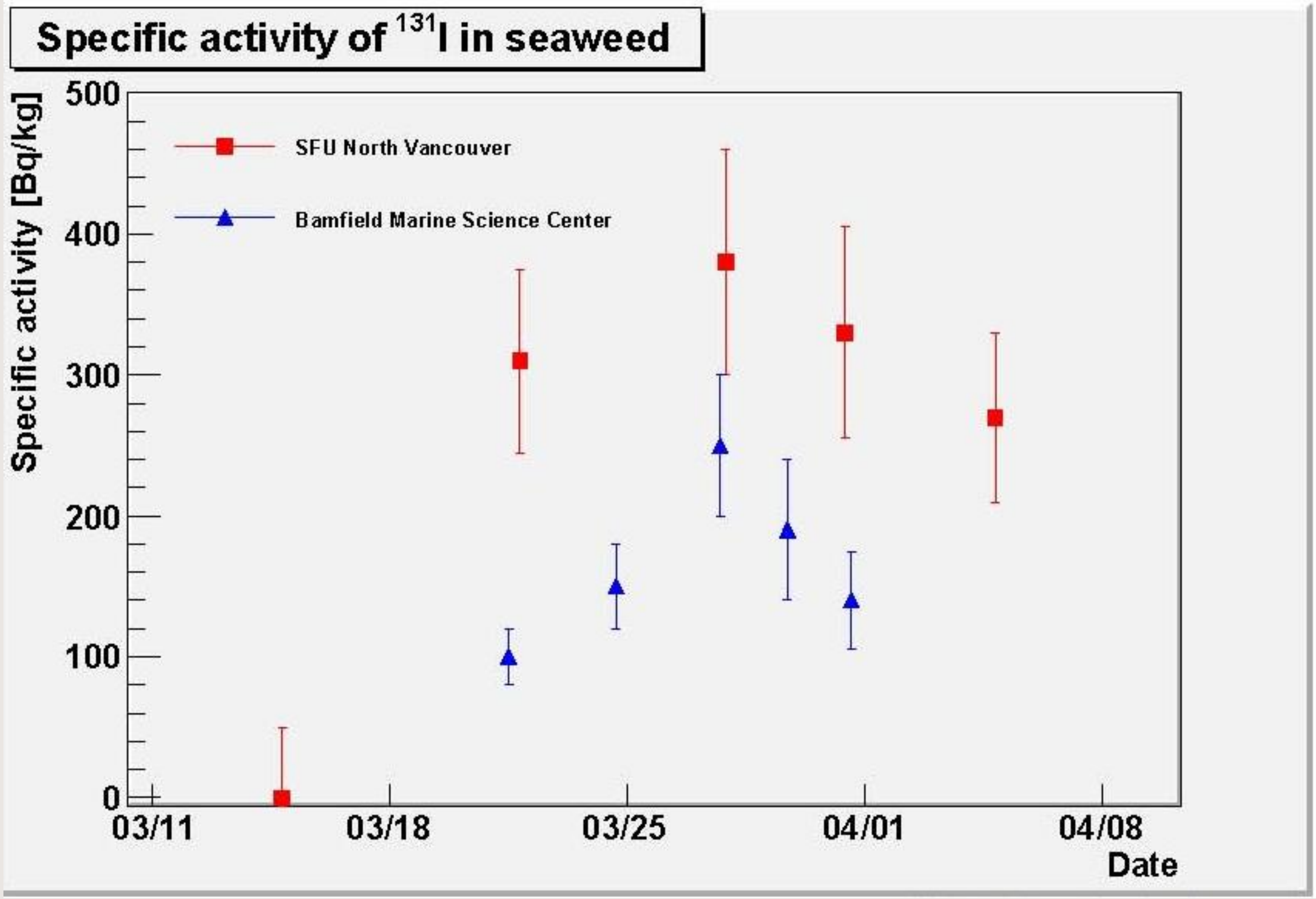
Rainwater and seaweed (SFU)

- Data: Krzysztof Starosta, SFU professor



Rainwater and seaweed (SFU) cont.



Rainwater and seaweed (SFU) cont.

- Estimated dose from water (conservative)
  - Assume somebody drinks pure rain water
  - Assume they drink 8 litres/day
  - Assume the peak I-131 concentration (13 Bq/litre)

(8 l/day) x (13 Bq/l) x 14 days = ~1500 Bq

Dose = 1500 Bq x (2.2 x 10^{-8} Sv/Bq) x 1000 mSv/Sv

= ~0.033 mSv

- Fraction of Vancouver background dose:

0.033 mSv / 1.2 mSv = ~0.03

Metro Vancouver reservoir samples

Capilano Intake

Analyte	Units	Date: Mar. 16, 2011		Date: Mar. 25, 2011		Date: Mar. 28, 2011		Date: Apr. 5, 2011	
		Result	D.L	Result	D.L	Result	D.L	Result	D.L
Cesium - 134	Bq/L	<0.05	0.05	<0.02	0.02	<0.02	0.02	<0.07	0.07
Cesium - 137	Bq/L	<0.02	0.02	<0.02	0.02	<0.04	0.04	<0.03	0.03
Gross alpha	Bq/L	0.05	0.02	<0.02	0.02	<0.01	0.01	0.02	0.01
Gross beta	Bq/L	0.03	0.01	0.04	0.02	0.02	0.02	0.03	0.02
Iodine - 131	Bq/L	<0.09	0.09	<0.05	0.05	<0.05	0.05	<0.09	0.09
Ruthenium - 103	Bq/L	<0.03	0.03	<0.04	0.04	<0.04	0.04	<0.08	0.08
Strontium - 90	Bq/L	N/D	N/D	<0.1	0.1	N/D	N/D	N/D	N/D
Tritium	Bq/L	N/D	N/D	15	15	N/D	N/D	<15	15
Thorium -234	Bq/L	<0.8	0.8	<0.7	0.7	<0.7	0.7	<1	1
Thorium -230	Bq/L	<5	5	<4	4	<3	3	<8	8
Radium - 226	Bq/L	<0.9	0.9	<0.9	0.9	<0.9	0.9	<2	2
Lead - 214	Bq/L	<0.5	0.5	<0.2	0.2	<0.2	0.2	<0.2	0.2
Bismuth - 214	Bq/L	<0.5	0.5	<0.1	0.1	<0.1	0.1	<0.2	0.2
Lead - 210	Bq/L	<0.8	0.8	<0.7	0.7	<0.7	0.7	<1	1
Actinium - 228	Bq/L	<0.2	0.2	<0.2	0.2	<0.2	0.2	<0.4	0.4
Lead - 212	Bq/L	<0.6	0.6	<0.09	0.09	<0.09	0.09	<0.1	0.1
Bismuth - 212	Bq/L	<0.4	0.4	<0.3	0.3	<0.4	0.4	<0.7	0.7
Thallium - 208	Bq/L	<0.3	0.3	<0.05	0.05	<0.07	0.07	<0.1	0.1
Uranium - 235	Bq/L	<0.06	0.06	<0.2	0.2	<0.3	0.3	<0.3	0.3
Thorium - 227	Bq/L	<0.1	0.1	<0.3	0.3	<0.2	0.2	<0.3	0.3
Radium - 223	Bq/L	<0.3	0.3	<0.2	0.2	<0.3	0.3	<0.5	0.5
Radon - 219	Bq/L	<0.3	0.3	<0.3	0.3	<0.3	0.3	<0.5	0.5
Lead - 211	Bq/L	<1	1	<1	1	<1	1	<2	2
Potassium - 40	Bq/L	<1	1	<1	1	2	2	<2	2

N/D - Not determined
D.L. - Detection Limit

Capilano Intake

Analyte	Date: Apr. 11, 2011		Date: Apr. 18, 2011		Date: April 26, 2011		Date: May 2, 2011	
	Result	D.L	Result	D.L	Result	D.L	Result	D.L
Cesium - 134	<0.04	0.04	<0.06	0.06	<0.05	0.05		
Cesium - 137	<0.07	0.07	<0.06	0.06	<0.06	0.06		
Gross alpha	0.02	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Gross beta	0.03	0.02	0.03	0.02	<0.02	0.02	0.05	0.02
Iodine - 131	<0.07	0.07	<0.1	0.1	<0.07	0.07		
Ruthenium - 103	<0.06	0.06	<0.04	0.04	<0.07	0.07		
Strontium - 90	<0.1	0.1	<0.1	0.1	<0.1	0.1		
Tritium	<15	15	<15	15	<15	15		
Thorium -234	<0.8	0.8	<1	1	<0.7	0.7		
Thorium -230	<4	4	<3	3	<5	5		
Radium - 226	<1	1	<2	2	<1	1		
Lead - 214	<0.2	0.2	<0.09	0.09	<0.2	0.2		
Bismuth - 214	<0.2	0.2	<0.09	0.09	<0.2	0.2		
Lead - 210	2	0.9	<1	1	<0.8	0.8		
Actinium - 228	<0.2	0.2	<0.1	0.1	<0.3	0.3		
Lead - 212	<0.1	0.1	<0.06	0.06	<0.1	0.1		
Bismuth - 212	<0.5	0.5	<0.2	0.2	<0.6	0.6		
Thallium - 208	<0.07	0.07	<0.05	0.05	<0.1	0.1		
Uranium - 235	<0.2	0.2	<0.2	0.2	<0.3	0.3		
Thorium - 227	<0.3	0.3	<0.2	0.2	<0.3	0.3		
Radium - 223	<0.1	0.1	<0.2	0.2	<0.6	0.6		
Radon - 219	<0.4	0.4	<0.3	0.3	<0.3	0.3		
Lead - 211	<0.6	0.6	<0.7	0.7	<1	1		
Potassium - 40	<2	2	<0.7	0.7	<1	1		

Metro Vancouver reservoir samples

Seymour Intake

Analyte	Units	Date: Mar. 16, 2011		Date: Mar. 25, 2011		Date: Mar. 28, 2011		Date: Apr. 5, 2011	
		Result	D.L	Result	D.L	Result	D.L	Result	D.L
Cesium - 134	Bq/L	<0.07	0.07	<0.04	0.04	<0.04	0.04	<0.04	0.04
Cesium - 137	Bq/L	<0.06	0.06	<0.06	0.06	<0.06	0.06	<0.05	0.05
Gross alpha	Bq/L	<0.02	0.02	0.11	0.02	<0.01	0.01	<0.02	0.02
Gross beta	Bq/L	0.04	0.02	0.04	0.02	0.03	0.02	0.02	0.02
Iodine - 131	Bq/L	<0.09	0.09	<0.06	0.06	<0.08	0.08	<0.04	0.04
Ruthenium - 103	Bq/L	<0.03	0.03	<0.04	0.04	<0.02	0.02	<0.05	0.05
Strontium - 90	Bq/L	N/D	N/D	<0.1	0.1	N/D	N/D	N/D	N/D
Tritium	Bq/L	N/D	N/D	<15	15	N/D	N/D	<15	15
Thorium -234	Bq/L	<0.9	0.9	<0.8	0.8	<0.8	0.8	<0.8	0.8
Thorium -230	Bq/L	<4	4	<3	3	<4	4	<4	4
Radium - 226	Bq/L	<1	1	<1	1	<1	1	<1	1
Lead - 214	Bq/L	<0.5	0.5	<0.1	0.1	0.3	0.1	<0.09	0.09
Bismuth - 214	Bq/L	<0.5	0.5	<0.1	0.1	<0.1	0.1	<0.1	0.1
Lead - 210	Bq/L	<5	5	<0.8	0.8	<0.8	0.8	<0.9	0.9
Actinium - 228	Bq/L	<0.2	0.2	<0.2	0.2	<0.2	0.2	<0.2	0.2
Lead - 212	Bq/L	<0.4	0.4	<0.09	0.09	<0.1	0.1	<0.09	0.09
Bismuth - 212	Bq/L	<0.4	0.4	<0.5	0.5	<0.4	0.4	<0.4	0.4
Thallium - 208	Bq/L	<0.3	0.3	<0.06	0.06	<0.06	0.06	<0.05	0.05
Uranium - 235	Bq/L	<0.08	0.08	<0.3	0.3	<0.2	0.2	<0.2	0.2
Thorium - 227	Bq/L	<0.2	0.2	<0.2	0.2	<0.2	0.2	<0.2	0.2
Radium - 223	Bq/L	<0.2	0.2	<0.2	0.2	<0.2	0.2	<0.2	0.2
Radon - 219	Bq/L	<0.3	0.3	<0.4	0.4	<0.1	0.1	<0.2	0.2
Lead - 211	Bq/L	<0.9	0.9	<1	1	<0.7	0.7	<0.9	0.9
Potassium - 40	Bq/L	<1	1	<0.9	0.9	<1	1	<1	1

N/D - Not determined
D.L. - Detection Limit

Seymour Intake

Analyte	Date: Apr. 11, 2011		Date: Apr. 18, 2011		Date: April 27, 2011		Date: May 2, 2011	
	Result	D.L	Result	D.L	Result	D.L	Result	D.L
Cesium - 134	<0.05	0.05	<0.02	0.02	<0.02	0.02		
Cesium - 137	<0.04	0.04	<0.02	0.02	<0.04	0.04		
Gross alpha	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Gross beta	<0.02	0.02	<0.02	0.02	<0.02	0.02	<0.02	0.02
Iodine - 131	<0.07	0.07	<0.06	0.06	<0.1	0.1		
Ruthenium - 103	<0.05	0.05	<0.03	0.03	<0.06	0.06		
Strontium - 90	<0.1	0.1	<0.1	0.1	<0.1	0.1		
Tritium	<15	15	<15	15	<15	15		
Thorium -234	<0.9	0.9	<0.6	0.6	<0.8	0.8		
Thorium -230	<5	5	<3	3	<3	3		
Radium - 226	<1	1	<0.8	0.8	<1	1		
Lead - 214	<0.1	0.1	<0.09	0.09	<0.1	0.1		
Bismuth - 214	<0.2	0.2	<0.09	0.09	<0.1	0.1		
Lead - 210	<1	1	<1	1	<1	1		
Actinium - 228	<0.2	0.2	<0.1	0.1	<0.2	0.2		
Lead - 212	<0.09	0.09	<0.2	0.2	<0.08	0.08		
Bismuth - 212	<0.5	0.5	<0.2	0.2	<0.4	0.4		
Thallium - 208	<0.07	0.07	<0.05	0.05	<0.06	0.06		
Uranium - 235	<0.2	0.2	<0.1	0.1	<0.2	0.2		
Thorium - 227	<0.3	0.3	<0.2	0.2	<0.3	0.3		
Radium - 223	<0.3	0.3	<0.1	0.1	<0.3	0.3		
Radon - 219	<0.3	0.3	<0.3	0.3	<0.3	0.3		
Lead - 211	<1	1	<0.7	0.7	<1	1		
Potassium - 40	<1	1	<0.7	0.7	<1	1		

Metro Vancouver reservoir samples

Coquitlam Intake

Analyte	Units	Date: Mar. 16, 2011		Date: Mar. 25, 2011		Date: Mar. 28, 2011		Date: Apr. 5, 2011	
		Result	D.L	Result	D.L	Result	D.L	Result	D.L
Cesium - 134	Bq/L	<0.04	0.04	<0.04	0.04	<0.02	0.02	<0.05	0.05
Cesium - 137	Bq/L	<0.05	0.05	<0.04	0.04	<0.04	0.04	<0.03	0.03
Gross alpha	Bq/L	<0.01	0.01	0.01	0.01	<0.01	0.01	<0.01	0.01
Gross beta	Bq/L	0.02	0.02	0.04	0.02	<0.02	0.02	0.02	0.02
Iodine - 131	Bq/L	<0.07	0.07	<0.06	0.06	<0.05	0.05	<0.1	0.1
Ruthenium - 103	Bq/L	<0.04	0.04	<0.03	0.03	<0.04	0.04	<0.03	0.03
Strontium - 90	Bq/L	N/D	N/D	<0.1	0.1	N/D	N/D	N/D	N/D
Tritium	Bq/L	N/D	N/D	20	15	N/D	N/D	<15	15
Thorium -234	Bq/L	<0.07	0.7	<0.7	0.7	<0.8	0.8	<0.8	0.8
Thorium -230	Bq/L	<3	3	<2	2	<3	3	<5	5
Radium - 226	Bq/L	<0.9	0.9	<0.8	0.8	2	0.8	<1	1
Lead - 214	Bq/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Bismuth - 214	Bq/L	<0.1	0.1	<0.1	0.1	0.2	0.1	<0.1	0.1
Lead - 210	Bq/L	<2	2	<0.9	0.9	<0.9	0.9	<1	1
Actinium - 228	Bq/L	<0.2	0.2	<0.2	0.2	<0.1	0.1	<0.1	0.1
Lead - 212	Bq/L	<0.3	0.3	<0.08	0.08	<0.08	0.08	<0.2	0.2
Bismuth - 212	Bq/L	<0.3	0.3	<0.3	0.3	<0.3	0.3	<0.2	0.2
Thallium - 208	Bq/L	<0.3	0.3	<0.05	0.05	0.1	0.06	<0.2	0.2
Uranium - 235	Bq/L	<0.07	0.07	<0.2	0.2	<0.2	0.2	<0.3	0.3
Thorium - 227	Bq/L	<0.2	0.2	<0.1	0.1	<0.3	0.3	<0.3	0.3
Radium - 223	Bq/L	<0.3	0.3	<0.2	0.2	<0.2	0.2	<0.2	0.2
Radon - 219	Bq/L	<0.4	0.4	<0.2	0.2	<0.3	0.3	<0.3	0.3
Lead - 211	Bq/L	<0.4	0.4	<0.8	0.8	<0.8	0.8	<1	1
Potassium - 40	Bq/L	<1	1	<0.7	0.7	<1	1	<0.9	0.9

Coquitlam Intake

Analyte	Date: Apr. 11, 2011		Date: Apr. 18, 2011		Date: April 26, 2011		Date: May 2, 2011	
	Result	D.L	Result	D.L	Result	D.L	Result	D.L
Cesium - 134	<0.04	0.04	<0.06	0.06	<0.03	0.03		
Cesium - 137	<0.05	0.05	<0.08	0.08	<0.04	0.04		
Gross alpha	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.01	0.01
Gross beta	0.03	0.02	<0.02	0.02	<0.02	0.02	0.03	0.02
Iodine - 131	<0.05	0.05	<0.06	0.06	<0.05	0.05		
Ruthenium - 103	<0.03	0.03	<0.03	0.03	<0.06	0.06		
Strontium - 90	<0.1	0.1	<0.1	0.1	<0.1	0.1		
Tritium	<15	15	<15	15	<15	15		
Thorium -234	<0.9	0.9	<1	1	<1	1		
Thorium -230	<3	3	<10	10	<4	4		
Radium - 226	<1	1	<2	2	<1	1		
Lead - 214	<0.1	0.1	<0.2	0.2	<0.1	0.1		
Bismuth - 214	<0.1	0.1	<0.2	0.2	<0.1	0.1		
Lead - 210	<1	1	<1	1	<1	1		
Actinium - 228	<0.2	0.2	0.5	0.3	<0.2	0.2		
Lead - 212	<0.09	0.09	<0.1	0.1	<0.09	0.09		
Bismuth - 212	<0.3	0.3	<0.6	0.6	<0.5	0.5		
Thallium - 208	<0.07	0.07	<0.08	0.08	<0.5	0.5		
Uranium - 235	<0.2	0.2	<0.6	0.6	<0.2	0.2		
Thorium - 227	<0.2	0.2	<0.5	0.5	<0.3	0.3		
Radium - 223	<0.2	0.2	<0.6	0.6	<0.8	0.8		
Radon - 219	<0.4	0.4	<0.7	0.7	<0.3	0.3		
Lead - 211	<1	1	<2	2	<2	2		
Potassium - 40	<1	1	<1	1	<1	1		

N/D - Not determined
D.L. - Detection Limit

Other rainwater and milk samples

- TRIUMF: assays performed for 4 samples:
  - Bottled water (pre-Fukushima control sample)

    Nothing found; detection limit 0.09 Bq/l
  - Rain water (April 4, west side of Vancouver)

    I-131 @ (0.41 ± 0.12) Bq/l
  - Local milk (1% b.f.)

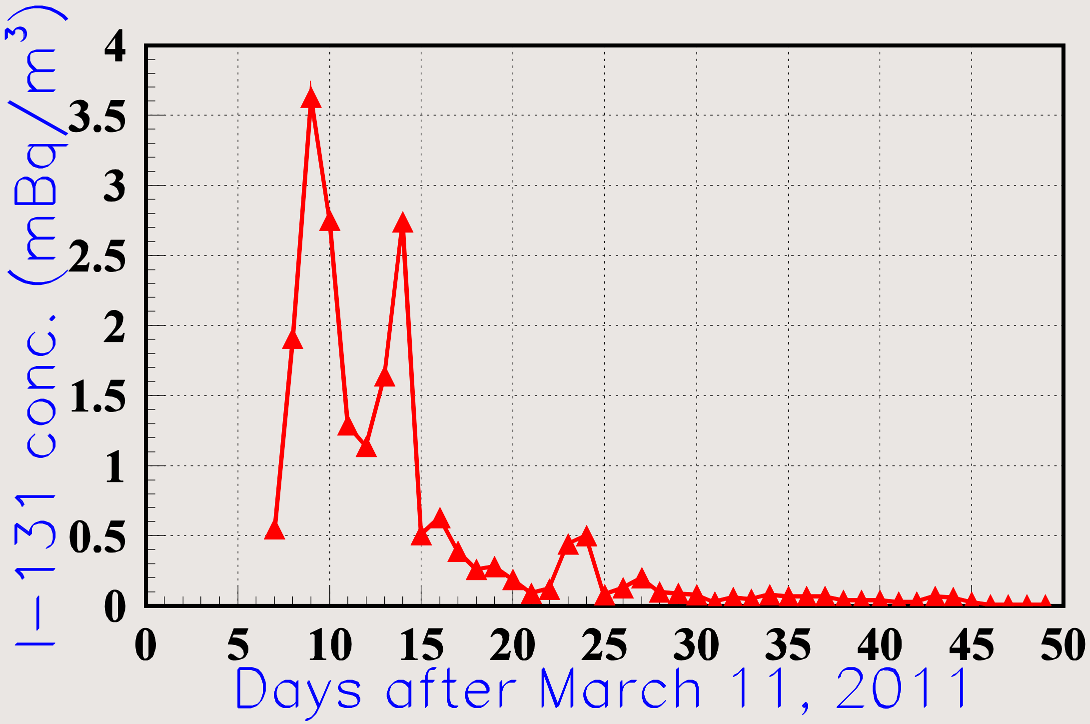
    K-40 @ (36.3 ± 2.5) Bq/l ; No I-131 (d.l. 0.17 Bq/l)
  - Local milk (3.25% b.f.)

    K-40 @ (40.5 ± 1.6) Bq/l ; No I-131 (d.l. 0.10 Bq/l)
- CFIA: 34 local milk samples (April 1-June 7)

  All below d.l. (2 Bq/kg) for I-131, Cs-134, Cs-137

Airborne I-131 concentrations (CTBTO)

- Nearest station: Sidney (Vancouver island)



- Dose from breathing this air: ~0.000004 mSv

Summary and Conclusions

- Radiation really is everyday and everywhere.
- Radiation risks can be *measured* and *compared* with other risks.
- Man-made radiation risks can be compared with everyday, everywhere background radiation risks.
- *Quantitative judgement* can be applied to determine whether the *additional risk* from man-made radiation is significant compared with everyday risk
- *Quantitative judgement* applied to the measured *additional risk* due to radiation from Fukushima suggests that BC residents were not subject to any significant increase in risk compared with what they already experience everyday and everywhere.

Thank you!

Merci!