Ionising radiation

- Spontaneous process characteristic of atoms with unstable nuclei in which the nucleus releases energy
- An unstable atom has excess internal energy
- $T_{1/2}$ - Time taken for 50% of a particular radioisotope to decay

Types of radiation

- Alpha particles - consist of 2 protons and 2 neutrons - heavy - collide with matter and lose their energy quickly - little penetrating power (note: ingestion)
- Beta particles - (electrons - smaller - penetrate 1-2 cm of water or human flesh)
- Gamma rays - energy transmitted in a wave - great penetrating power
- X-rays similar to gamma except artificially produced
- Neutrons - very penetrating - come from splitting atoms in nuclear reactors

Units of measurement

- Radioactive emission: Bequerel (Bq): one nuclear disintegration/sec (1 Bq = 27 x 10^{-12} curies)
- Absorbed radioactivity: Gray (Gy) - 1 Joule of energy/kg tissue
- Measure of destructive dose: Sievert (Sv)
Sources

- Natural
  - Cosmic rays
  - Uranium - all uranium atoms are mildly radioactive
    - Radon produced as part of the uranium decay
  - Tritium
    - Produced by the reaction of cosmic rays with atmospheric gases such as oxygen and nitrogen

- Manufactured
  - Health Sciences
    - Diagnostic
    - Nuclear medicine
    - Therapeutic radiation
  - Nuclear Weapons
    - Manufacturing
    - Testing
    - Exploding
  - Nuclear Power production
    - Includes mining, uranium fuel fabrication, waste storage and disposal

Targets

- DNA
- Lipids
- Proteins
- Carbohydrates

Tissue sensitivity

- Most sensitive:
  - Blood-forming organs
  - Reproductive organs
  - Skin
  - Bone and teeth
  - Muscles
- Least sensitive:
  - Nervous system
- Fetus more sensitive in first trimester
Sources

- Accidents
- Since 1952 14 accidents
  - Three Mile Island (1979)
  - Chernobyl (1986)
    - $2 \times 10^{18}$ Bq of radioactivity was released
    - $^{131}$Iodine
    - $^{134,137}$Cesium (137- half life 30 years)
  - Killed 32 people, 237 cases of acute radiation sickness

Agricultural and Environmental Impacts

- Forest
- Large areas of land in former Soviet Union unusable
- Strict control over distribution of agriculture and dairy production

Radiation doses

<table>
<thead>
<tr>
<th>Radiation doses (1 Sv = 100 rem)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 sieverts (0.010 mSv)</td>
</tr>
<tr>
<td>2-10 Sv</td>
</tr>
<tr>
<td>1 Sv</td>
</tr>
<tr>
<td>0.1-0.6 mSv/yr (approx)</td>
</tr>
<tr>
<td>0.001-0.01 mSv/yr (approx)</td>
</tr>
</tbody>
</table>

Health Risk  Estimated Life Expectancy Lost

<table>
<thead>
<tr>
<th>Health Risk</th>
<th>Estimated Life Expectancy Lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking 20 cigarettes a day</td>
<td>6 years</td>
</tr>
<tr>
<td>Overweight by 15%</td>
<td>2 years</td>
</tr>
<tr>
<td>Alcohol (US average)</td>
<td>1 year</td>
</tr>
<tr>
<td>All accidents</td>
<td>207 days</td>
</tr>
<tr>
<td>All natural hazards</td>
<td>7 days</td>
</tr>
<tr>
<td>Occupational dose of 3 mSv/year</td>
<td>15 days</td>
</tr>
</tbody>
</table>

Source: these estimates are taken from NRC Draft Guide DG-8012 and were adapted from B. L. Cohen and L. S. Lee, "Catalogue of Risks Extended and Updated," Health Physics, Vol. 61, September 1991.