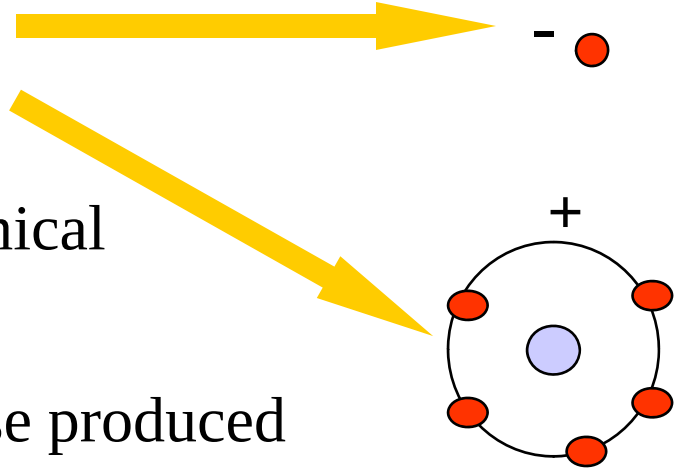
Health Effects of Radiation

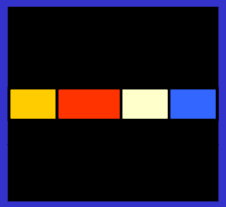
How does radiation injure people?



- High energy radiation breaks chemical bonds.
- This creates free radicals, like those produced by other insults as well as by normal cellular processes in the body.
- The free radicals can change chemicals in the body.
- These changes can disrupt cell function and may kill cells.

DNA is the most important molecule that can be changed by radiation

Effects of DNA Damage

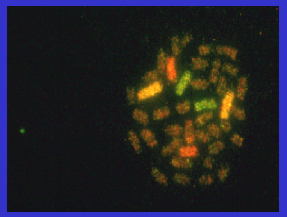


Gene Expression

A gene may respond to the radiation by changing its signal to produce protein. This may be protective or damaging.

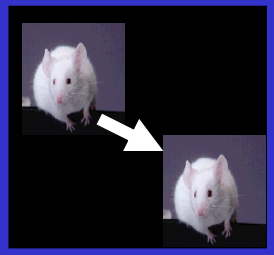
Gene Mutation

Sometimes a specific gene is changed so that it is unable to make its corresponding protein properly



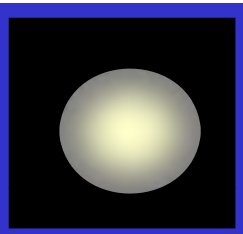
Chromosome Aberrations

Sometimes the damage effects the entire chromosome, causing it to break or recombine in an abnormal way. Sometimes parts of two different chromosomes may be combined



Genomic Instability

Sometimes DNA damage produces later changes which may contribute to cancer.

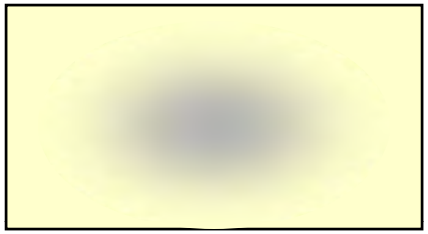


Cell Killing

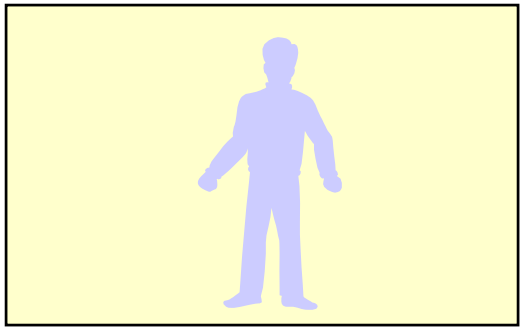
Damaged DNA may trigger apoptosis, or programmed cell death. If only a few cells are affected, this prevents reproduction of damaged DNA and protects the tissue.

Studies have shown that most radiation-induced DNA damage is normally repaired by the body

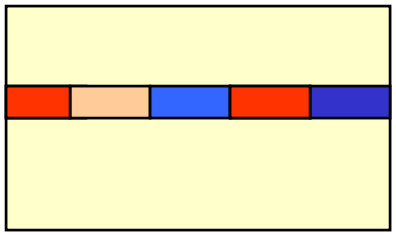
How does this damage from ionizing radiation effect our bodies?



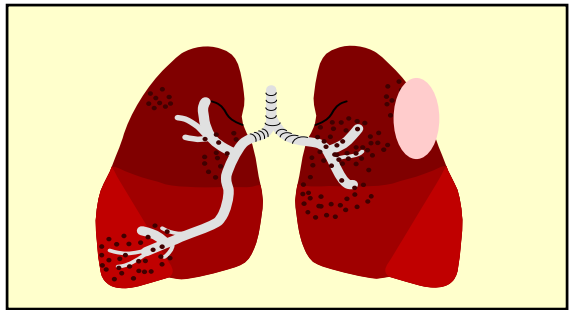
Sufficient Cell Killing



Radiation Sickness



Sufficient Genetic Alterations



Cancer

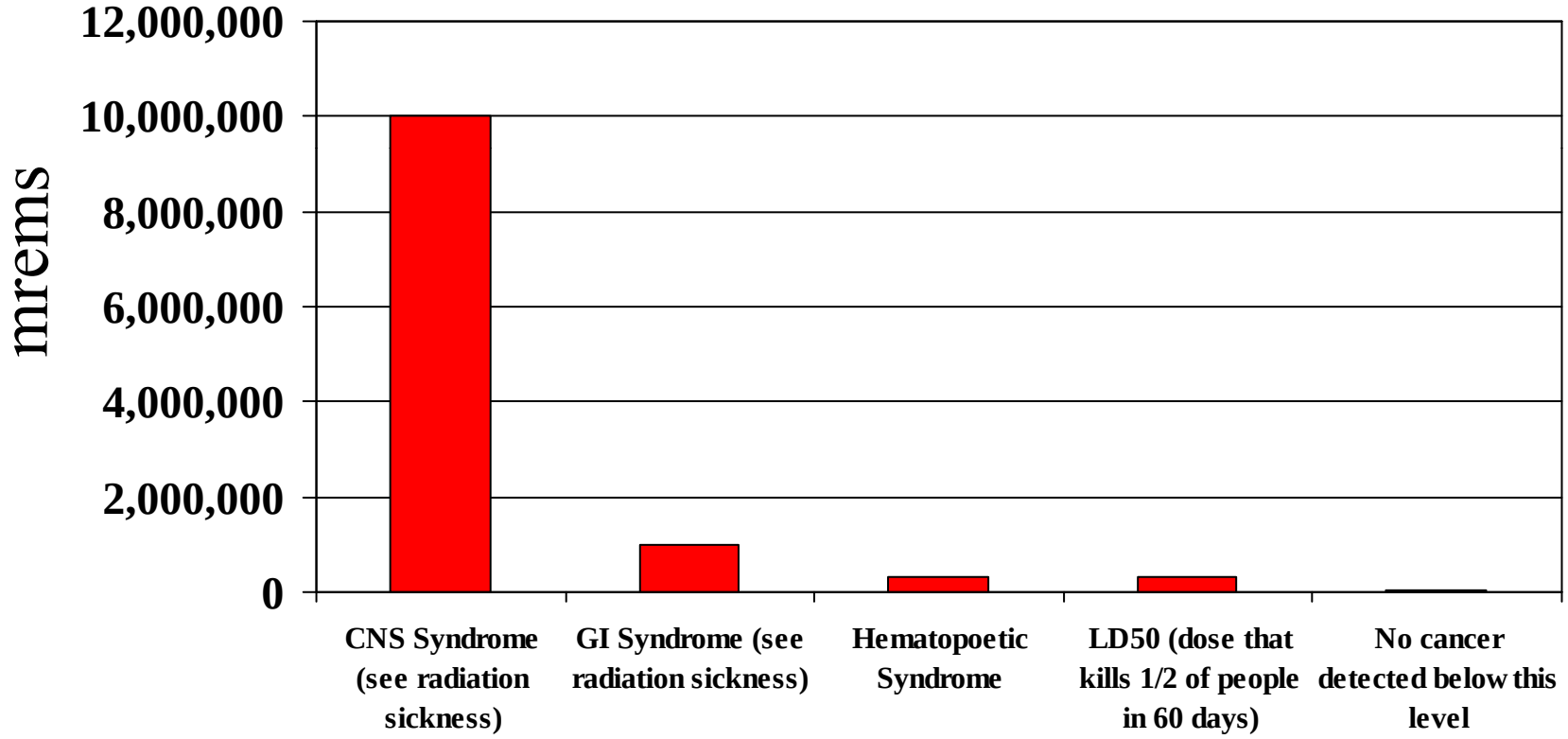
Very high doses of radiation can cause serious and immediate effects (acute effects)

- After whole body exposure to very large doses of radiation, particularly sensitive cells die, resulting in serious damage to select organs and systems.
- Radiation sickness is caused by damage to organs or systems after exposure to very high doses of radiation. The symptoms depend upon the dose and time of exposure.

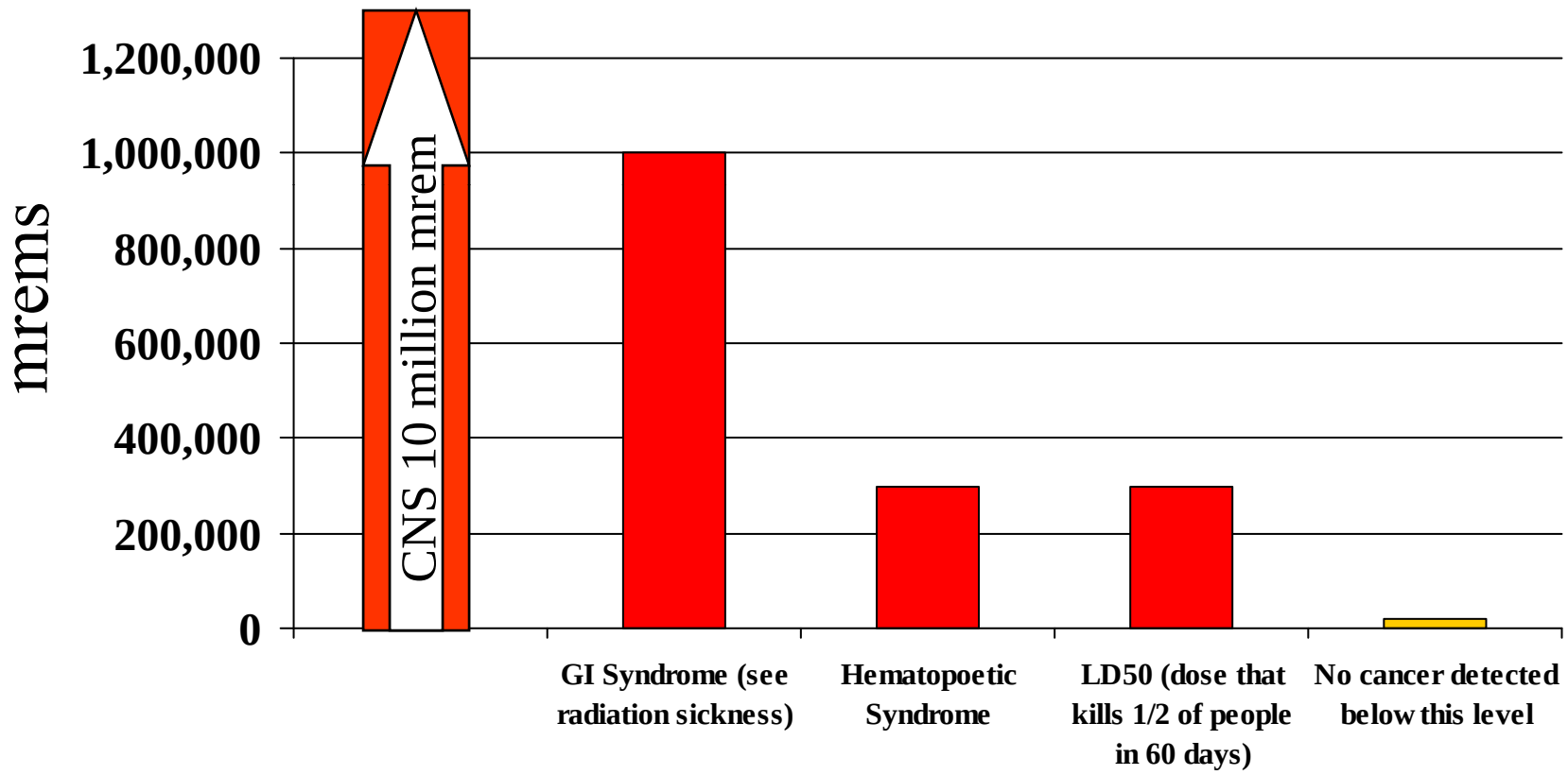
RADIATION SICKNESS

System effected/ Syndrome	**Symptoms**	Dose
Nervous system **CNS or Cerebrovascular Syndrome**	Shock, severe nausea, disorientation, seizures, coma	10, 000,000 mrem
G.I. system Gastrointestinal Syndrome	Nausea, vomiting, diarrhea, dehydration	1,000,000 mrem
Blood cells / bone marrow **Hematopoietic Syndrome**	Chills, fatigue, hemorrhage, ulceration, infections, anemia	300,000-800,000 mrem
Skin **Erethema**	Burning/ infection, sloughing of skin, hair loss	1,000,000 mrem
Ovaries/ Testes	**Sterility**	60,000-80,000 mrem/ 250,000-600,000 mrem

Radiation sickness occurs at very high doses



Radiation sickness occurs at very high doses



High doses of radiation can also produce effects long after the exposure (late effects)

TIME

Minutes	CNS Syndrome
Days	GI Syndrome,
Weeks	Hematopoetic Syndrome
Months	Birth defects, LD_{50}
Years	Cancer

Sources of data for late effects of high doses of ionizing radiation

- Cancer
  - Leukemia (A-bomb data)
  - Thyroid (Chernobyl data)
  - Bone and other solid cancers (A-bomb data)
- Birth defects (A-bomb data)
- Genetic effects (only animal data)

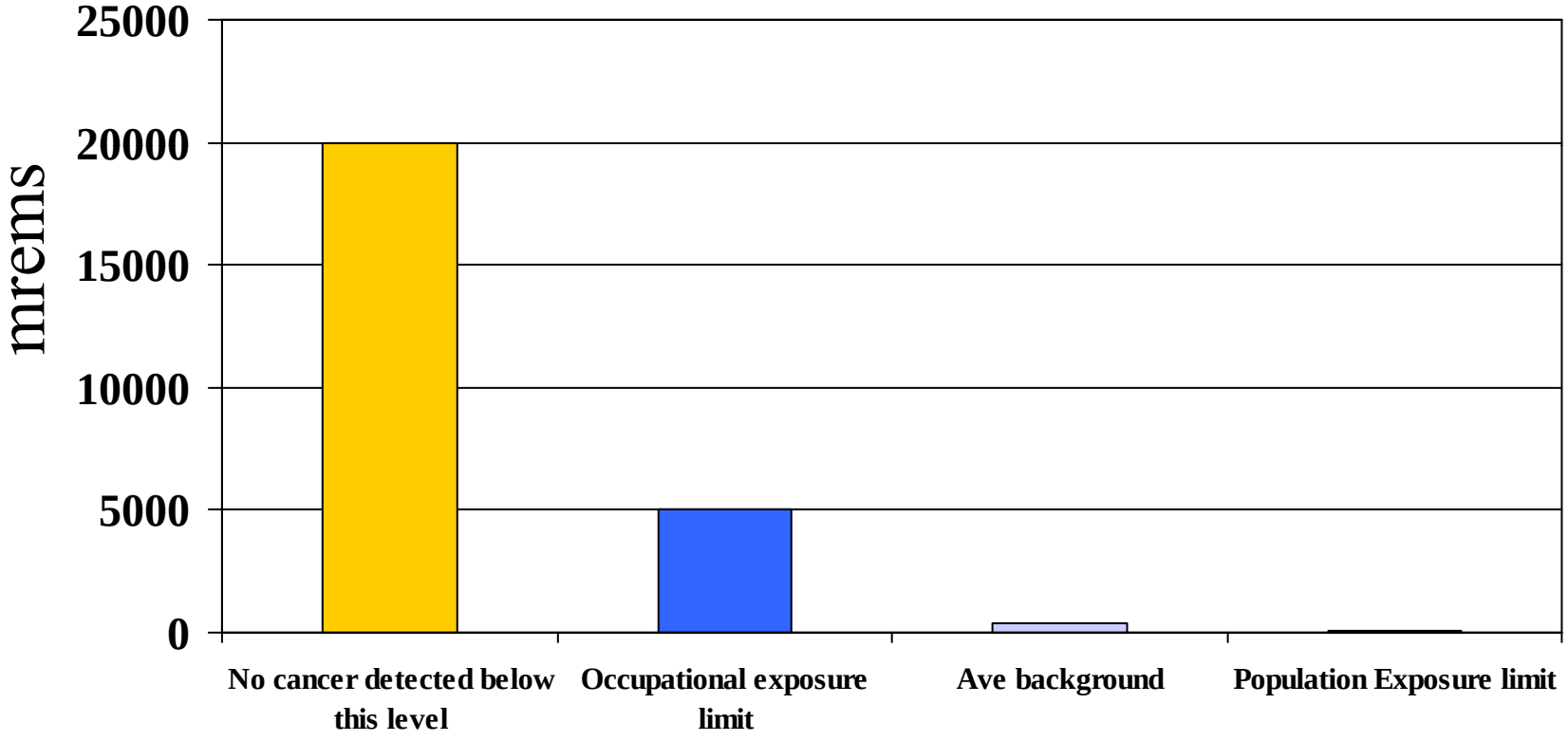
Cancer caused by radiation

- Radiation is a much better cell killer than carcinogen. Very high doses of radiation, such as those used in radiation treatment to destroy cancer cells are very effective.
- High but non-lethal doses of radiation to specific tissues can cause changes which can lead to certain types of cancer.

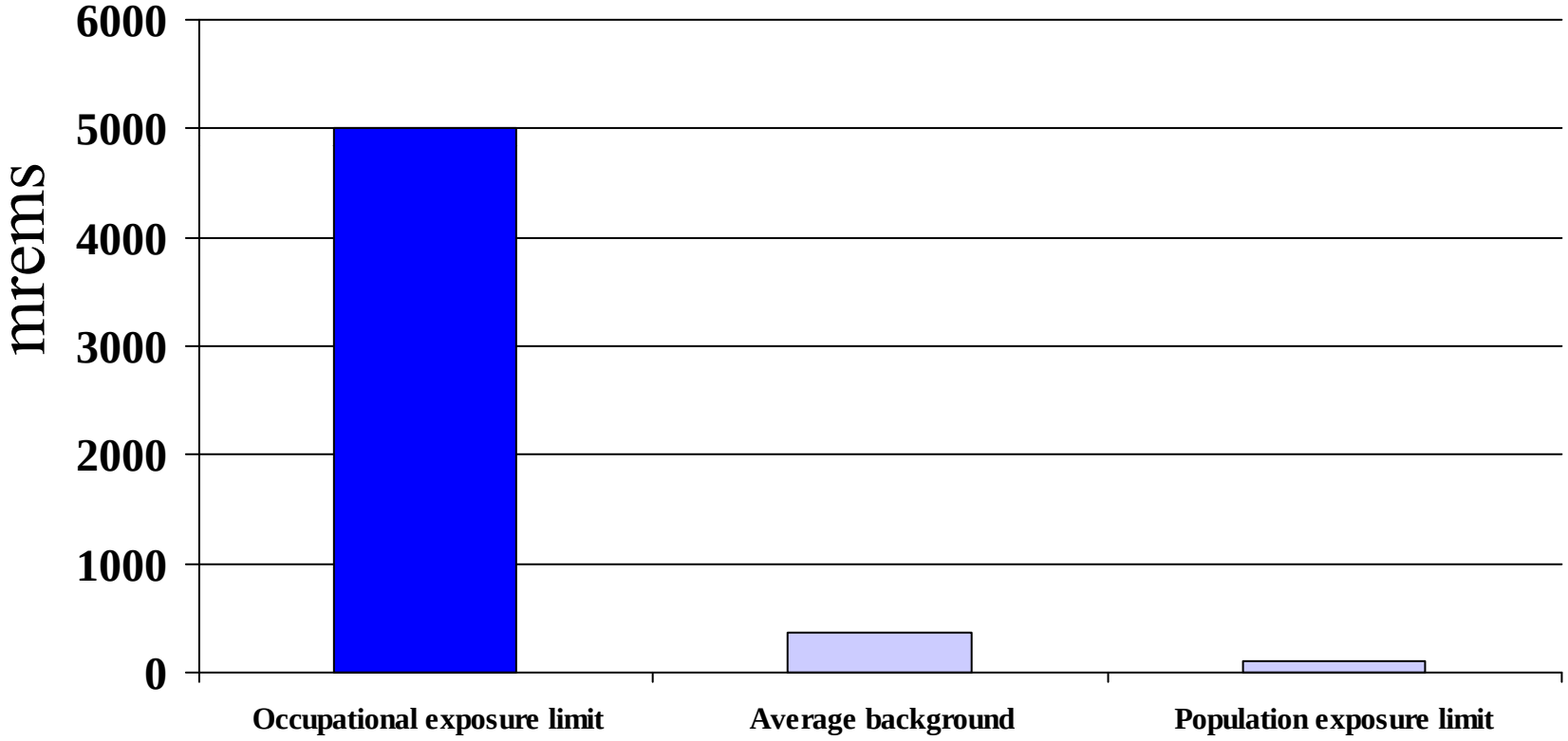
Response to low doses of radiation is different than to high doses

- Cancer has never been seen following low doses of radiation
- High dose studies are used to estimate risks from cancer
- These high dose risks are then extrapolated to estimate risk following low dose

Most exposure to radiation is at very low levels of radiation



Health effects cannot be seen at low levels of radiation



Why is it so difficult to determine if low doses of radiation cause cancer?

- Background radiation is often higher than the level of added radiation exposure.
- There is a high and variable rate of cancer in the human population.
- There is no way to tell a radiation-induced cancer from a spontaneous cancer.

High doses of radiation have been shown to cause many biological responses

- Increased cell proliferation
- Inflammation
- Cell killing
- Apoptosis or programmed cell death
- DNA damage
- Chromosome aberrations
- Mutations
- Genomic instability
- Cell transformation
- Cancer

Low doses of radiation show different biological responses

- Increased activity of repair genes
- Adaptive response
- Cell/cell communication

- ? Genomic instability?
- ? Cell transformation?
- ? Cancer?

Summary

- Both early and late effects and risks from high levels of radiation are well defined and understood.
- The radiation risks associated with exposure to low levels of radiation are difficult to measure and still have major uncertainties associated with them.
- Rapid advances in technology, techniques in cell and molecular biology are now making it possible to detect and understand biological changes after low doses of radiation.