

# Radioactivity

Lecture 1

Environmental and Societal Implications

Michael Wiescher



# Radioactivity has a fear factor



More than 2000 Nuclear Weapons Tests  
1945-1999, with major emission of  
radioactivity into the atmosphere

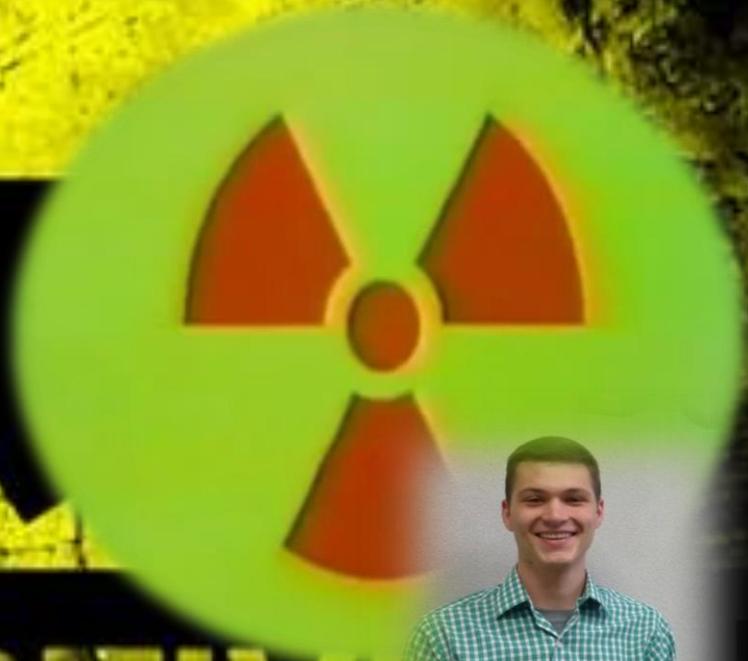




# CAUTION



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A more multi-faceted picture of

# RADIOACTIVE

# What will we cover - the painful stuff first!

## 1. The phenomenon of radioactivity

1.1. The discovery of radioactivity

1.2. The physics of radioactive decay

1.3. The laws and detection of radioactivity

1.4. Natural and induced radioactivity

1.5. Dosimetry and exposure limits

1.6. The biological impact of radioactivity

Henri Becquerel

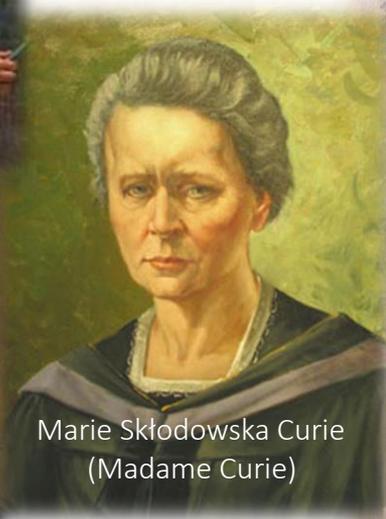


# Scientific heroes

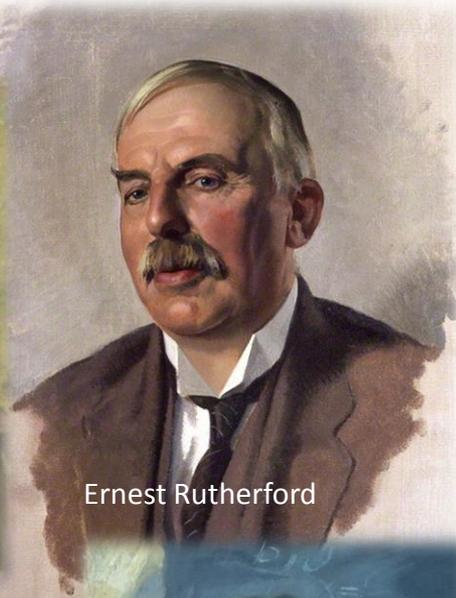
Conrad Wilhelm Röntgen



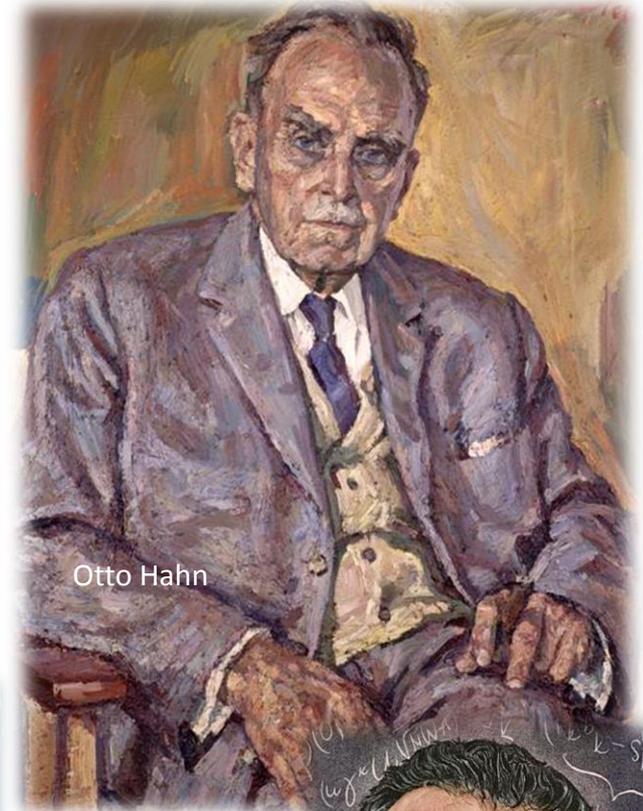
Marie Skłodowska Curie  
(Madame Curie)



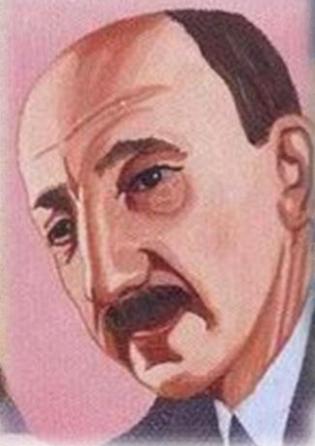
Ernest Rutherford



Otto Hahn



Pierre Curie



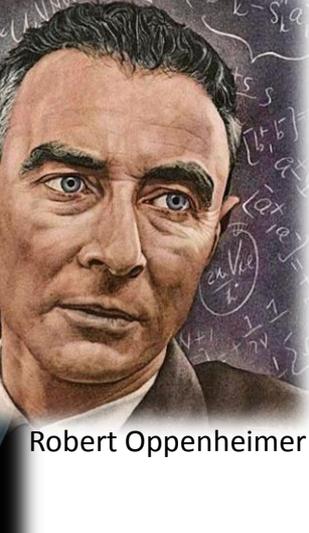
George de Hevesy



Enrico Fermi



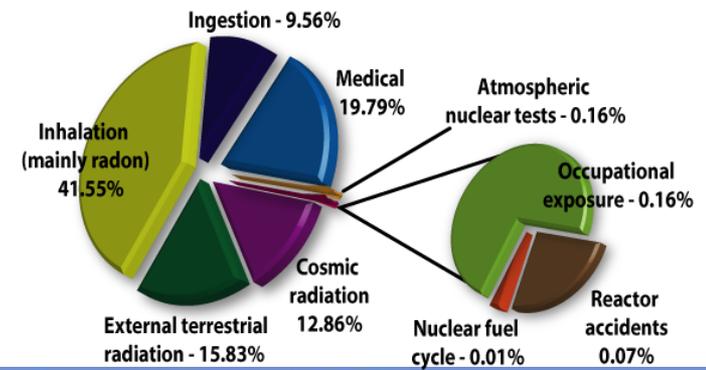
Liese Meitner



Robert Oppenheimer



# Radiation Sources



Natural sources 84%

Artificial sources 16%

Cosmic rays 12%

Gamma rays from the ground and buildings 13%

Food and drink 9%

Medical 15.5%

Fall out 0.2%

Industrial and power generation 0.3%

Radon gas from the ground 50%



STOP

UNTIL LANE  
CLEARS

SLOW  
DOWN  
MAXIMUM  
SPEED  
5 MPH

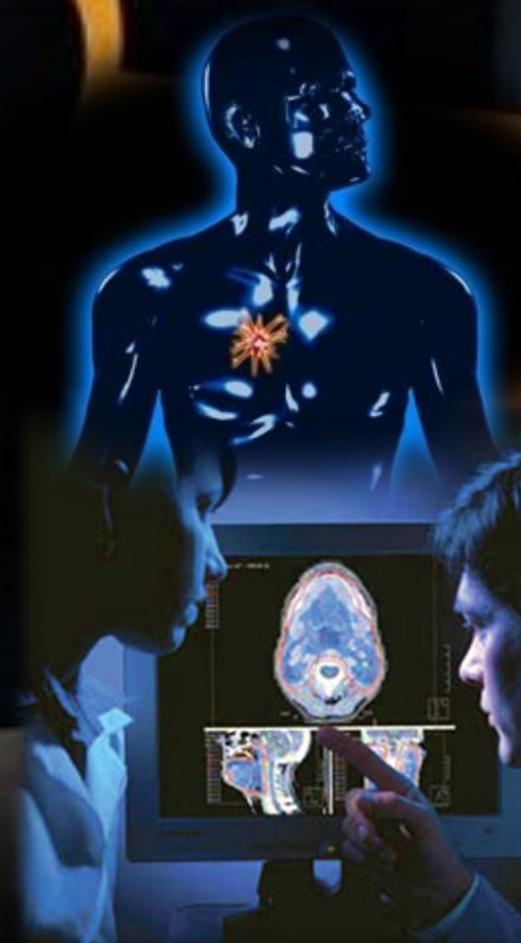
# Radiation Detection

U.S. CUSTOMS & BORDER PROTECTION



This plastic is fluorescing strongly under UV light. It will also scintillate when exposed to X-rays.

# Dosimetry



Direct-Reading Dosimeter

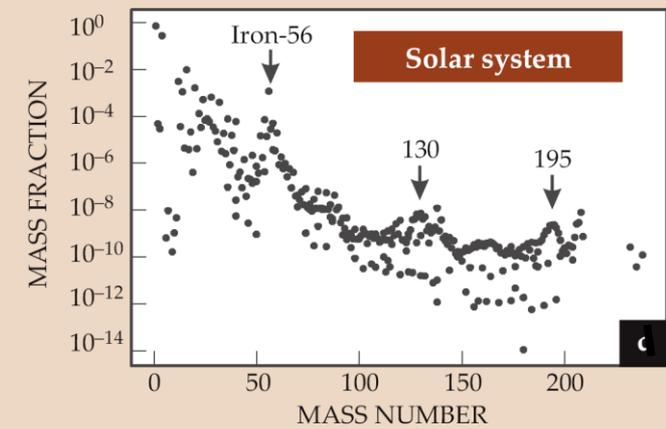
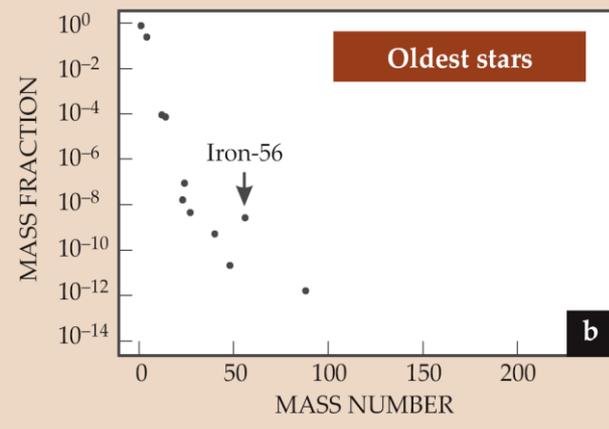
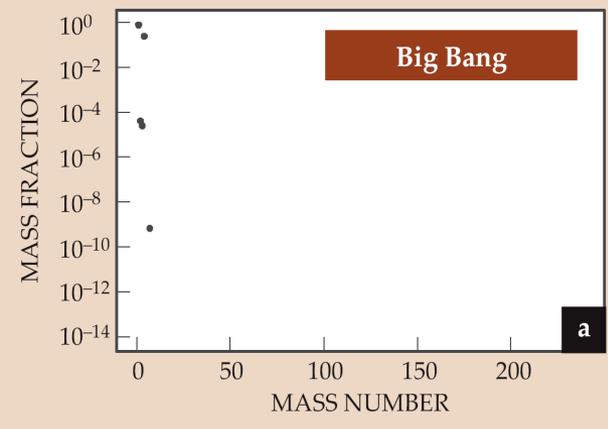
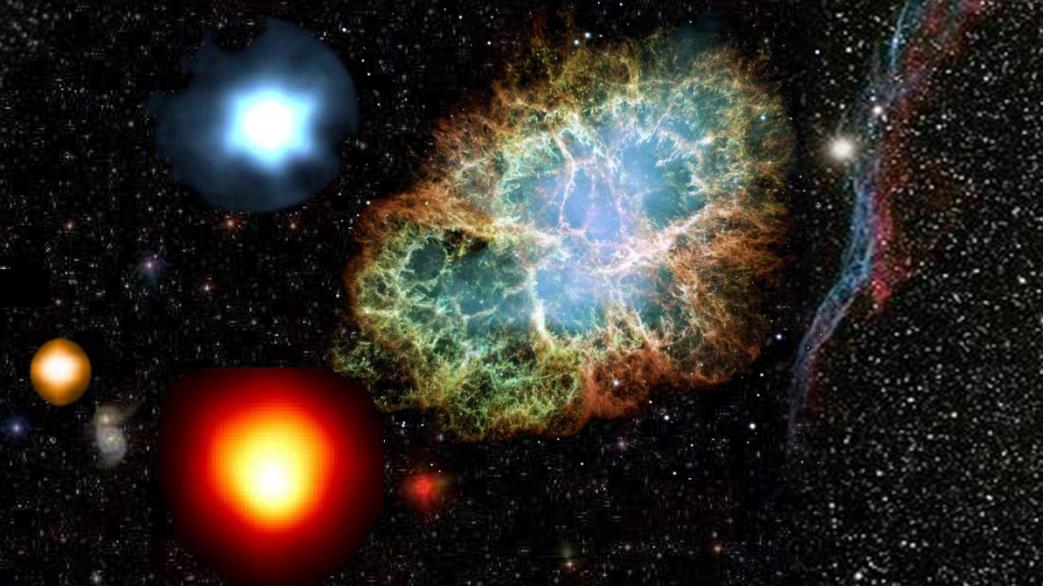
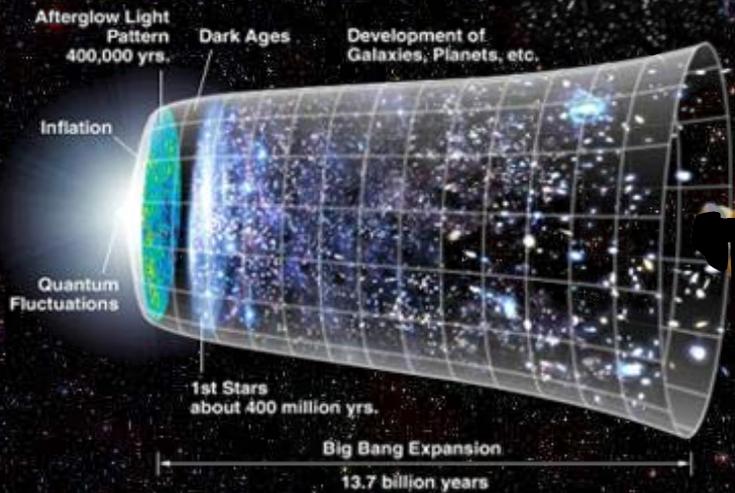


[www.Dosimeter.com](http://www.Dosimeter.com)

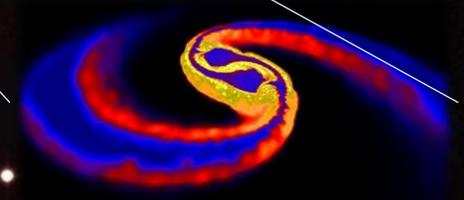
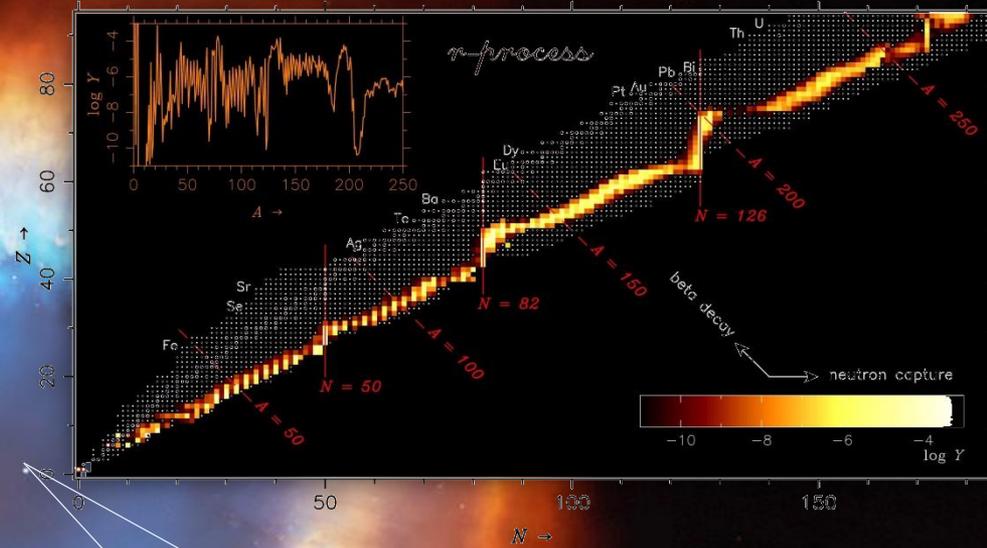
# What will follow - from astro- to geo- to bioscience!

- **2. The origin of radioactivity**
- 2.1. The origin of the elements
- 2.2. The radioactive universe
- 2.3. The radioactive earth
- 2.4. Geological implications and consequences
- 2.5. The human radioactivity cycle
- 2.6. The origin and evolution of life

# Galactic Chemical Evolution



# The origins of the heavy elements

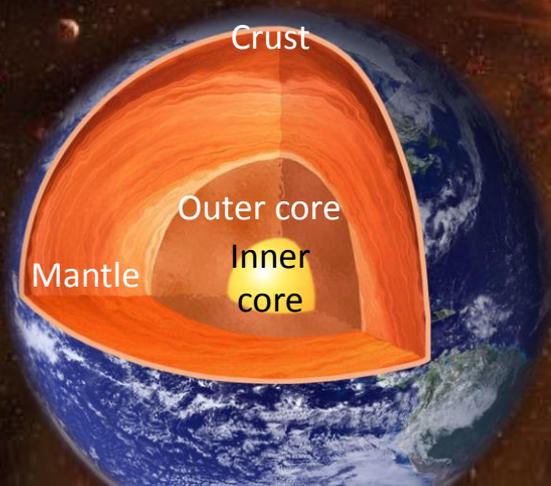


# The Origin of the Solar System



Gravitational contraction of pre-solar cloud possibly initiated by near by supernova ( $^{60}\text{Ni}$  as decay product of  $^{60}\text{Fe}$ ,  $t_{1/2}=2.6\text{Ma}$ ). Dust clusters to rocks, rocks cluster to planetesimals, planetesimals cluster to planets. Lots of violent interaction in the early solar system when orbits around the sun intersect and rocks, planetesimals, and planets scatter around during the early 1 Billion years of the solar system.

# Early Earth



Hadean Period

# Expedition Underground



Radioactivity underground

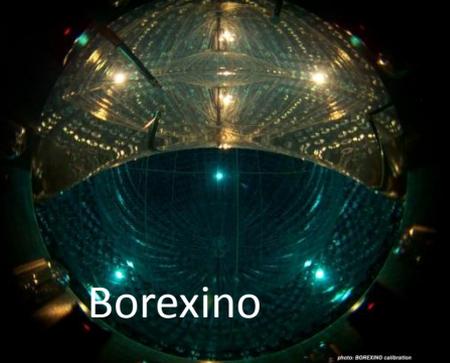
Journey to the Center of the Earth  
by Jules Verne



Kurf



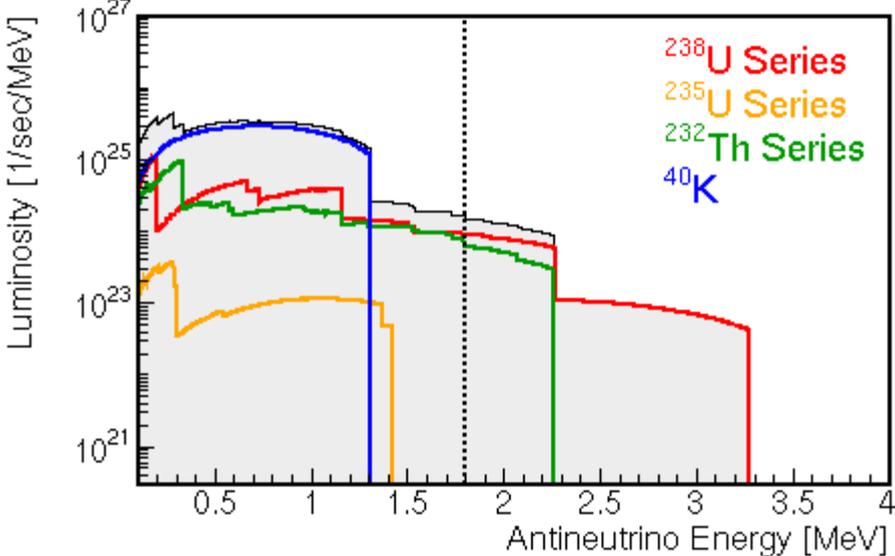
Surf



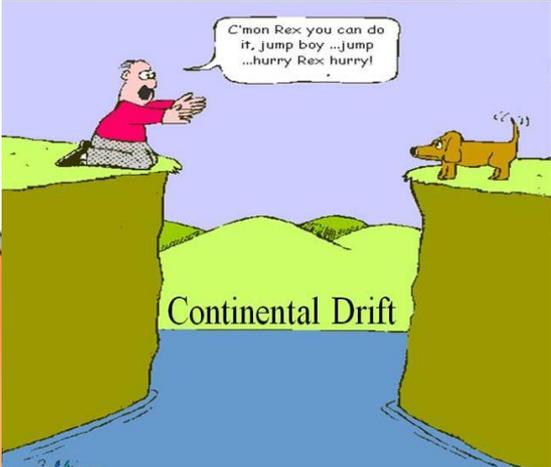
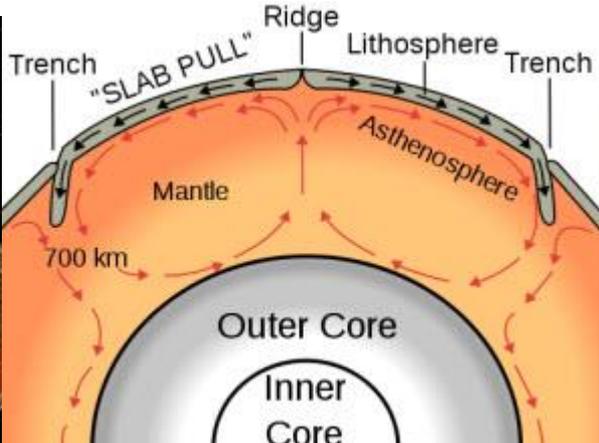
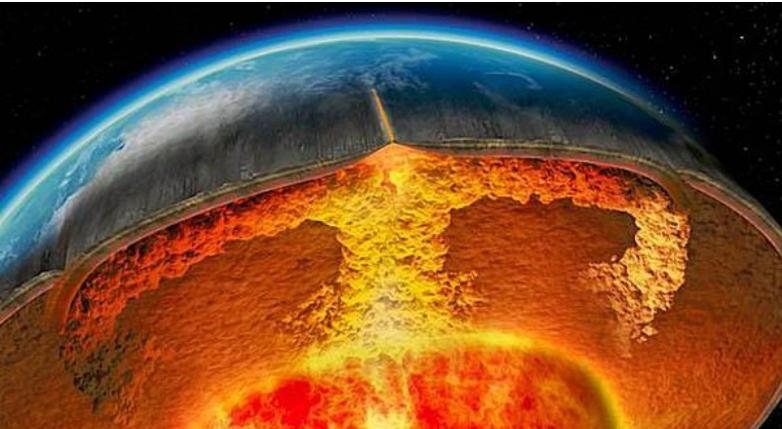
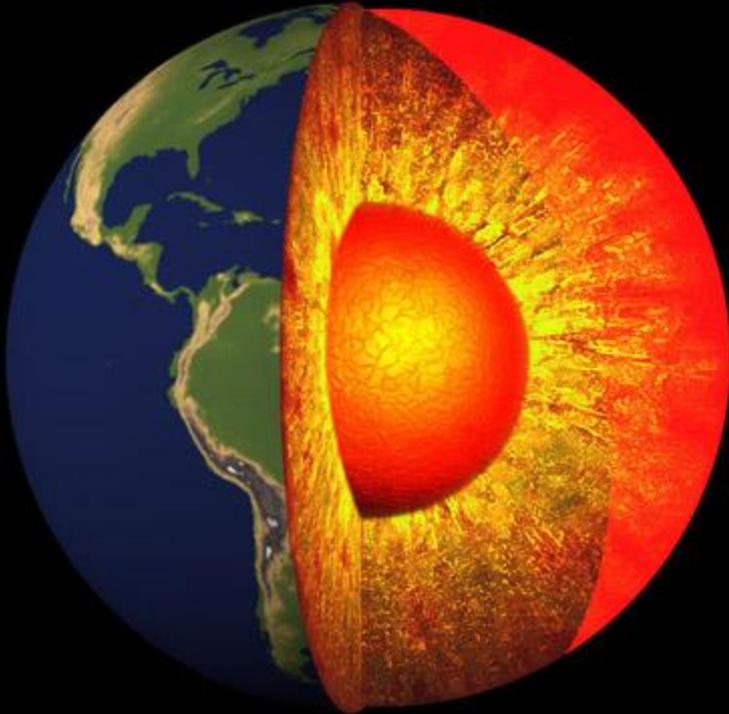
Borexino

# Geothermal Heat

Geoneutrino Luminosity



11 May 2006 00:51:51 JST: geoneutrino-luminosity-2.kino



# Human Radioactivity

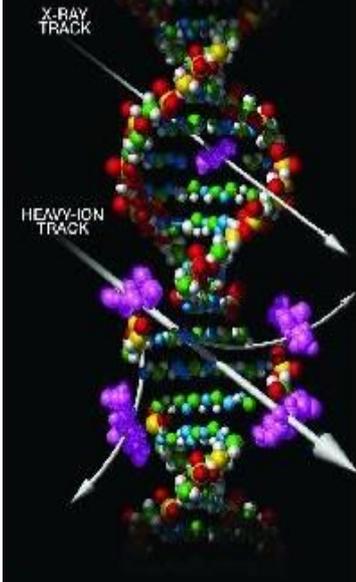
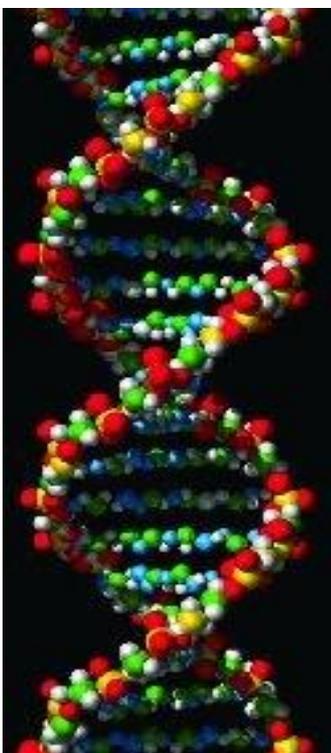
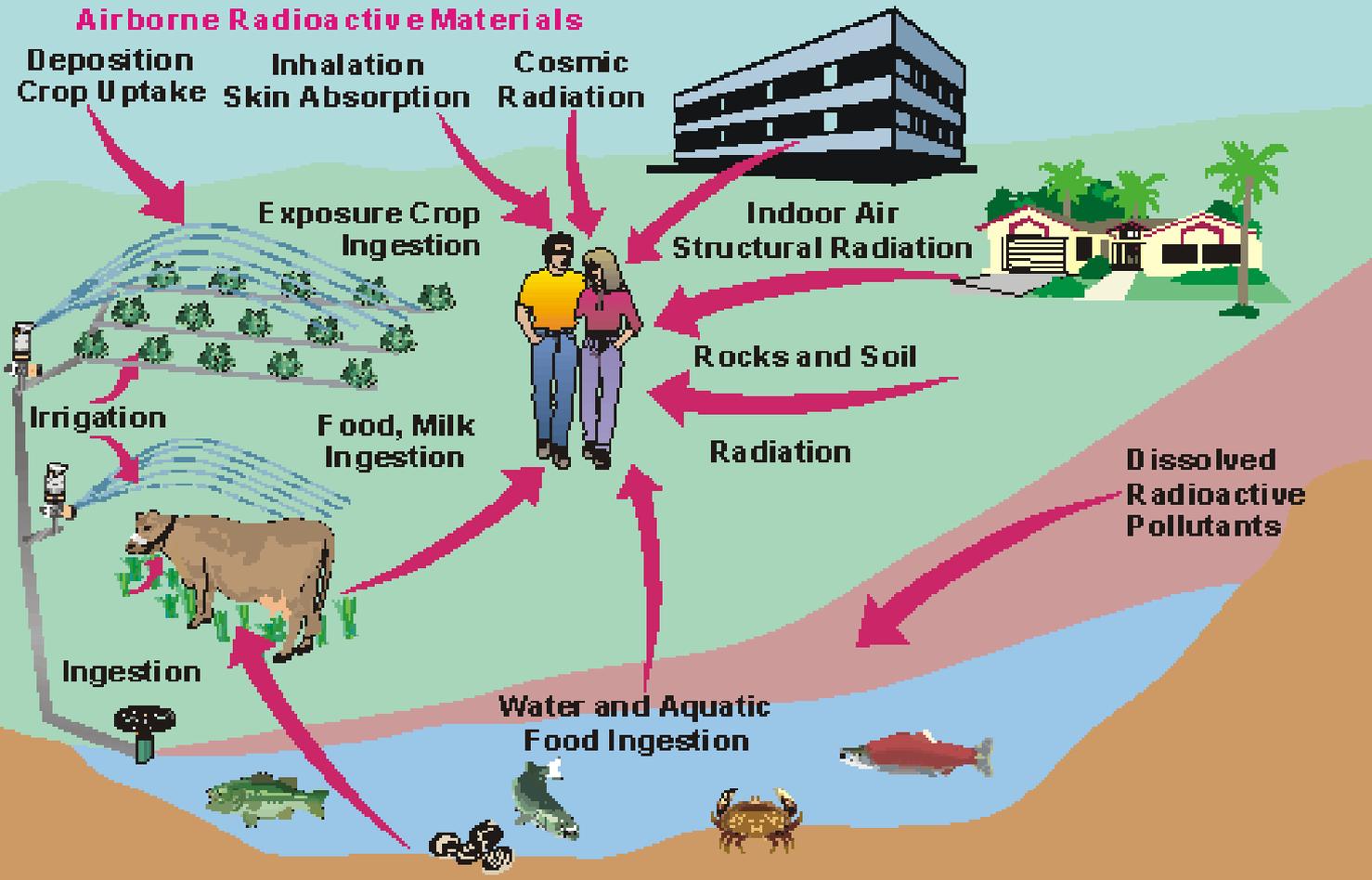
## RADIATION EXPOSURE PATHWAYS

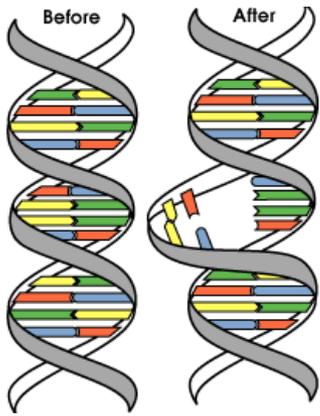
### Airborne Radioactive Materials

Deposition  
Crop Uptake

Inhalation  
Skin Absorption

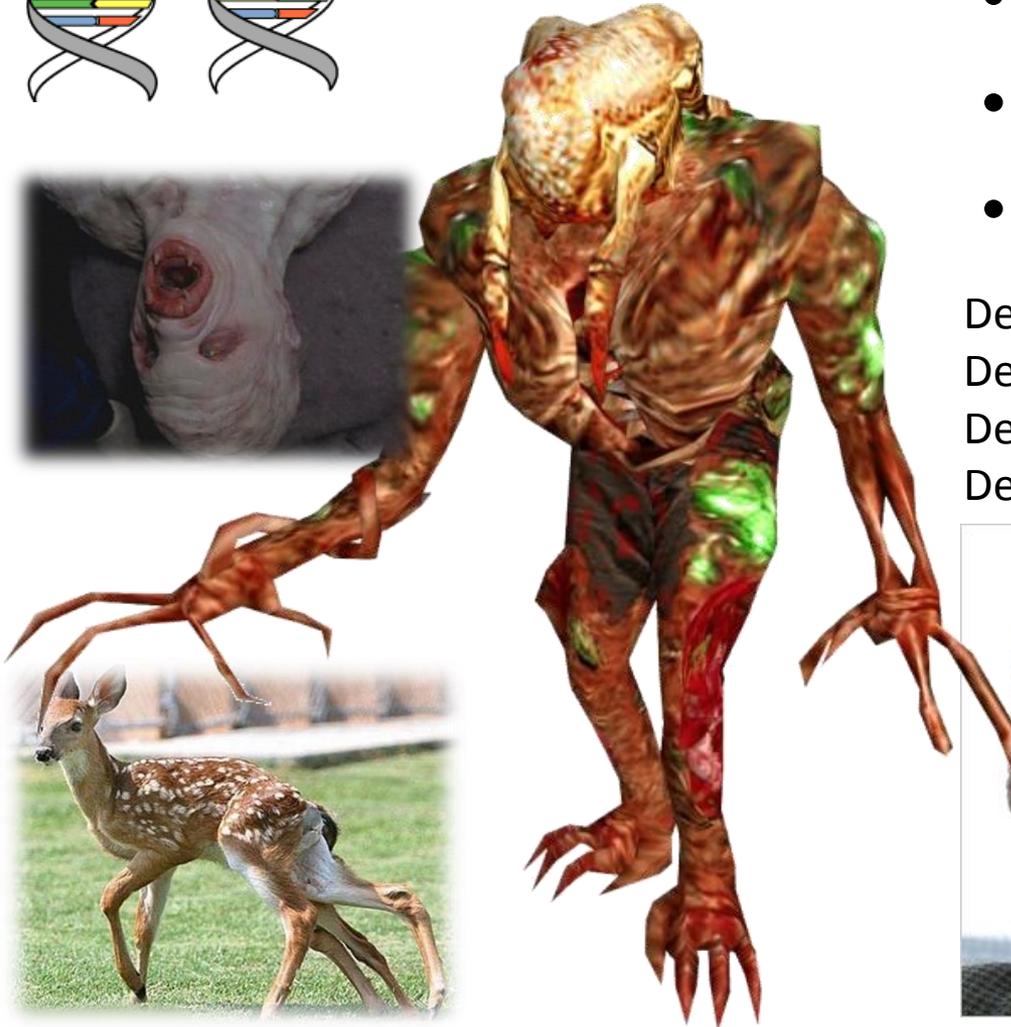
Cosmic  
Radiation





# Consequences?

- Mutation
- Evolution
- Death
- Cancer
- Death

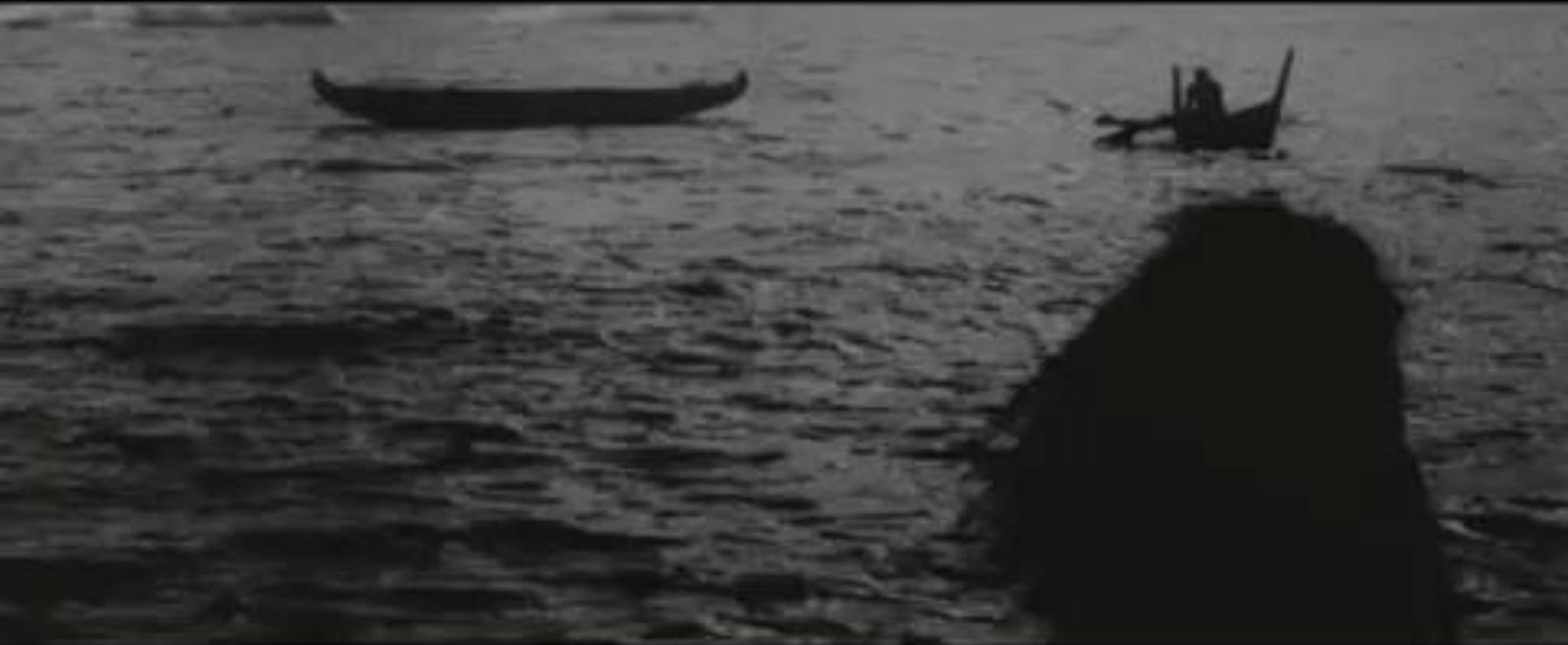


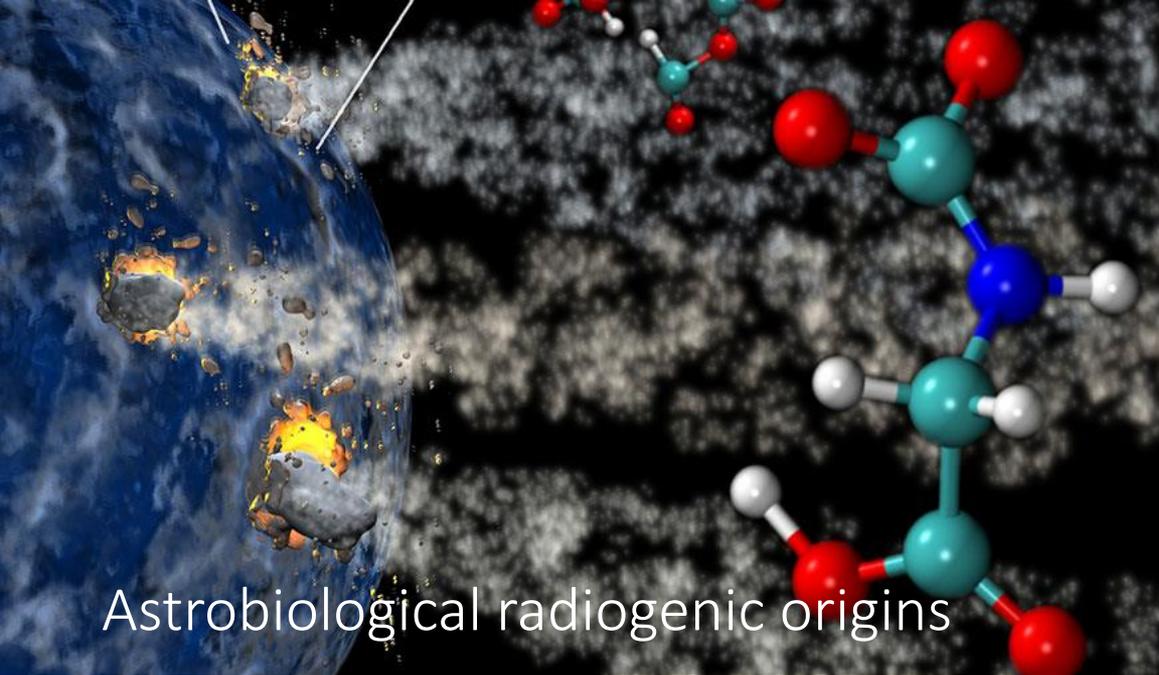
Depends on radiation dose (radiation sickness)  
Depends on radiation damage  
Depends on enzyme repair mechanisms  
Depends on natural selection (survivability)



Alexander Litvinenko, 1962-2006

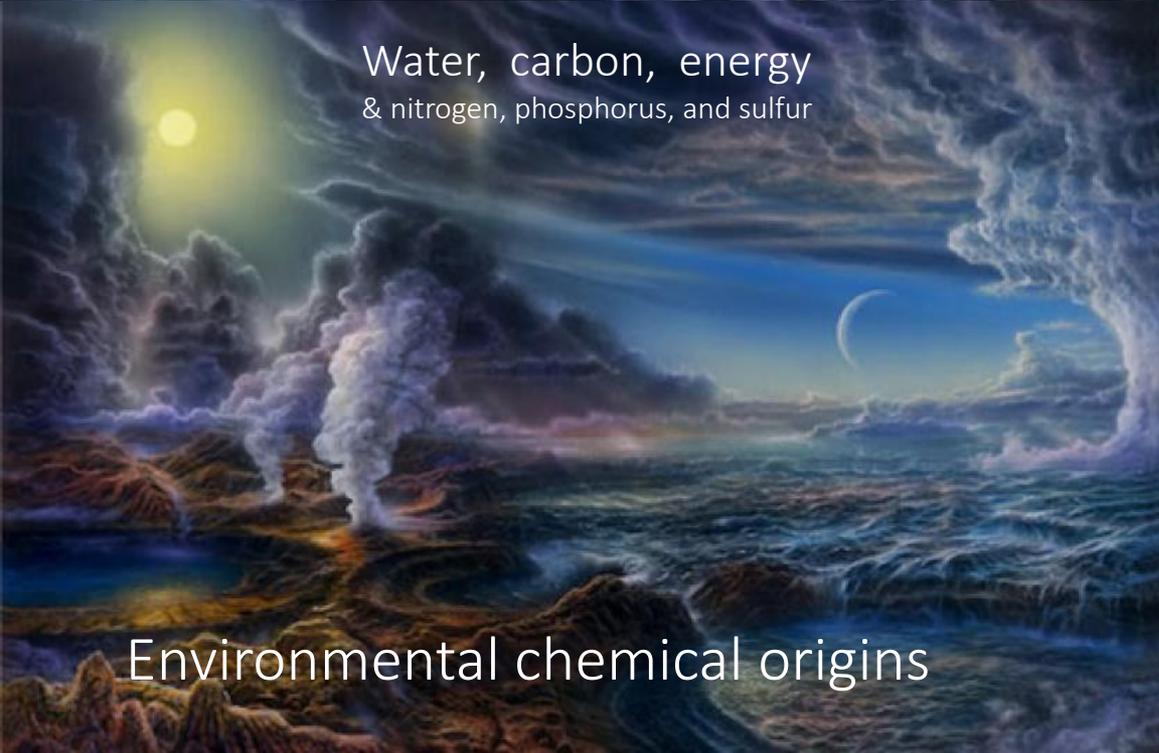
# Godzilla the ultimate mutant





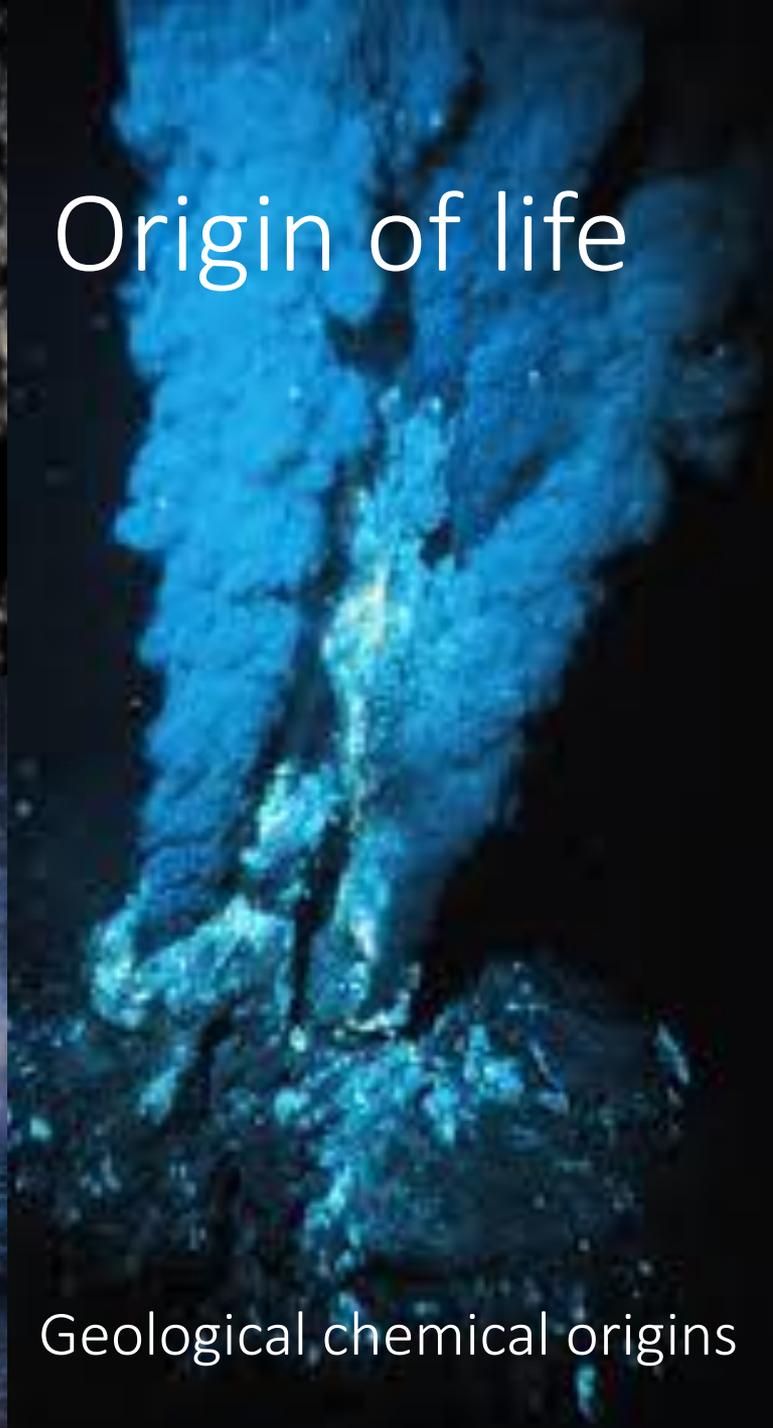
Astrobiological radiogenic origins

Origin of life



Water, carbon, energy  
& nitrogen, phosphorus, and sulfur

Environmental chemical origins

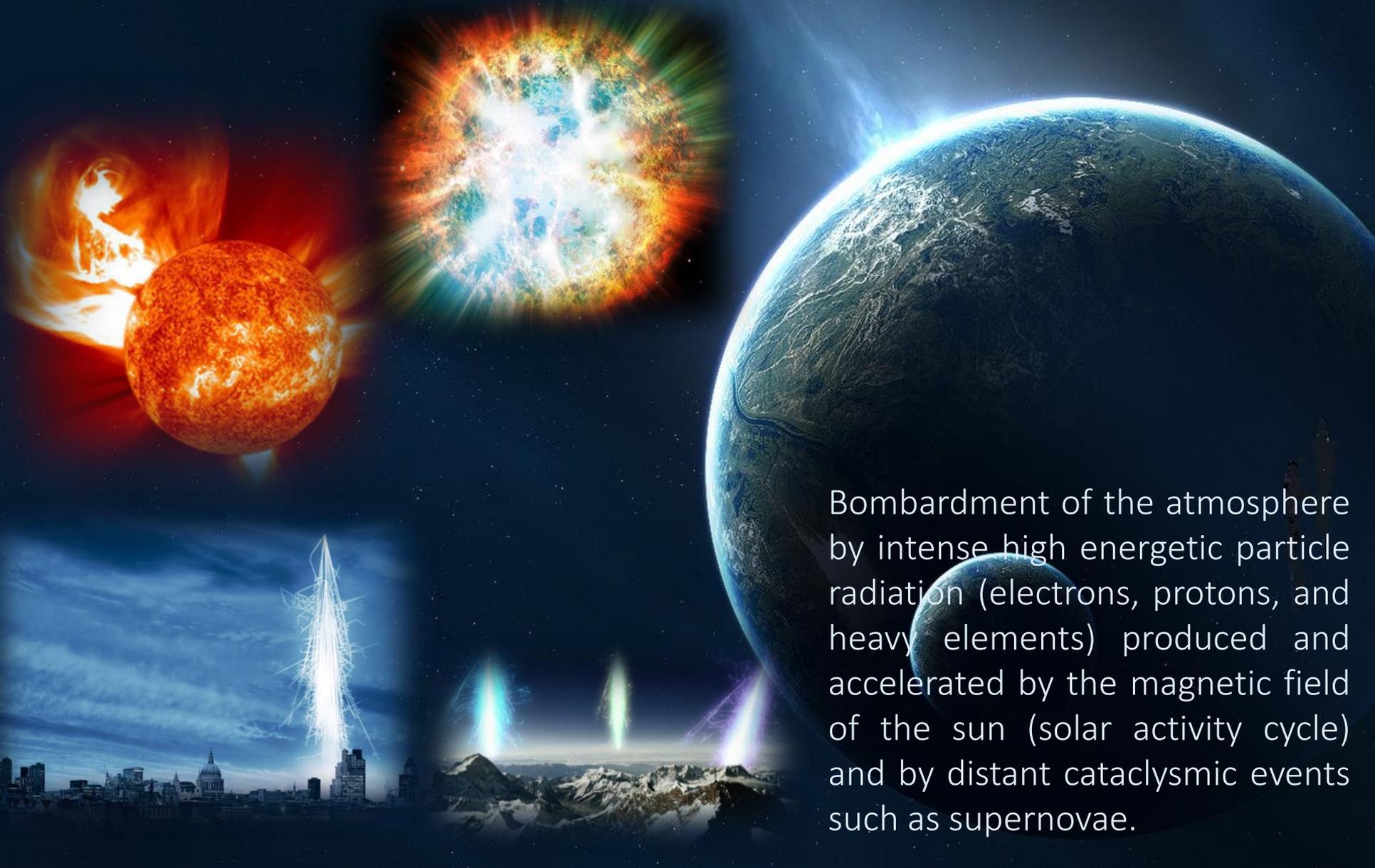


Geological chemical origins

# From Geocene to Anthropocene

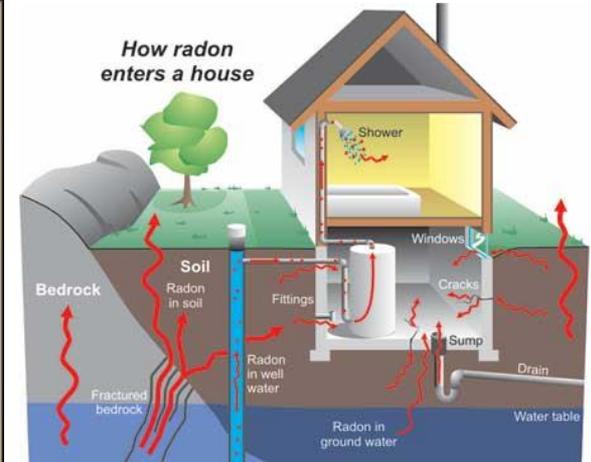
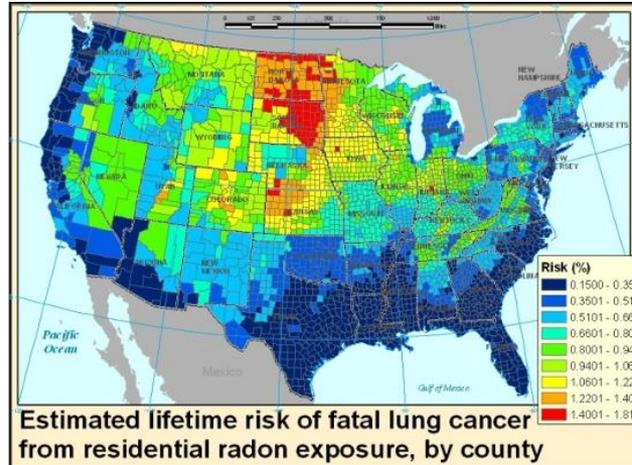
- **3. The environmental impact of radioactivity**
- 3.1. Atmospheric Radioactivity
- 3.2. Radioactivity in agriculture
- 3.3. Radioactivity in building materials
- 3.4. Radioactivity and natural resources
- 3.5. Radioactivity and renewable energy
- 3.6. Radioactivity and nuclear energy

# Cosmogenic Radioactivity

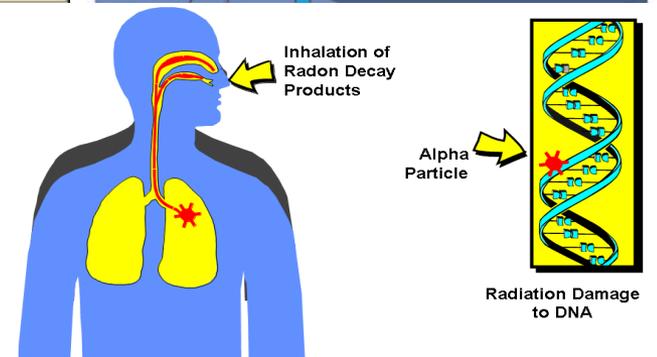


Bombardment of the atmosphere by intense high energetic particle radiation (electrons, protons, and heavy elements) produced and accelerated by the magnetic field of the sun (solar activity cycle) and by distant cataclysmic events such as supernovae.

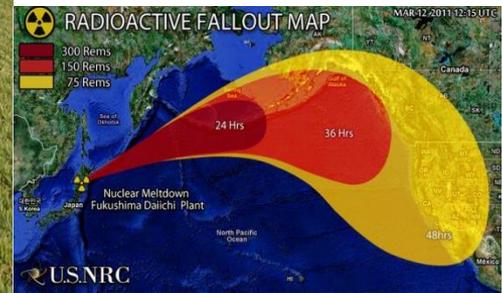
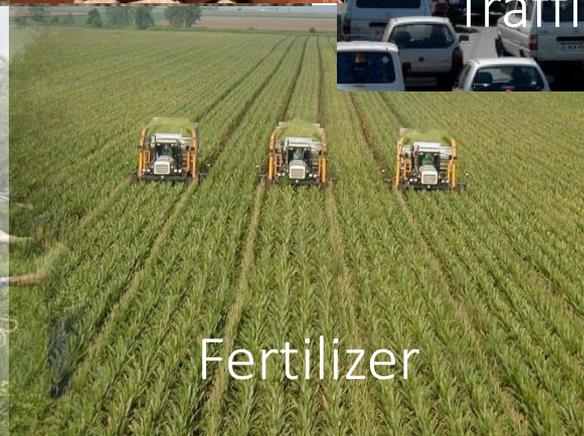
# Radon exposure – from mines to buildings



Radon is a noble gas, it's radioactive components  $^{220}\text{Rn}$ ,  $^{222}\text{Rn}$  are produced as part of the natural decay chain. Radon gas cannot be chemically bound, it diffuses into soil or bedrock and into basements of buildings where it accumulates and can be inhaled, potentially causing lung cancer by subsequent  $\alpha$  emission of it's decay products, breaking DNA bonds.



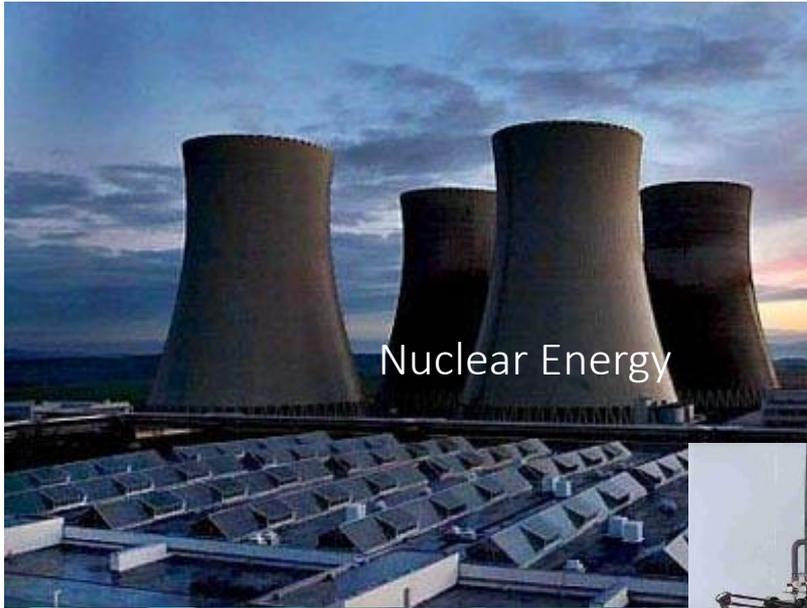
# Anthropogenic radioactivity



# Should we, can we, must we live with it?

- **4. Societal impact of radioactivity**
- 4.1. Radioactivity in the industrial production process
- 4.2. Radioactivity in the art market
- 4.3. Radioactivity and homeland security
- 4.4. Radioactivity and medical applications
- 4.5. Radioactivity in war
- 4.6. Radioactivity and fear

# Radioactivity in Industry



Nuclear Energy



Fire Safety



Oil Search



Food Irradiation



Material Analysis

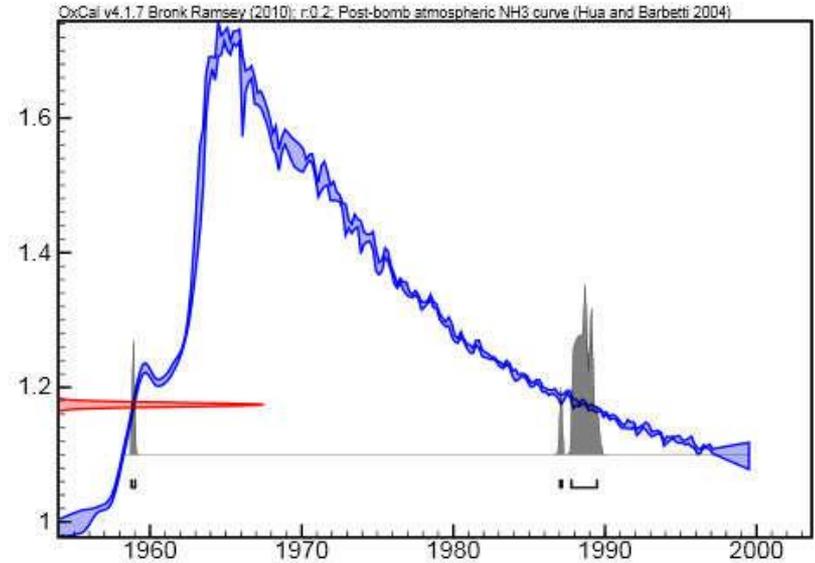


Quality Control

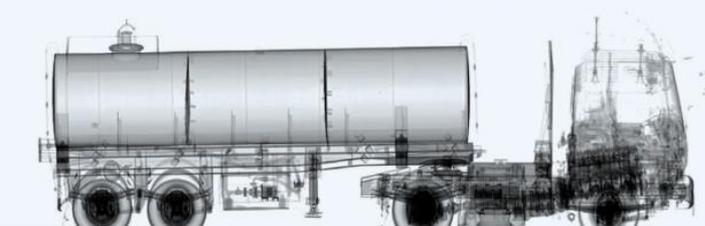
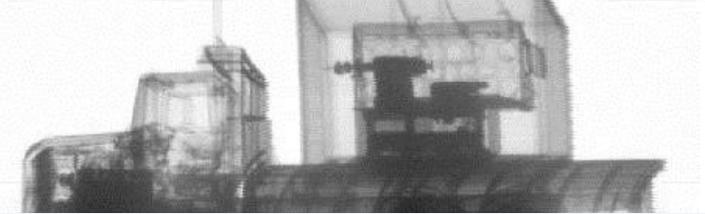
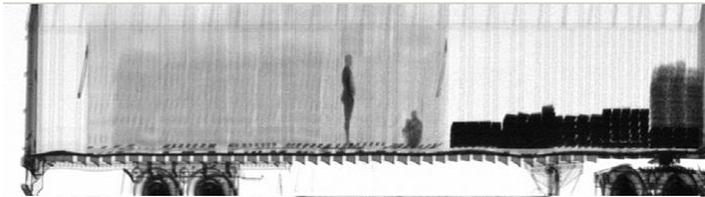


Solar Panels

# Radioactivity as human tool in art



# Radioactivity in homeland security



# Nuclear medicine

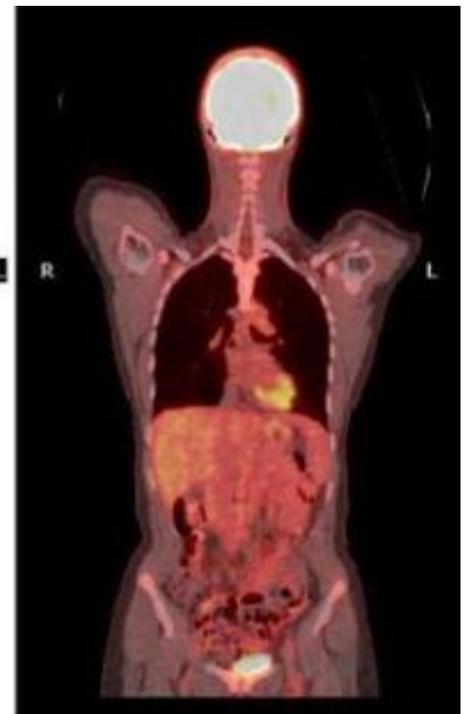
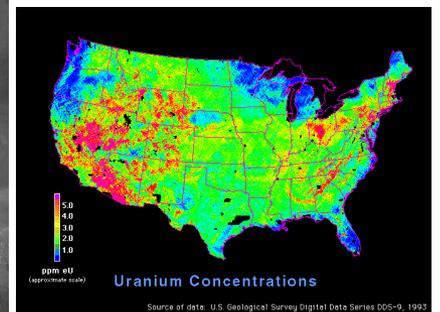
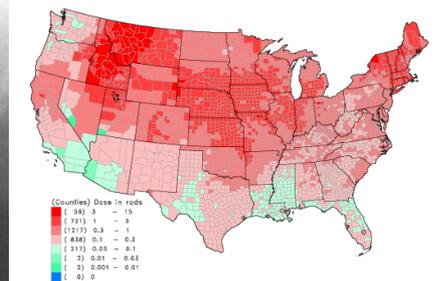


Fig. TS/S/CD Per capita thyroid doses for the population of each county  
Test Series: Tumbler-Snapper (1952)



# Nuclear bomb tests





Nuclear Nightmare triggers nuclear fears