Low Dose Radiation Risk

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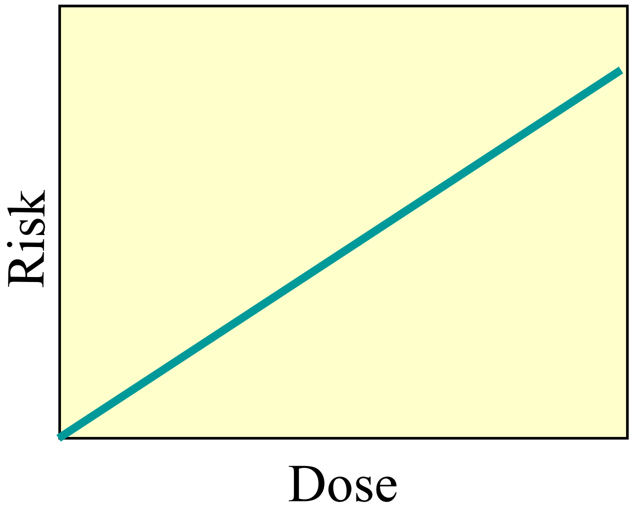
My Background

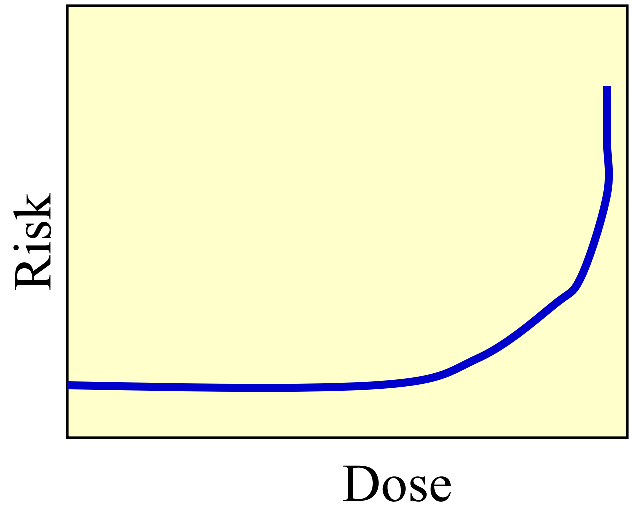
- Early interest in radiation
  (Watching atomic weapons in southern Utah)
- MS in radiation ecology (Chasing fallout)
- PhD in radiation biology in genetics
  (Trying to discover what radiation is actually doing inside people)
- Investment of my life in research on health effects of low doses of radiation

Risk Models

Linear No Threshold



Non-Linear Threshold

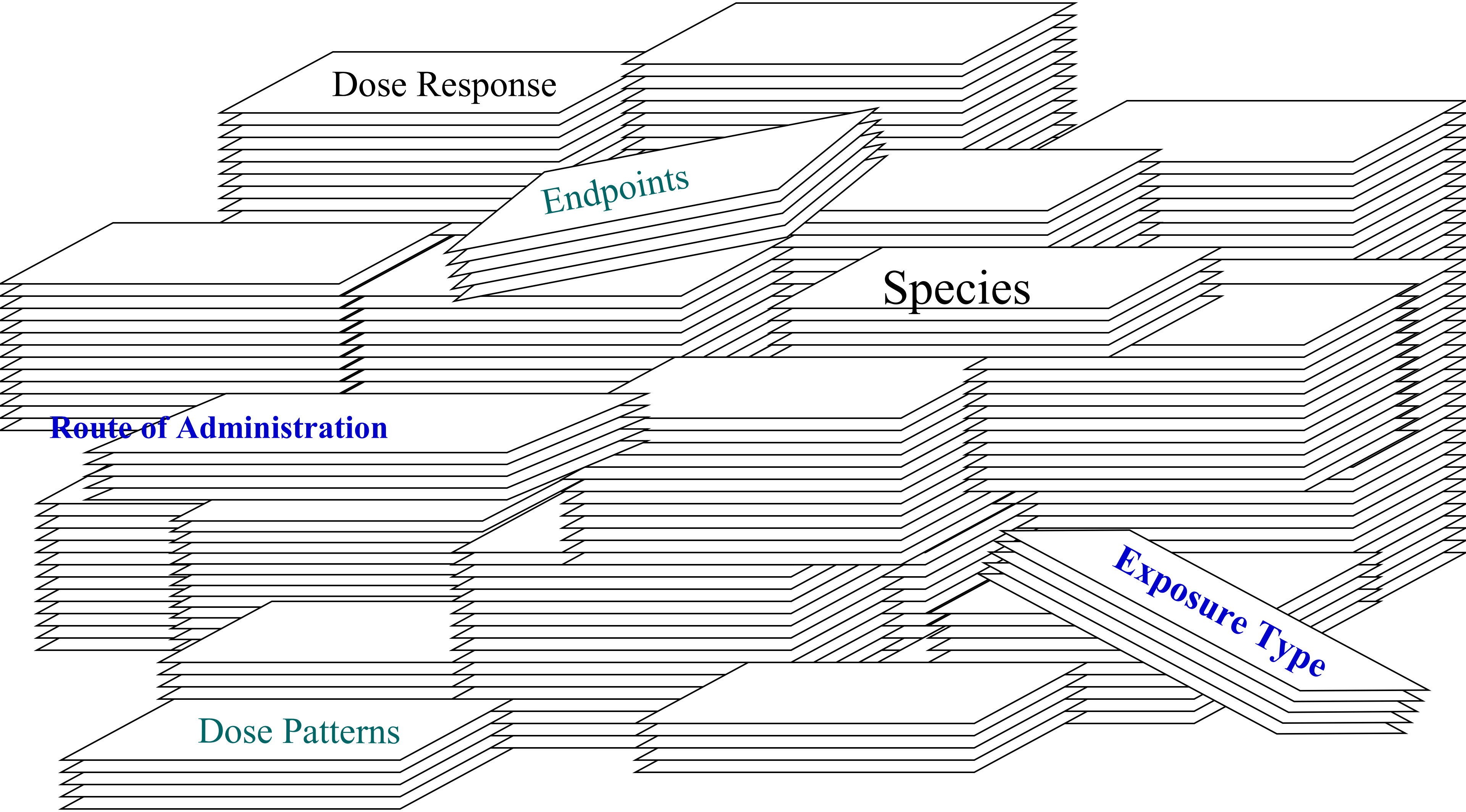


Is risk always proportional to dose?

Can any amount dose increase risk?

Can a single radioactive ionization can cause cancer?

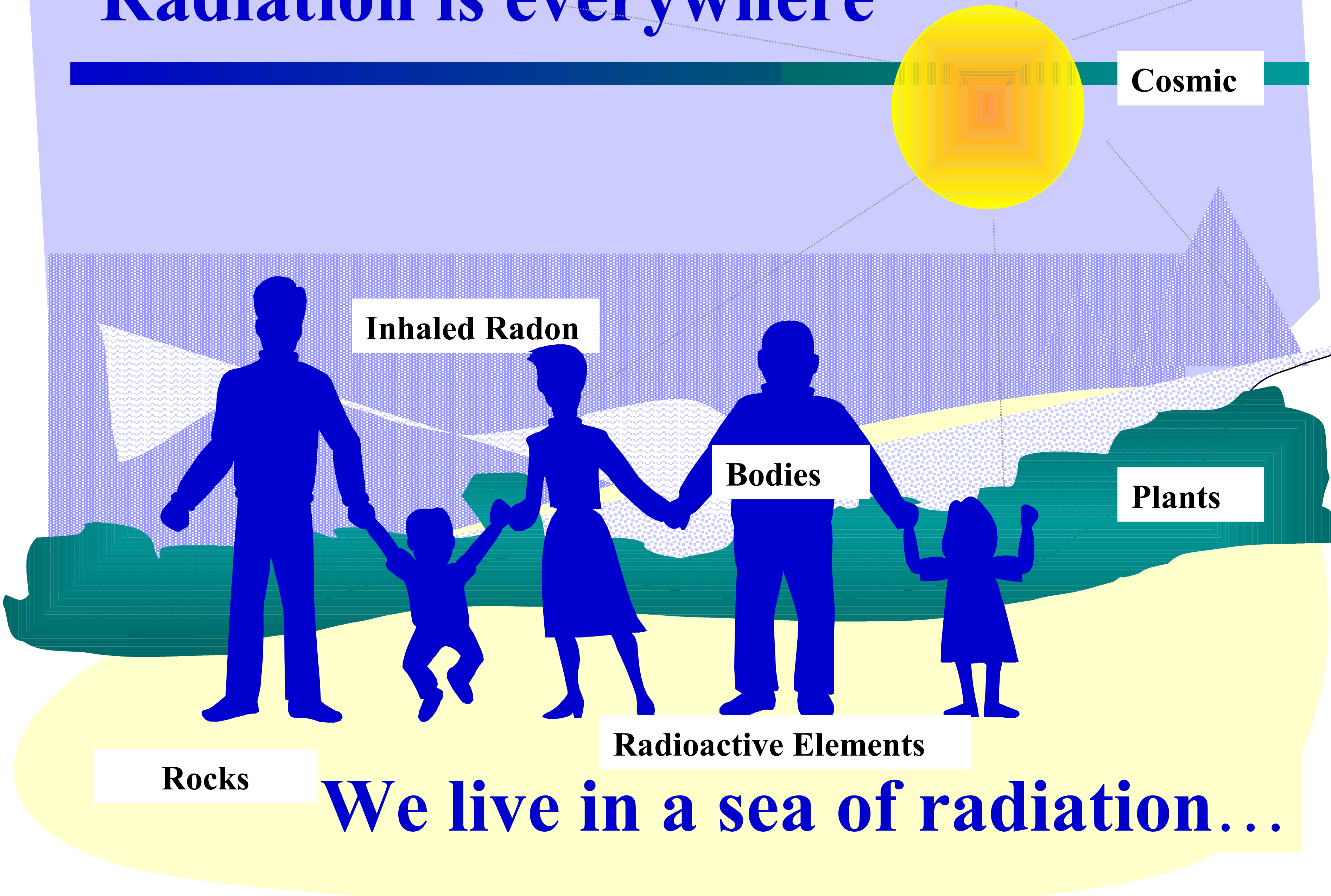
Learn from the Past



Background Radiation and Background Cancer

Background Radiation

Radiation is everywhere



We live in a sea of radiation…

BACKGROUND RADIATION

The average background radiation per person is **370 millirems** (mrem) per year. This varies widely depending on where someone lives, and their occupation, health and lifestyle.

Background Radiation

Most background radiation is natural.

It is part of nature.

It has always been here.

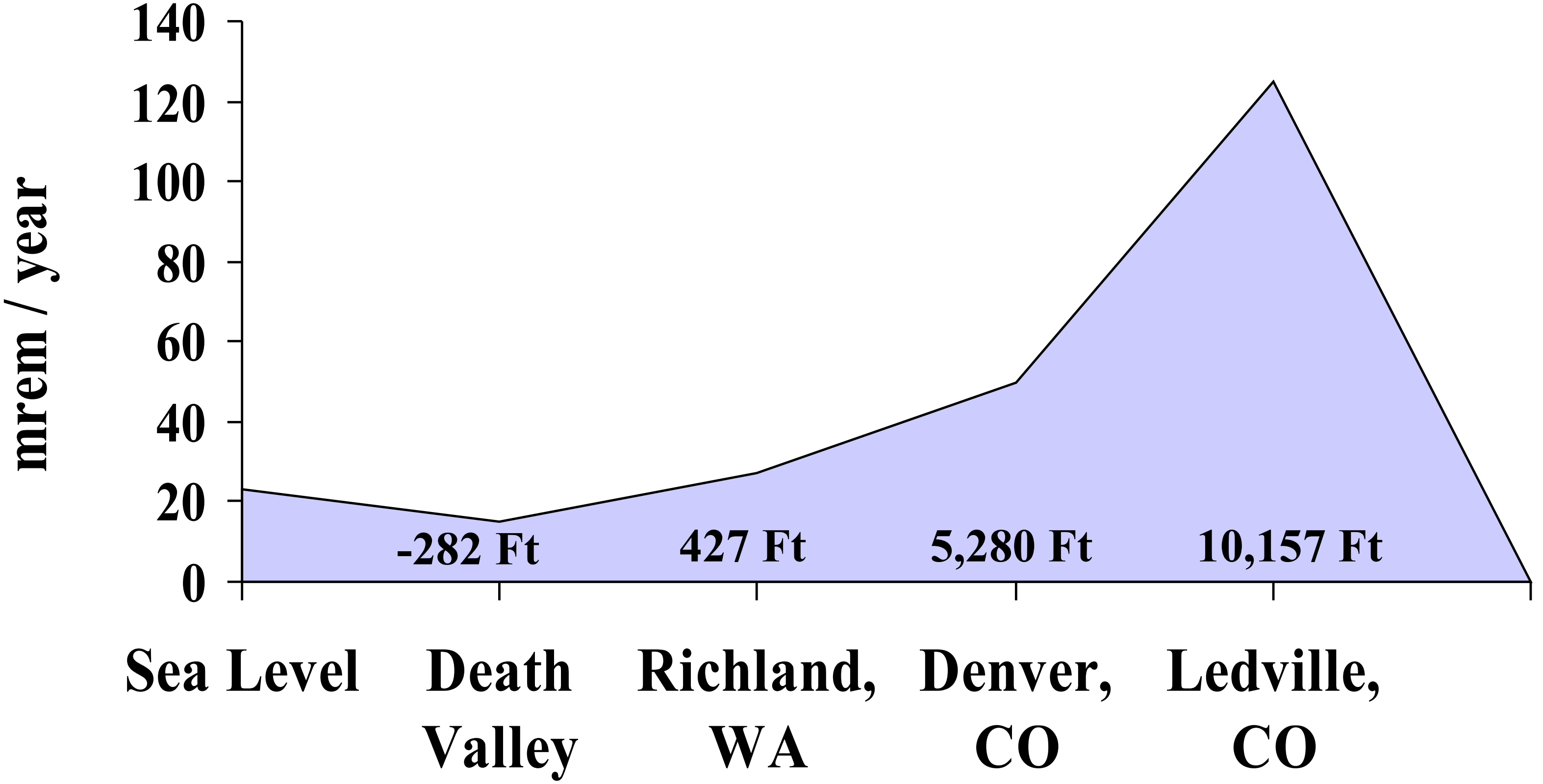
People have always lived with it.

Radiation comes from space- sun and cosmic rays

Because this type of radiation is somewhat shielded by the atmosphere, the dose is higher at higher altitudes.

Space and airline travel has higher radiation doses.

Background Radiation Exposure at Different Elevations



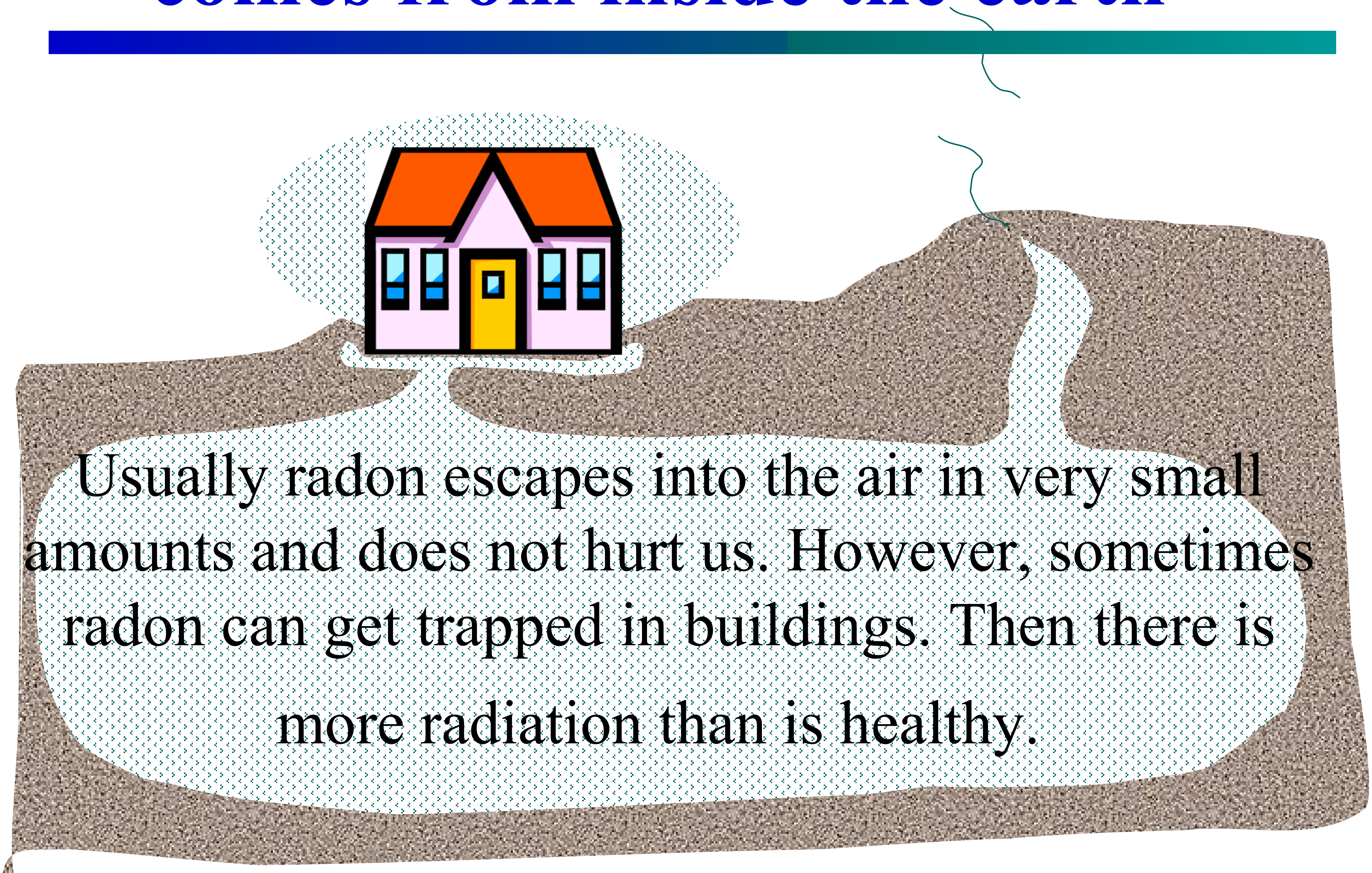
Every 200 feet increase in altitude increases dose 1 mrem/year

Radiation comes from the earth

Some rocks, like Uranium are radioactive. So are coal and some building materials such as granite.

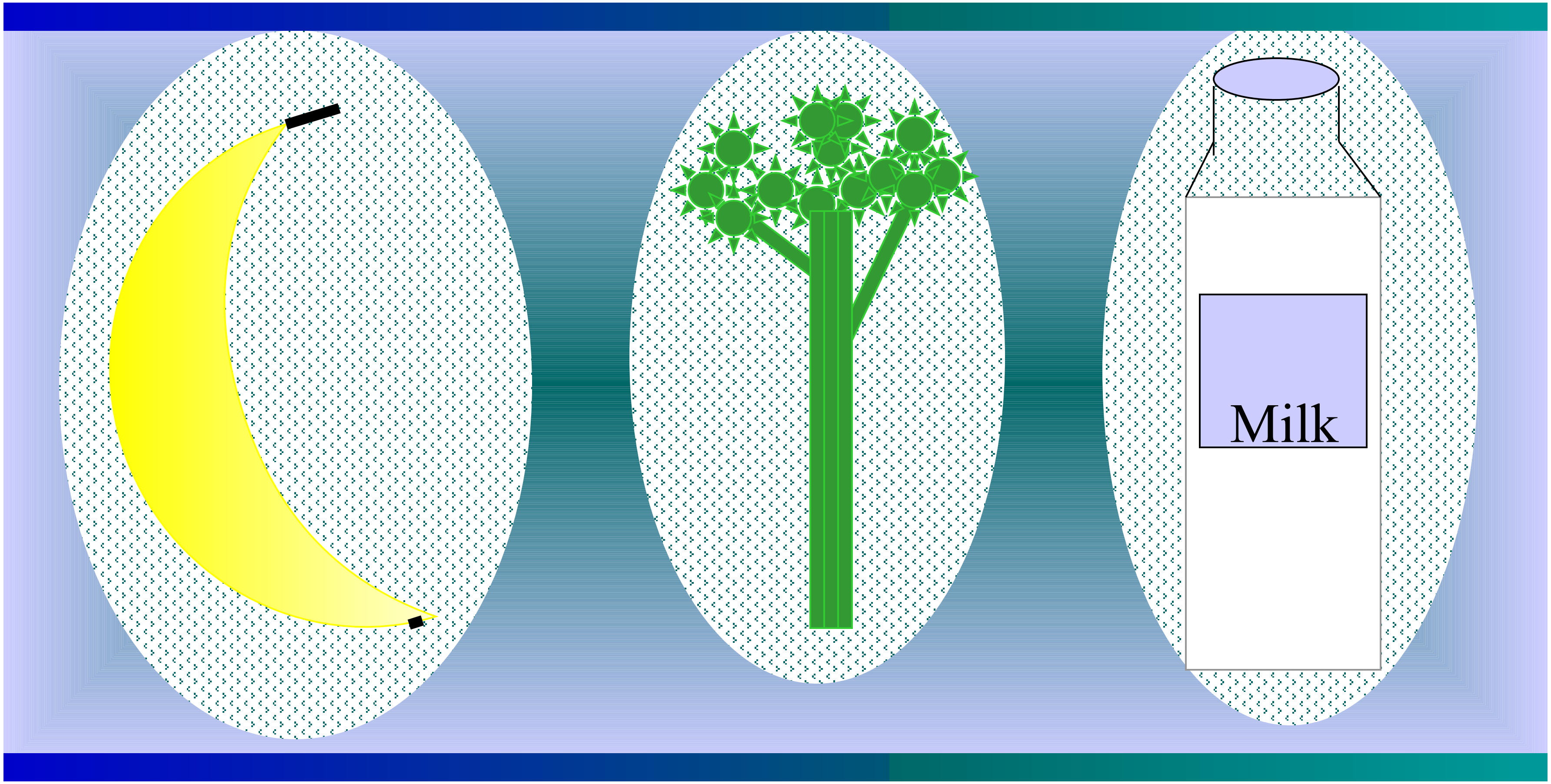
The natural radiation from the granite in Grand Central Station is higher than is allowed to certify a nuclear power plant.

Radon is a radioactive gas that comes from inside the earth



Usually radon escapes into the air in very small amounts and does not hurt us. However, sometimes radon can get trapped in buildings. Then there is more radiation than is healthy.

Cells in our body contain radioactive elements, such as Potassium, which come from the food we eat



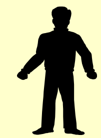
Background Radiation

- Are low levels of radiation an essential part of life?
- The body does not distinguish between natural and man-made.
- Neither natural nor man-made background radiation have been shown to be harmful.
- The body has developed repair mechanisms to deal with negative effects of high levels of radiation.

Normal annual exposure from natural radiation

About 300 mrem/yr


- Radon gas 200 mrem
- Human body 40 mrem
- Rocks, soil 28 mrem
- Cosmic rays 27 mrem




Normal annual exposure from man-made radiation

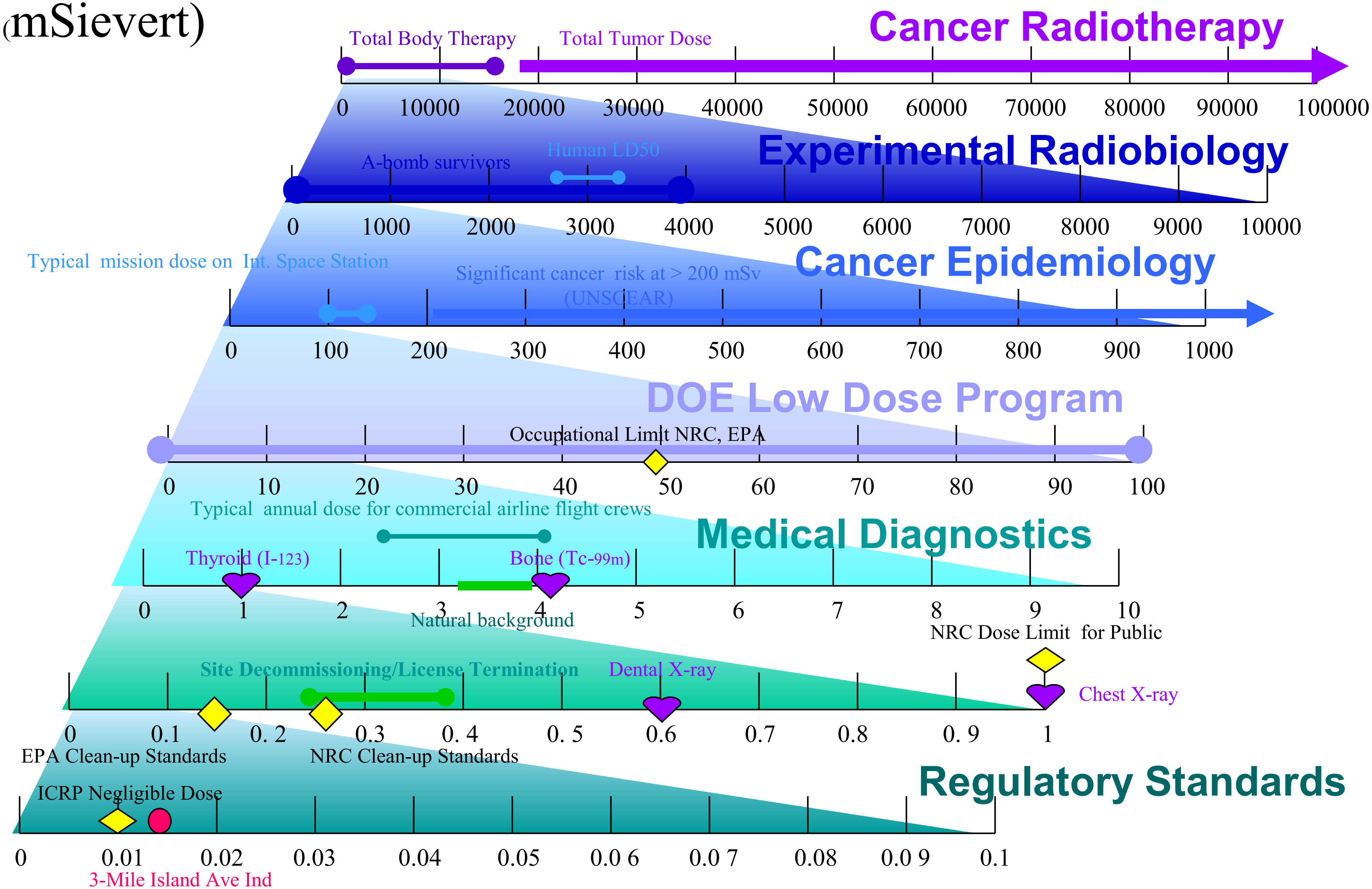
About 70 mrem/yr

- Medical procedures 53 mrems
- Consumer products 10 mrems
- One coast to coast airplane flight 2 mrems
- Watching color TV 1 mrem
- Sleeping with another person 1 mrem
- Weapons test fallout less that 1 mrem
- Nuclear industry less than 1 mrem

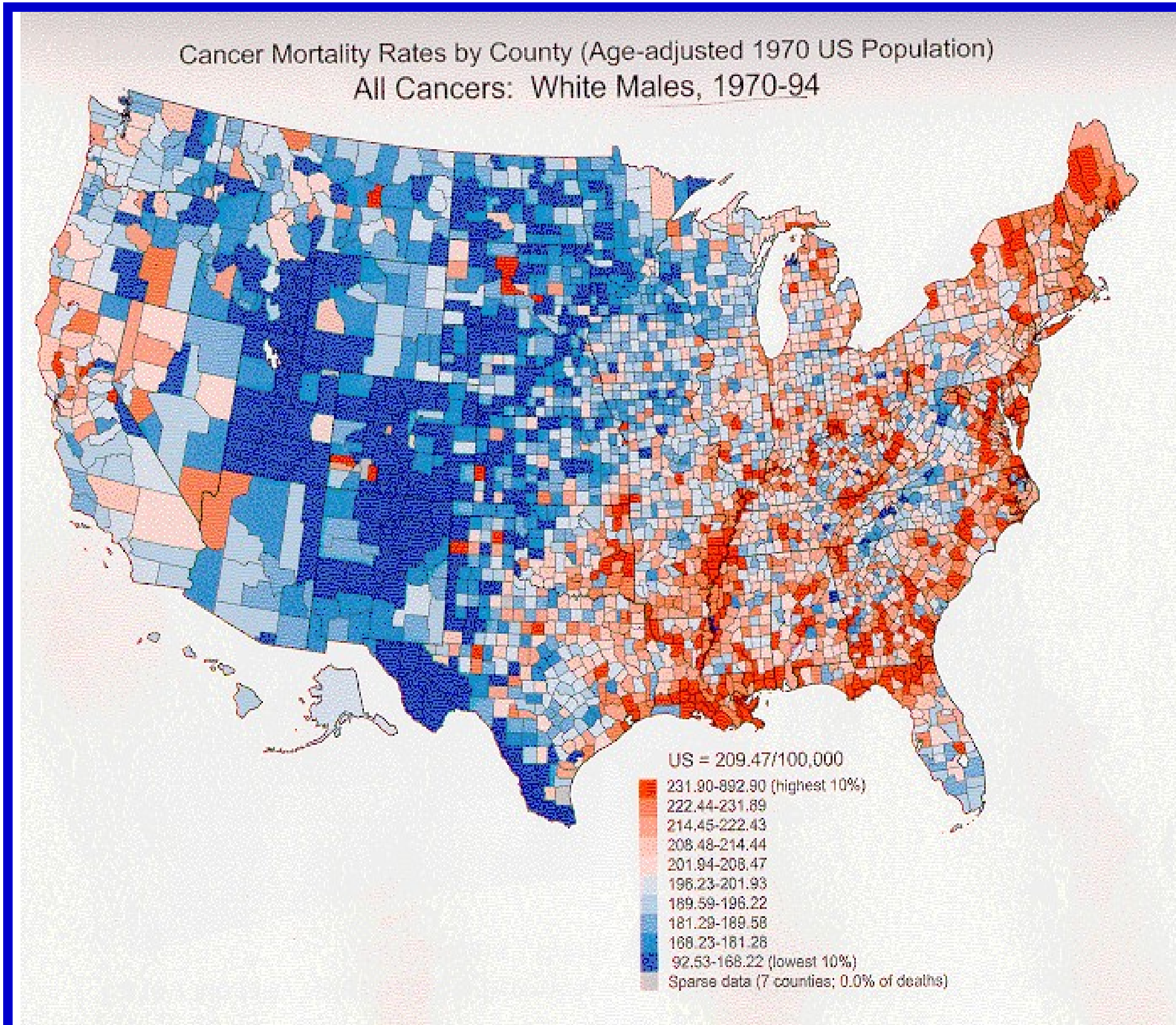



Dose Ranges

(mSievert)

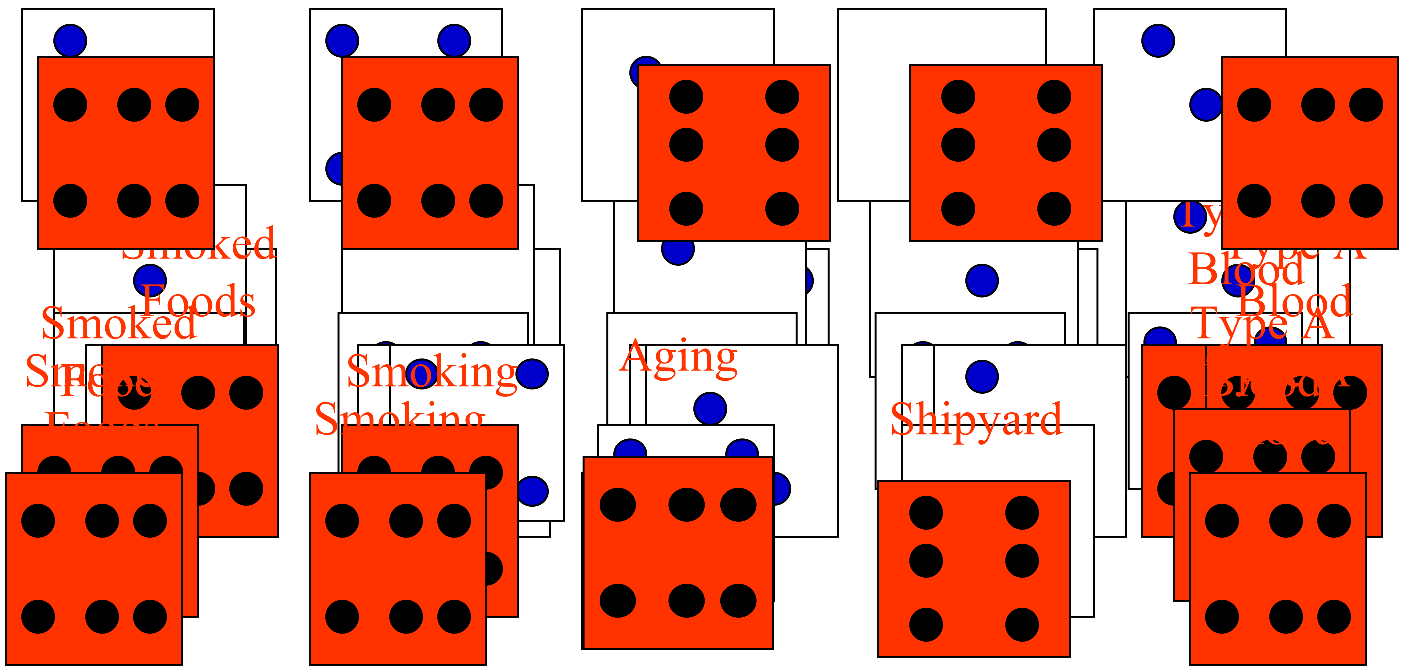


Background
Cancer


Cancer Mortality Rates by County (Age-adjusted 1970 US Population)
All Cancers: White Males, 1970-94
US = 209.47/100,000
231.90-892.90 (highest 10%)
222.44-231.89
214.45-222.43
208.48-214.44
201.94-208.47
196.23-201.93
189.59-196.22
181.29-189.58
168.23-181.28
92.53-168.22 (lowest 10%)
Sparse data (7 counties; 0.0% of deaths)

Stomach Cancer Risk

Multiple factors impact cancer



Effects of Atomic Bomb

- Killed outright by the bomb or acute radiation effects. — 100,000 people
- Survived for lifespan study — 86,572 people

Atomic Bomb Survivor Excess Cancer

Population of Survivors Studied **86,572**

Total Cancers observed after the Bomb	8,180
Total Cancers Expected without Bomb	7,743
Total Cancer Excess	**437**

Excess Tumor		Excess Leukemia		
334	+	104	=	437

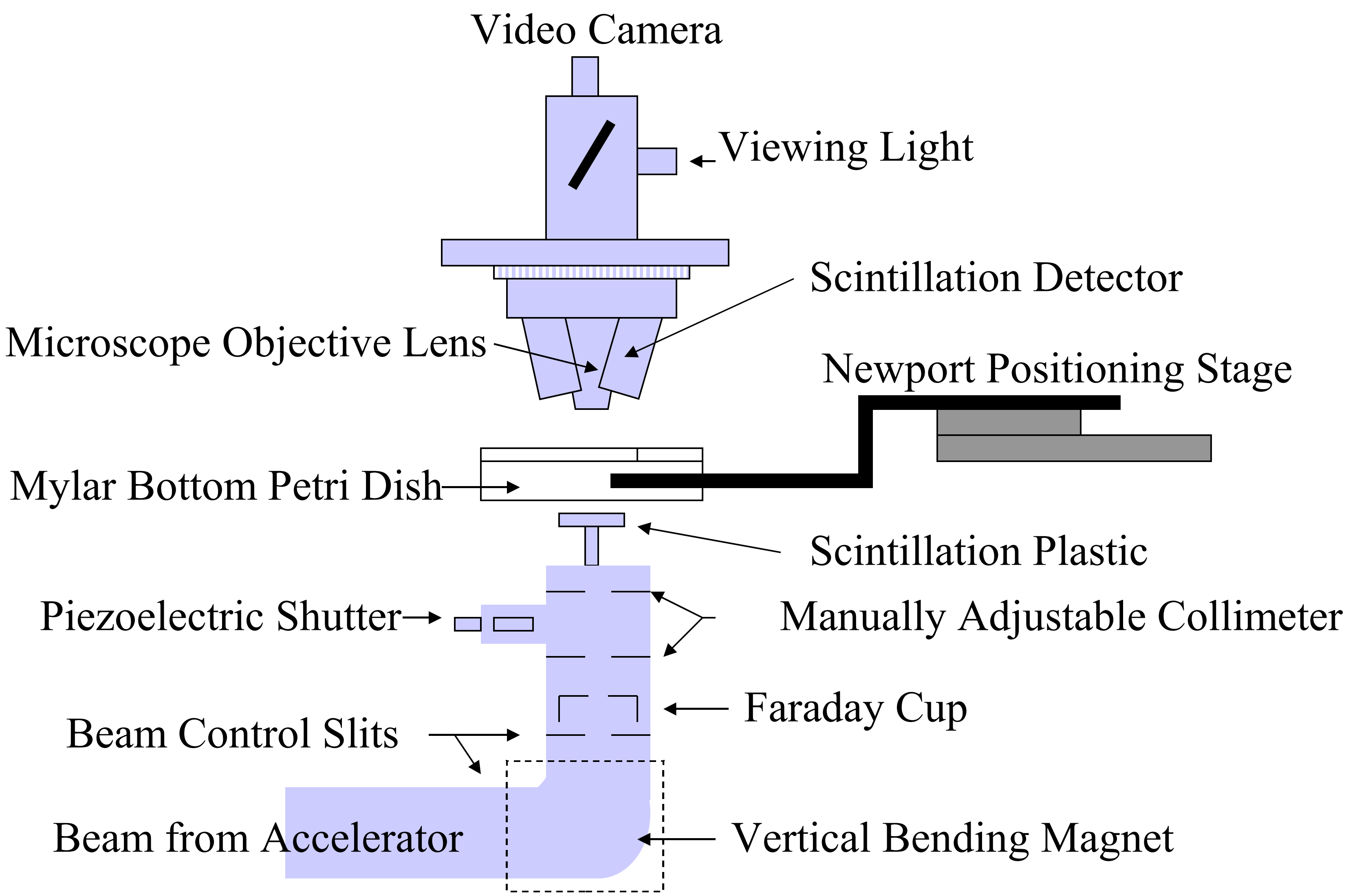
Why now?

- Standards have been set from high dose effects, but low dose effects have not been measurable until now
- New technological developments and biological discoveries have made it possible to study low dose effects

Key Research Areas

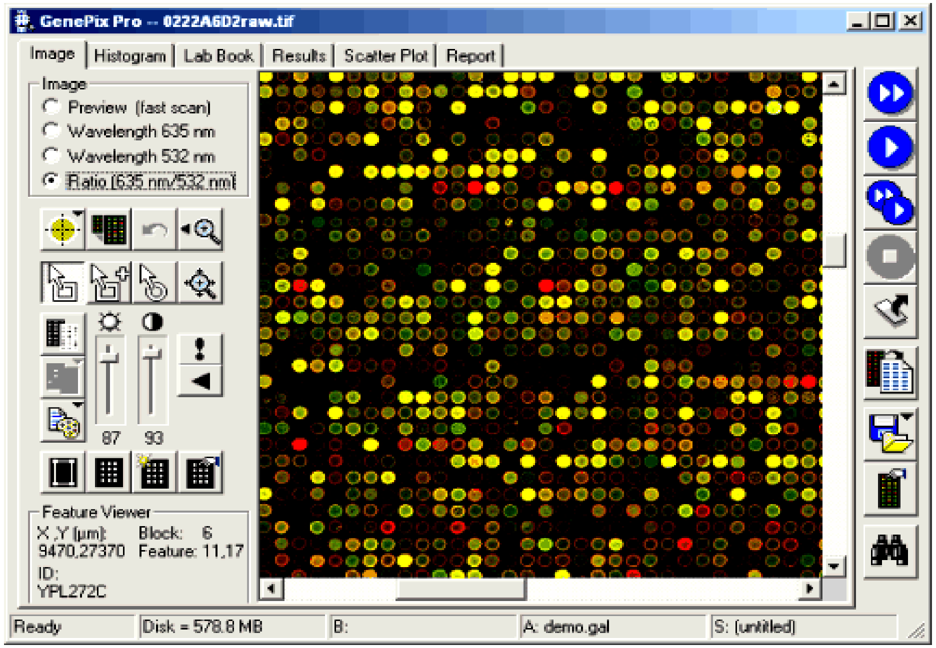
- Technological Advances
- Biological Advances

Alpha-Particle Radiation System



Texas A&M

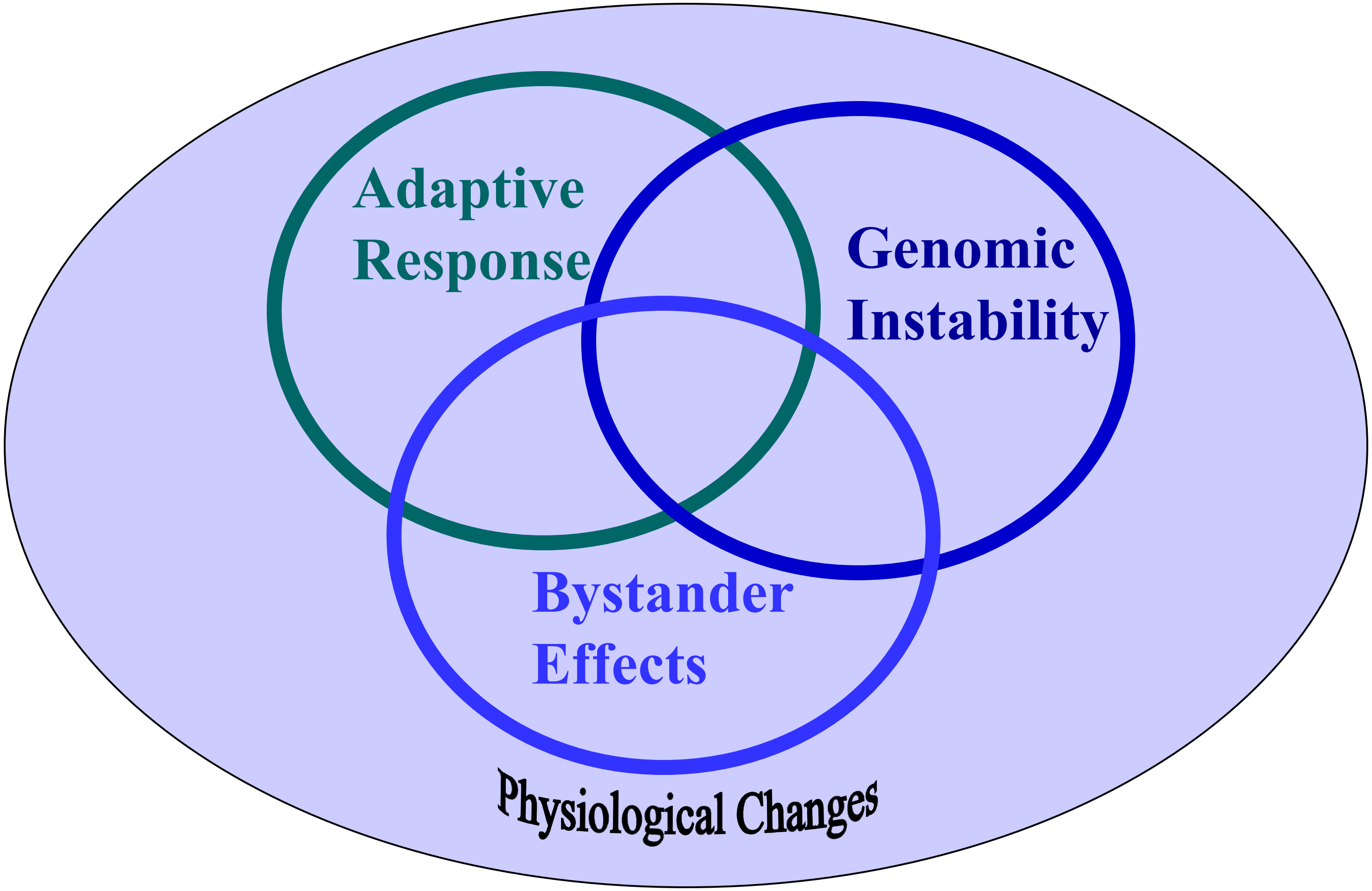
GenePix: scanner by Axon



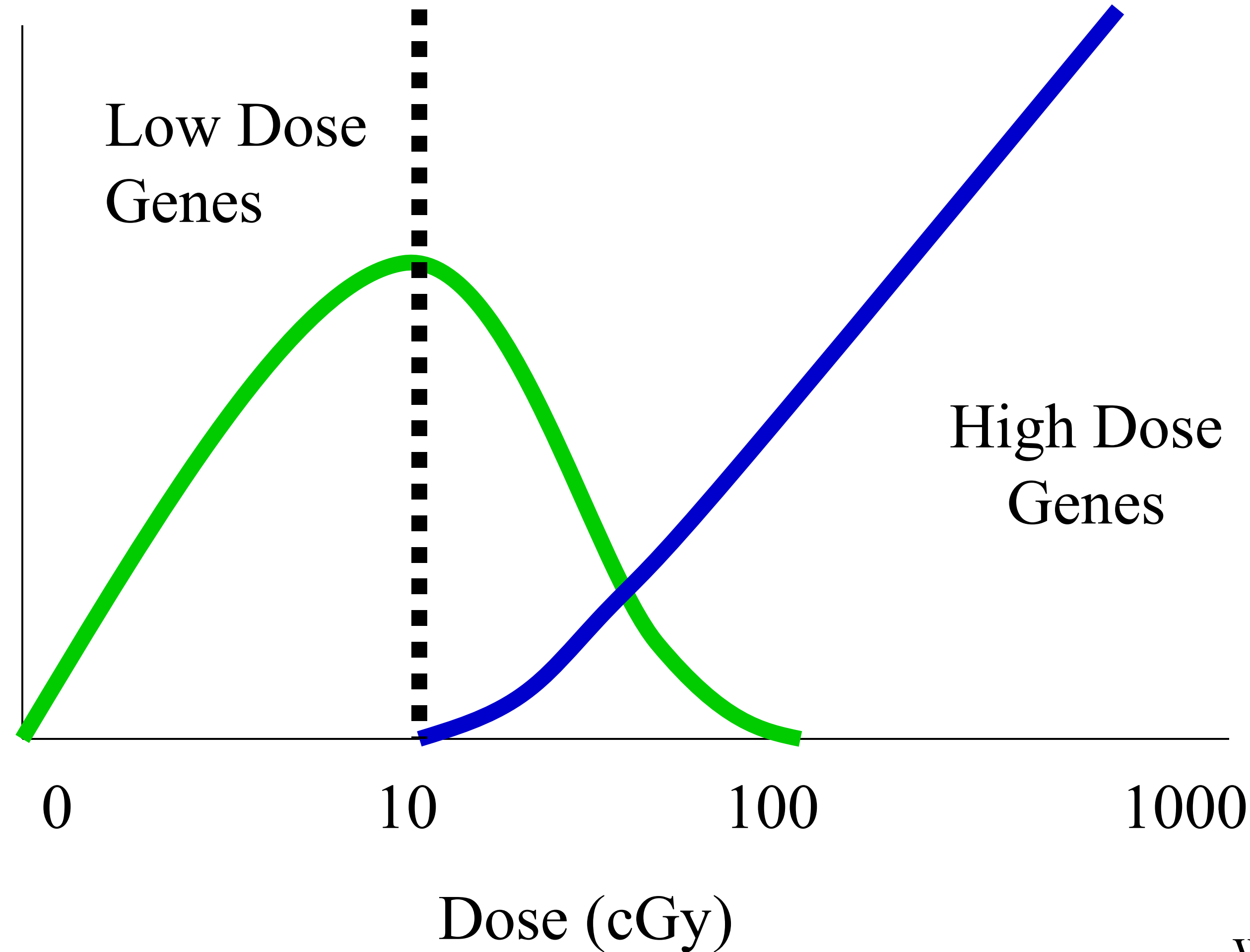
2 color laser
Confocal imaging

LLNL

Relationship between biological responses to radiation



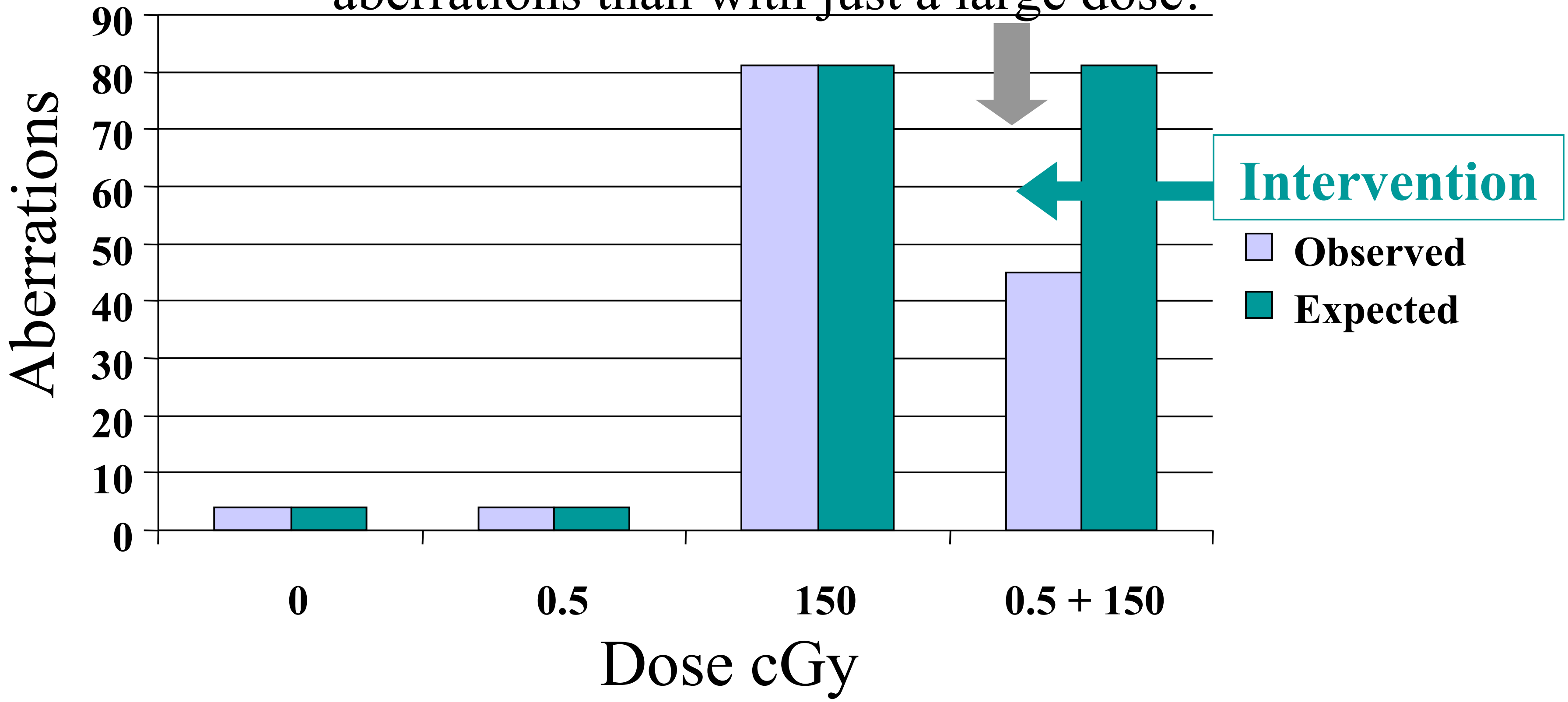
Radiation-induced changes in gene expression



Wyrobek

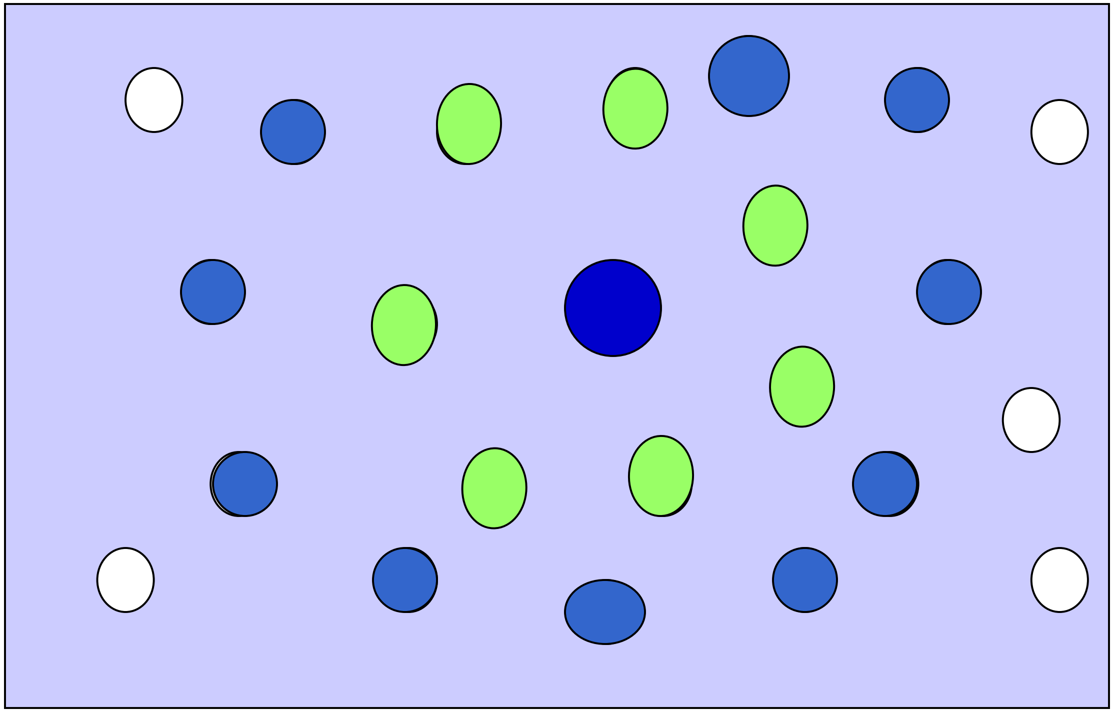
Adaptive Response

When a small dose of radiation is given before a larger one, it would be expected there would be more chromosome aberrations than when just the large dose was given. But that is not what happens. With a small "tickle" dose before the larger dose, there were only about half as many aberrations than with just a large dose!

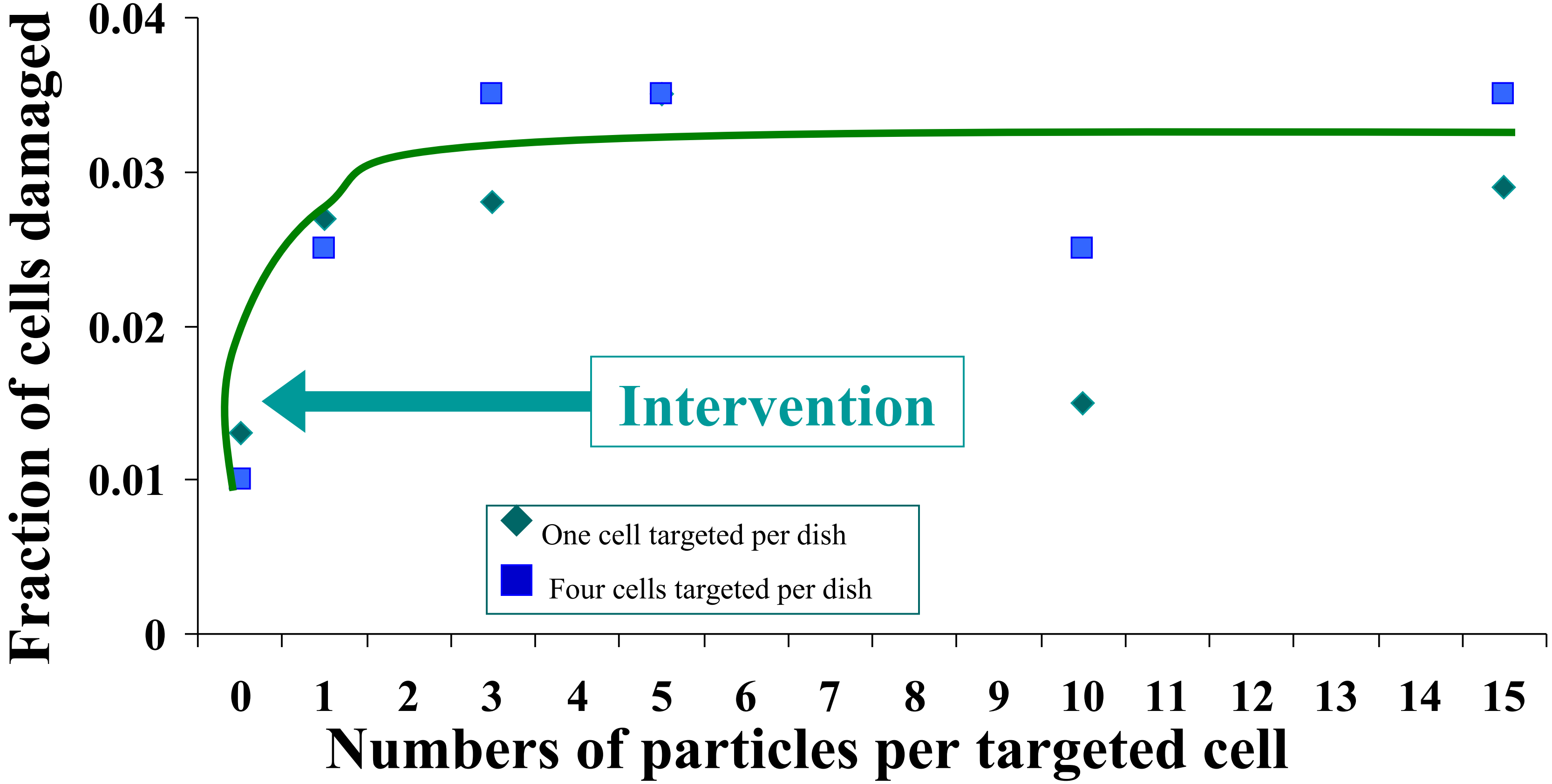


Shadley and Wolff 1987

Bystander Effects



Bystander Effect
All-or-none dose response

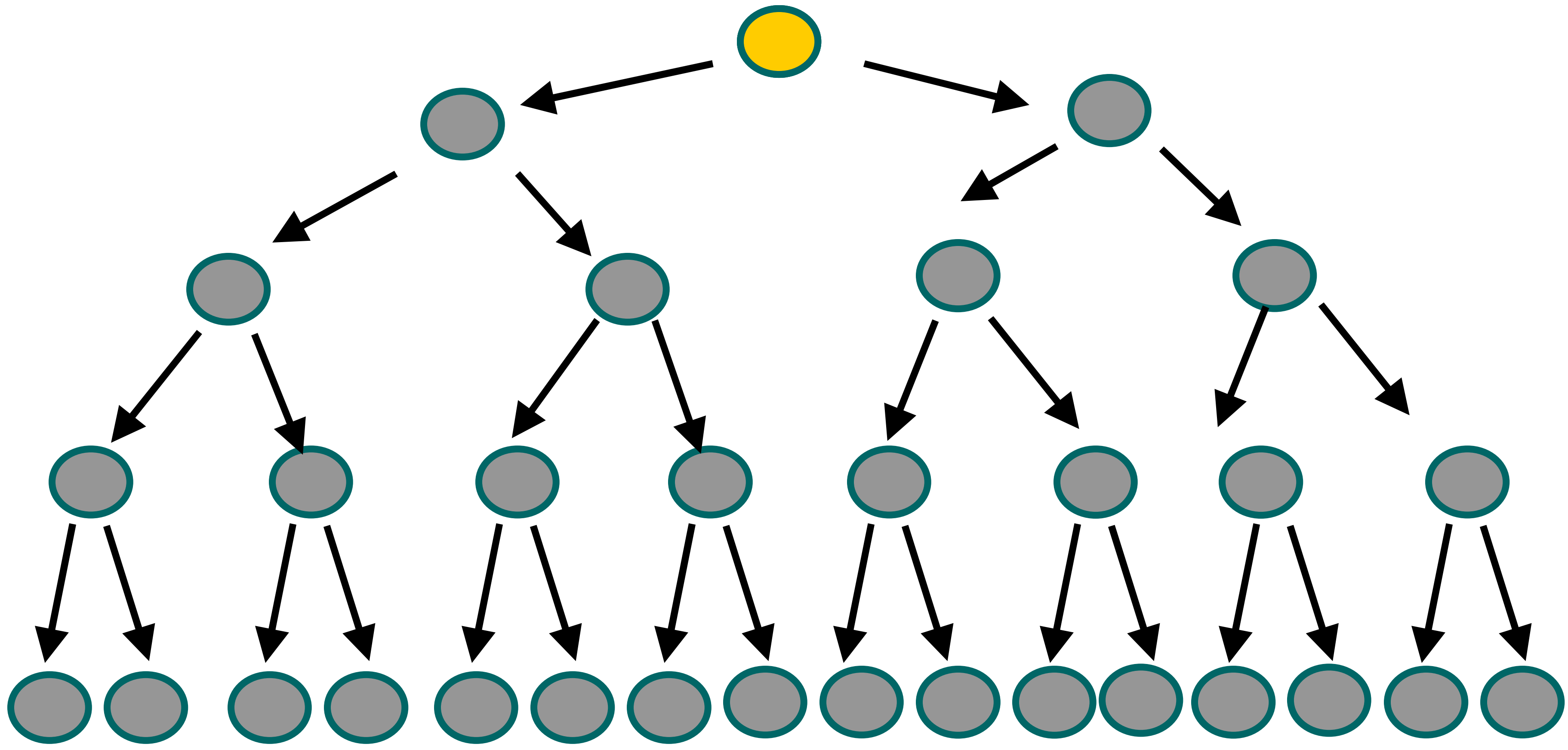


Belyakov et al. 2001

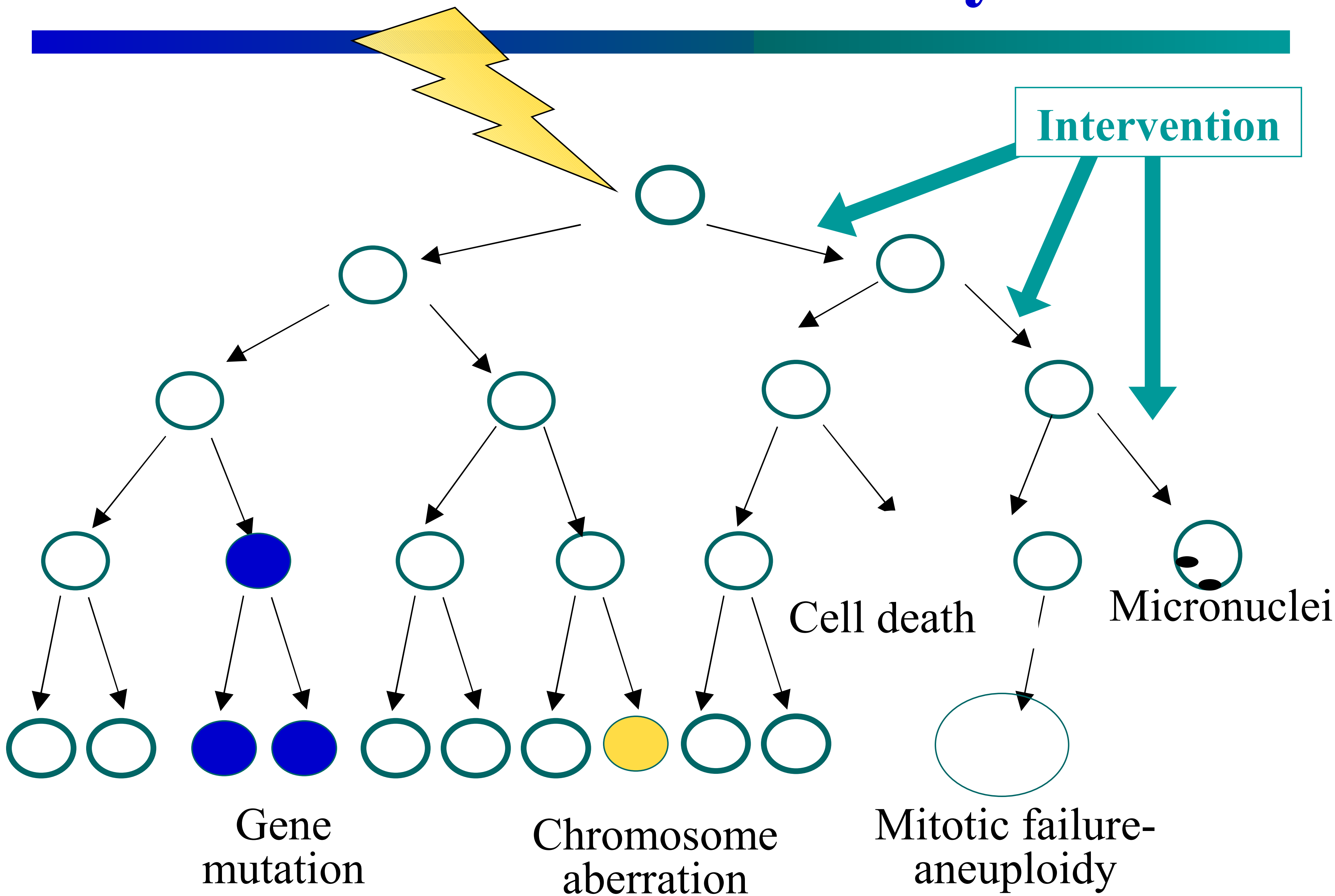
Radiation-induced Genetic Damage

Old Paradigm

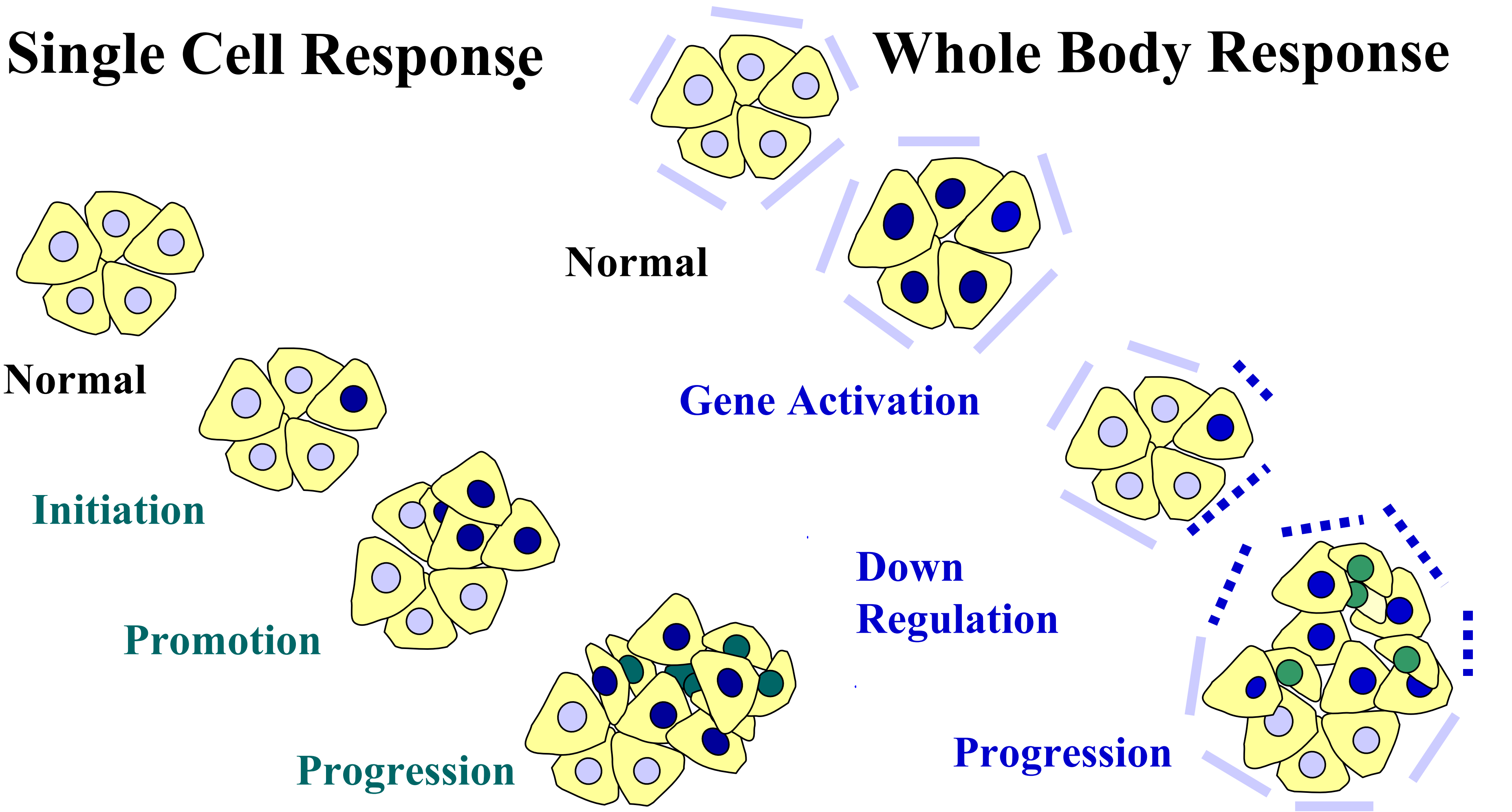
After a cell is damaged by radiation, all of its progeny are damaged



Genomic Instability



Gene Mutation and Expression in Cancer



Gene Mutation- a rare event

Gene Expression- a common event

There is a need for a change in interpreting radiation biology

- Adaptive response and protective effects vs detrimental effects
- Hit theory vs. bystander effects
- Mutation vs. gene induction
- Single cell vs tissue responses

What have we learned?

- High doses of radiation can produce cancer
- Radiation is a good cell killer
- Radiation is a poor mutagen/carcinogen
- Low doses of radiation produce different cell and molecular responses than high doses (Protective vs harmful?)
- Linear extrapolation of risk is conservative