

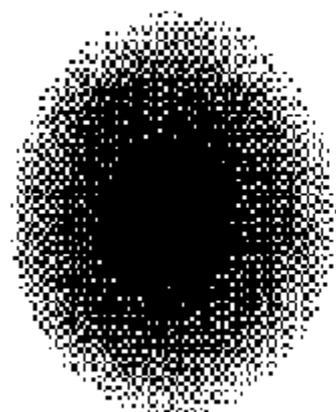


# Physiological Effects of Plasma Radiation on Astronaut Health





Radiation Source



**Alpha Particles**

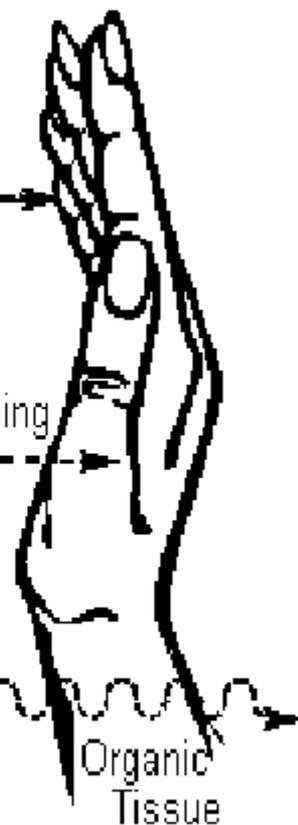
Stopped by a sheet of paper

**Beta Particles**

Stopped by a layer of clothing or by a few millimeters of a substance such as aluminium

**Gamma Rays**

Stopped by several feet of concrete or a few inches of lead





### SOLAR WIND

- Low hazard and continuous
- Low energy protons, electrons, and other particles travelling at about  $5 \times 10^5$  m/s

### SOLAR FLARE

- Very hazardous
- Intermittent and lasting for 1 to 2 days
- High energy protons traveling at the speed of light ( $3 \times 10^8$  m/s)



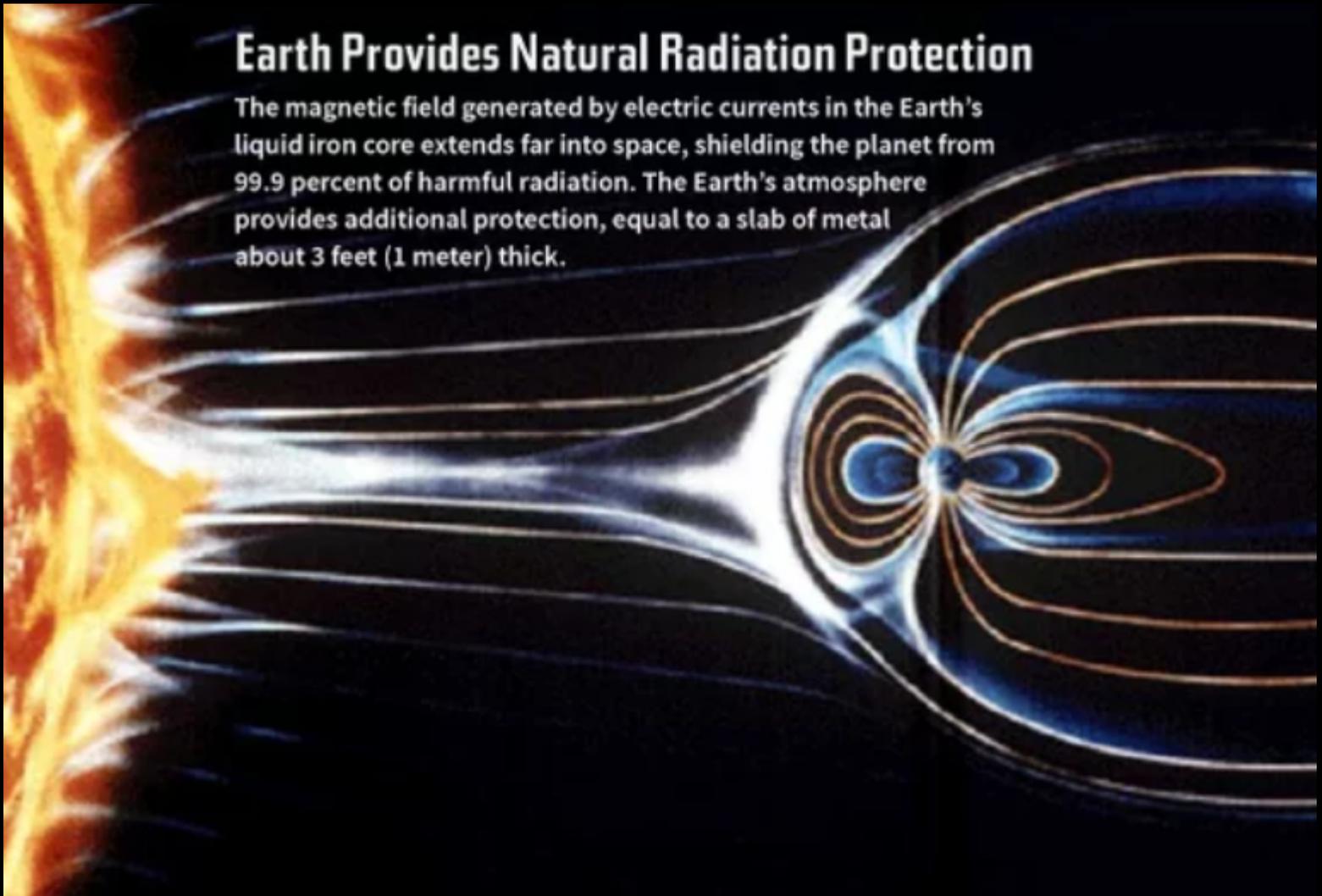
### GALACTIC COSMIC RAYS

- Hazardous and continuous
- Composed primarily of gamma rays



## Earth Provides Natural Radiation Protection

The magnetic field generated by electric currents in the Earth's liquid iron core extends far into space, shielding the planet from 99.9 percent of harmful radiation. The Earth's atmosphere provides additional protection, equal to a slab of metal about 3 feet (1 meter) thick.





<b>Radiosensitivity of Various Cell Types</b>	
<b>Radiosensitivity</b>	<b>Cell Type</b>
Low	Nerve cells Muscle cells
Intermediate	Osteoblast Endothelial cells Fibroblast Spermatids
High	Spermatogonia Lymphocytes Stem Cells Intestinal mucosa cells Erythroblast



## Organ Sensitivity To The Effects Of Radiation

### LOW

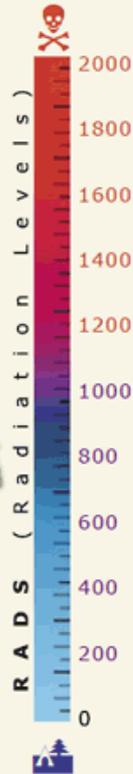
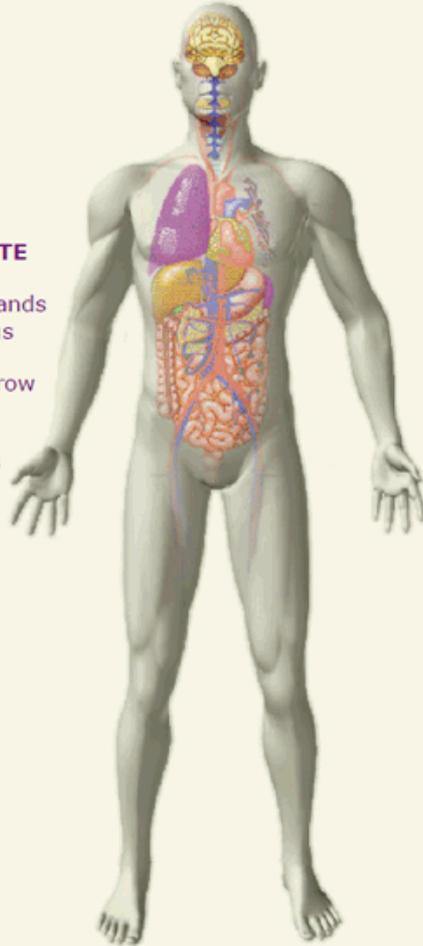
Skin  
Bones  
Spleen  
Kidneys

### MODERATE

Brain  
Lymph Glands  
Esophagus  
Thyroid  
Bone Marrow  
Liver  
Pancreas  
Intestines  
Ovaries

### HIGH

Lungs  
Breasts  
Stomach  
Colon

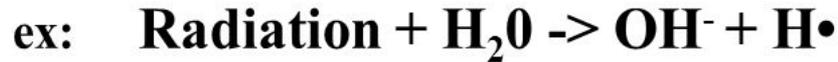




# Radiation Damage - Ionization

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- ◆ Radiation causes *Ions and free radicals* in cell



- ◆ These free radicals and ions react with parts of the cell
  - attack sensitive areas
  - cause damage
- ◆ May have direct damage to “targets” also

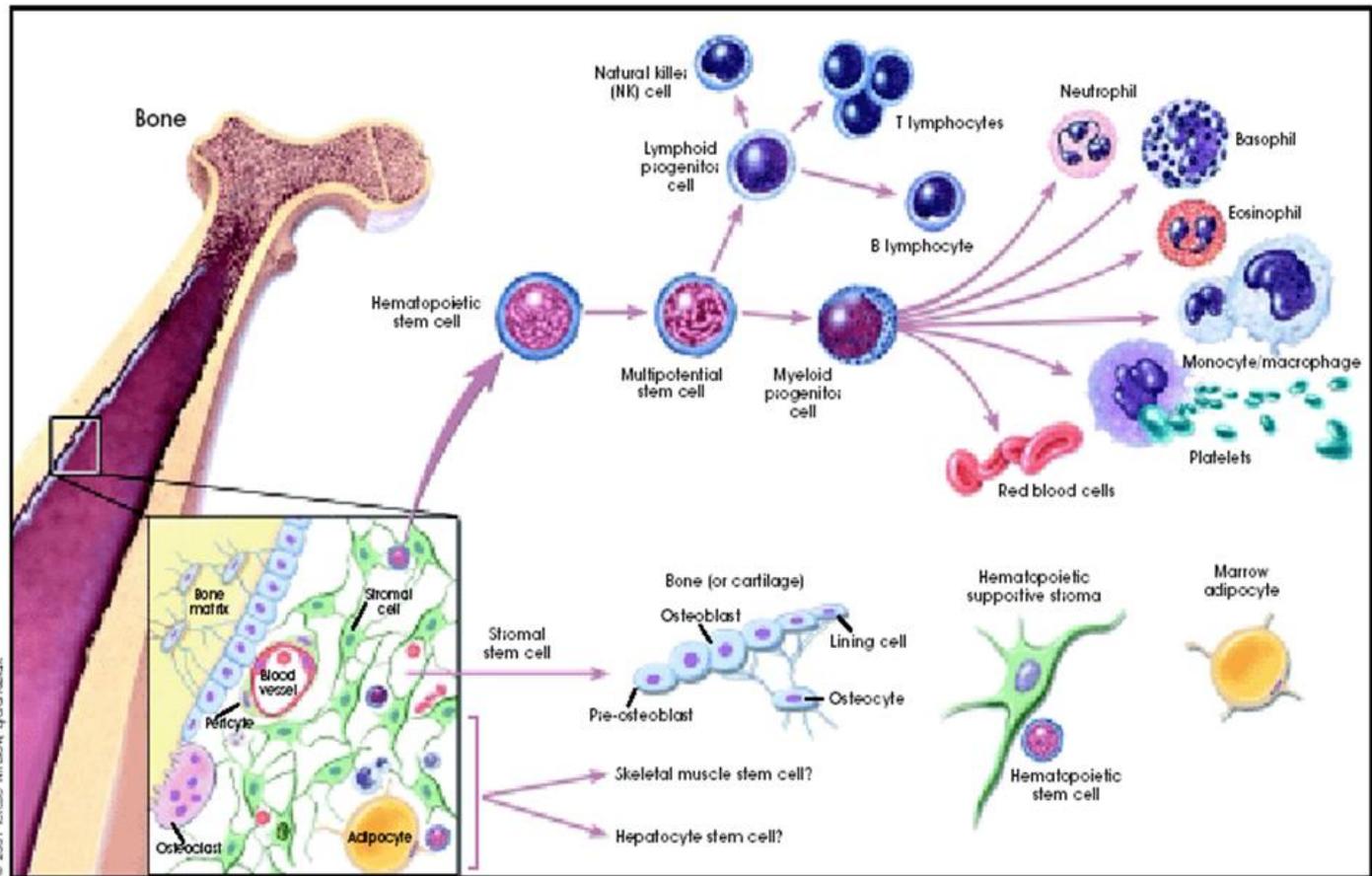
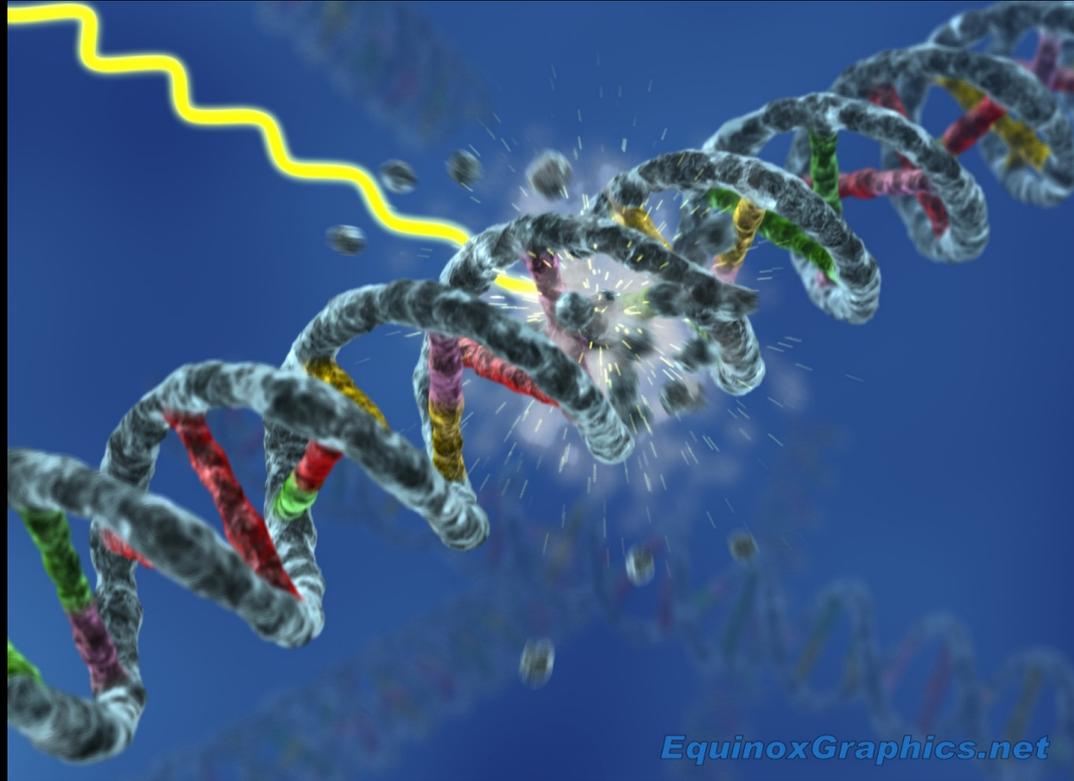


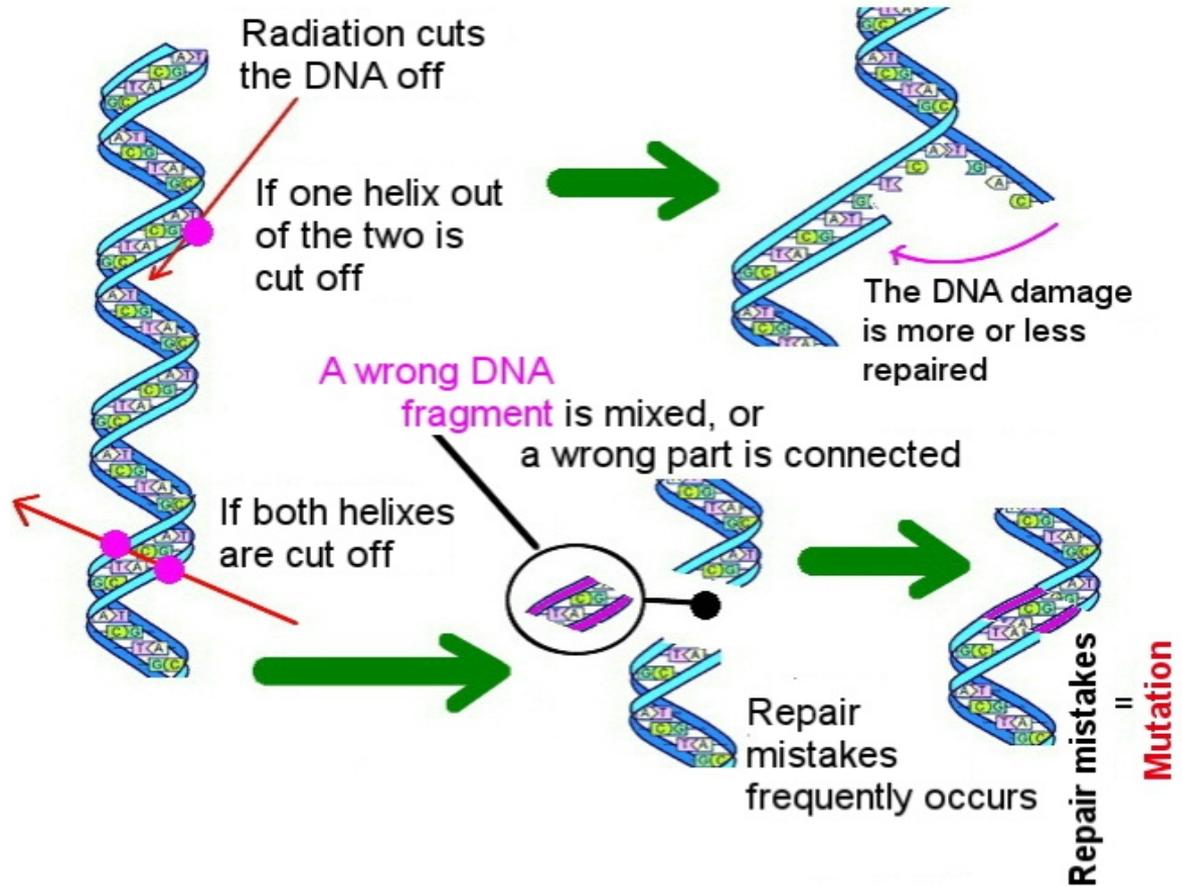
Figure 4.3. Hematopoietic and Stromal Stem Cell Differentiation.



*EquinoxGraphics.net*



## DNA cut off by radiation



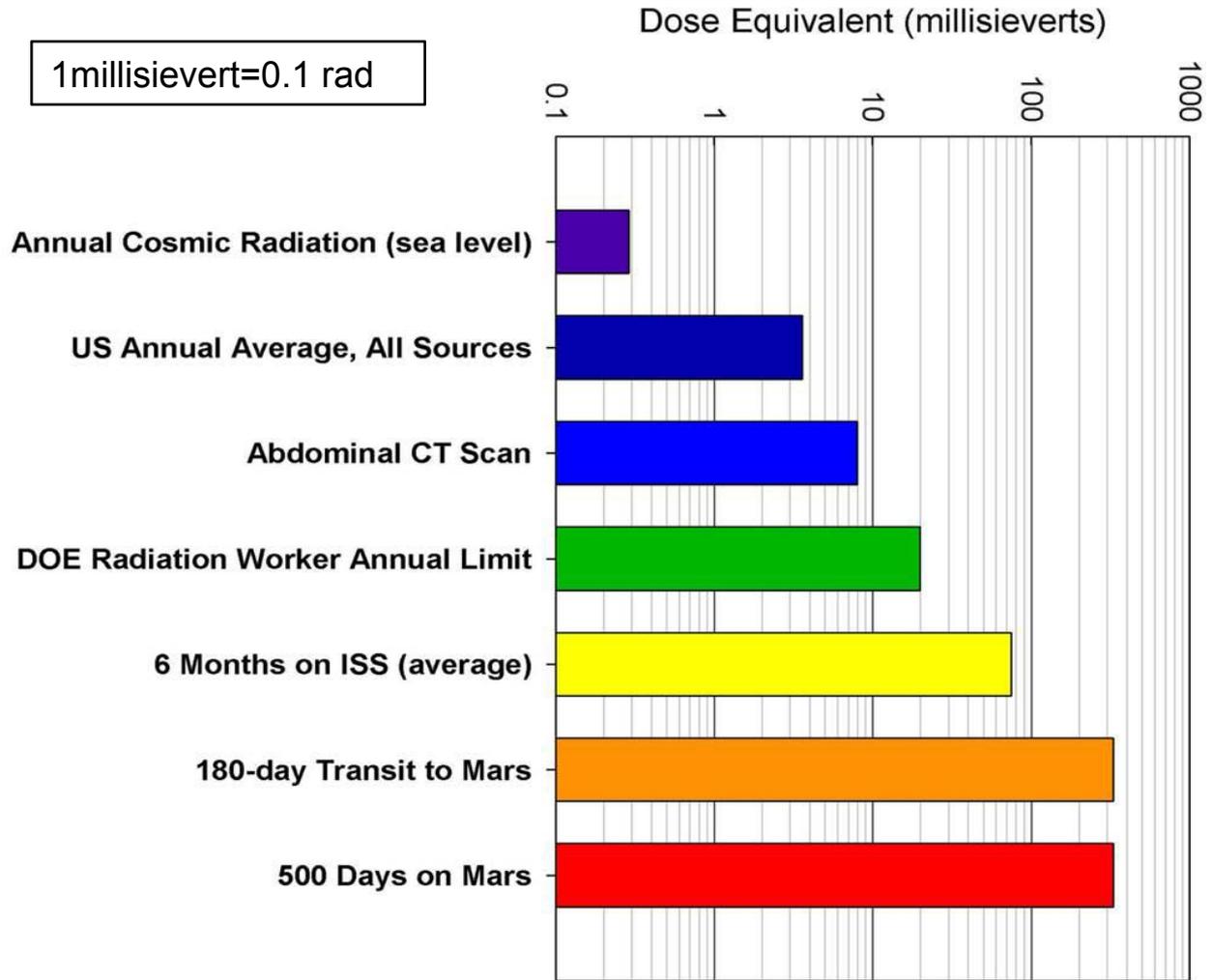


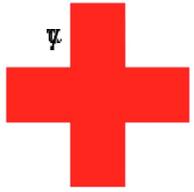
Comparison of Radiation Doses – includes the amount detected on the trip from Earth to Mars

Kerr, Richard, May 31, 2013).

["Radiation Will Make Astronauts' Trip to Mars Even Riskier". \*Science\*. 340 \(6136\)](#)

1 millisievert=0.1 rad





## ***The Radiation Biological Effectiveness***

### ***RBE of Various Forms of Radiation***

Radiation		RBE
x-rays and $\gamma$ -rays		1
particles with energies larger than 0.03 MeV		1
particles with energies less than 0.3 MeV		1.7
thermal (slow-moving) neutrons		3
fast-moving neutrons or protons		10
$\alpha$ -particles or heavy ions		20



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### LOW

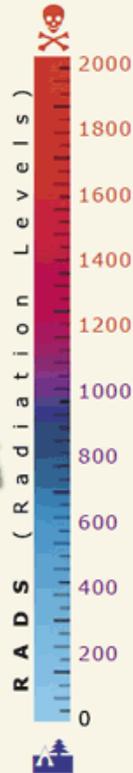
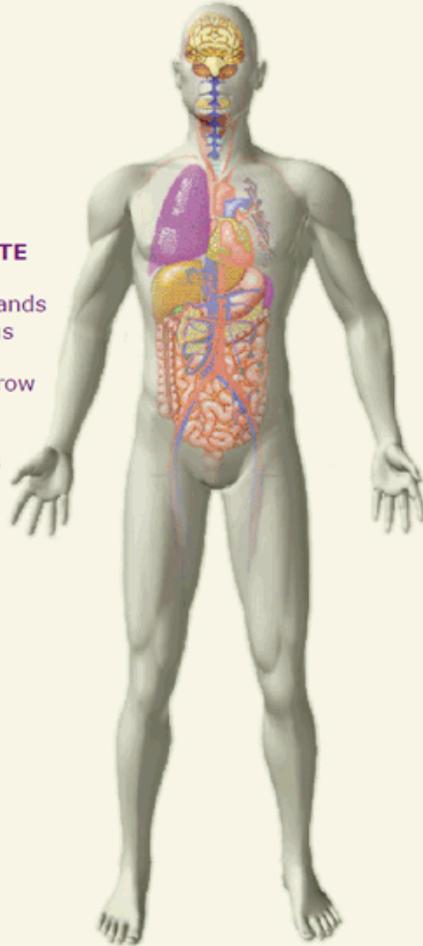
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Ovaries

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Stomach  
Colon





## Mitigation

- Use plastic-rich materials rather than Aluminum for construction of spacecraft
- Use Liquid Hydrogen or Water for shielding
- Use of Drugs
- Timeliness of space travel

