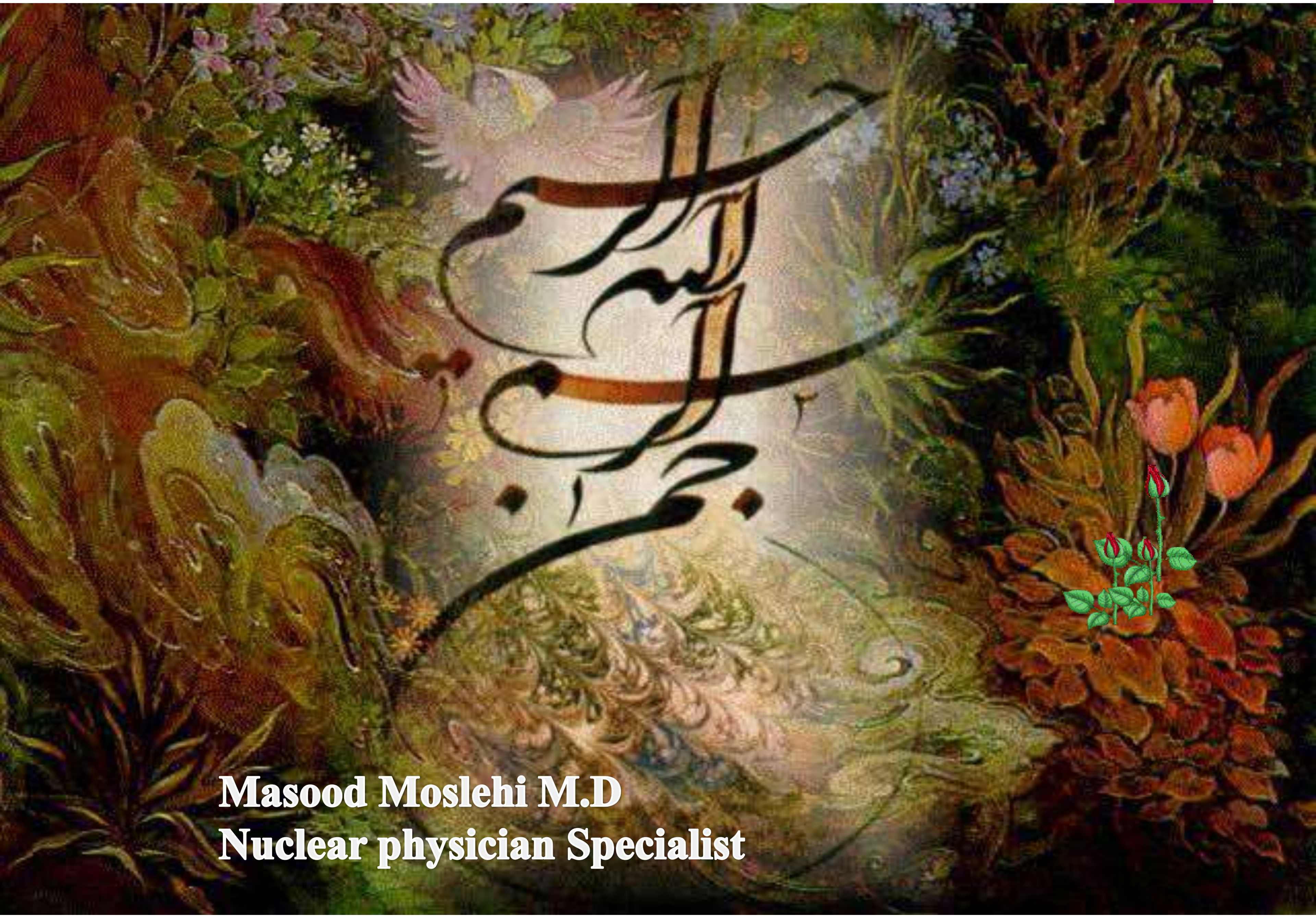

Masood Moslehi M.D
Nuclear physician Specialist

Iodine thyroid blocking

Guidelines for use in planning for and responding to radiological and nuclear emergencies

World Health Organization 2017

Introduction

- During a nuclear accident, radioactive iodine may be released in a plume, or cloud, contaminating the environment (i.e. air, water, soil, surfaces, plants, etc.) and settling on skin and clothing, resulting in external radiation exposure.

- Inhalation of contaminated air and ingestion of contaminated food and drinking water may lead to internal radiation exposure and uptake of radioactive iodine mainly by the thyroid.

- Absorption through the skin is a possible route but negligible.

Introduction

- If radioactive iodine is inhaled or ingested, it will be absorbed by the thyroid gland.
- Studies of atomic bomb survivors indicate that thyroid tumors may develop following external exposure to ionizing radiation.
- The Chernobyl nuclear reactor accident in 1986 caused a large release of iodine-131 (I-131) and short-lived radioactive iodine into the environment. Higher rates of thyroid cancer were observed in individuals living in contaminated areas of Belarus, Ukraine and the western part of the Russian Federation.
- This increase in thyroid cancer incidence was linked to the internal exposure to radioactive iodine .

Introduction

Children and adolescents are at higher risk of developing radiation-induced thyroid cancer compared to adults.

- Higher uptake rate of radioiodine during the development of the thyroid gland in childhood and adolescence, and a higher tissue dose due to the small size of the thyroid gland in children.

- Younger children have different food intake than adults. For example, after the Chernobyl accident, milk was one of the main sources of exposure to radioiodine and its access was not immediately restricted. Since children tend to consume more milk than adults, this led to children being disproportionately affected.

Introduction

- Prenatal exposure to I-131 may also increase the risk of thyroid cancer .

- Potential transfer of I-131 from mothers to infants during breastfeeding has also been investigated as a risk factor. The younger the individual is at the time of exposure, the higher the risk of developing thyroid cancer.

- Iodine deficiency was associated with an increased risk of radiation-induced thyroid cancer in populations affected by the Chernobyl accident.

ITB (Iodine thyroid blocking)

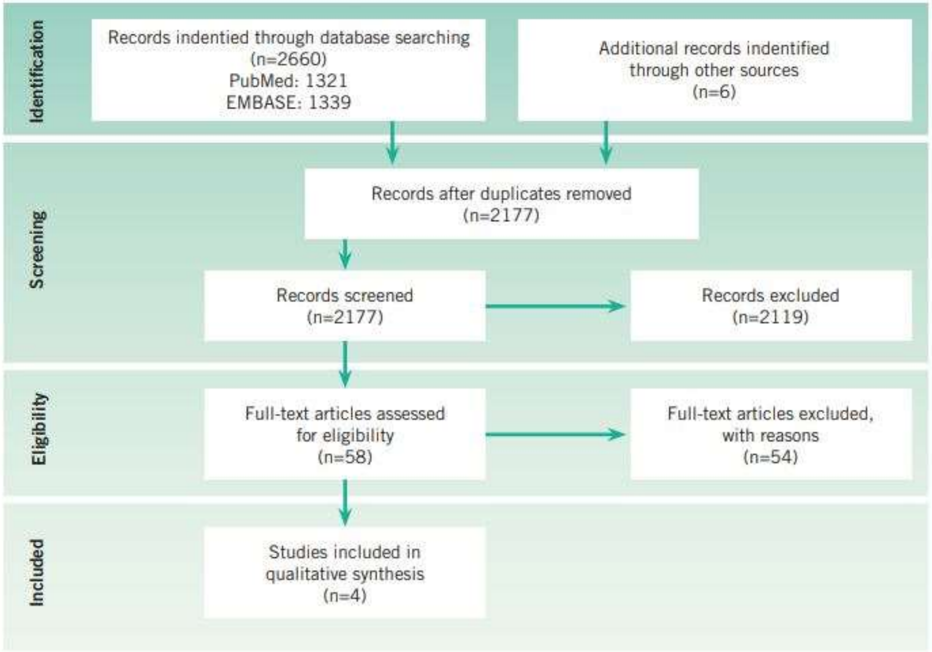
- Oral administration of stable iodine is considered an appropriate strategy for avoiding the risk of thyroid cancer in people exposed to an accidental release of radioactive iodine.

- If taken before, or at the onset of exposure to radioactive iodine, stable iodine blocks the uptake of radioactive iodine by saturating the thyroid gland with stable iodine, thus effectively reducing internal exposure of the thyroid.

- The use of iodine thyroid blocking (ITB) as an urgent protective action following the release of radioiodine.

- The 2015 IAEA report on Fukushima states that, “Administration of stable iodine for iodine thyroid blocking was not implemented uniformly, primarily due to the lack of detailed arrangements highlighting the need for additional guidance on ITB implementation.

Figure 1. Search strategy PRISMA flowchart



Thyroid Cancer

- The systematic review found evidence that use of stable iodine administration after a nuclear accident reduced the risk of thyroid cancer in children.

- However, most of the identified studies were not specifically designed to address the protective effect of stable iodine or the timing of the administration, and the effects of the methods of stable iodine administration and the dosage applied were not described. Therefore, the overall evidence was assessed as of either low or very low quality .

RCT?

- Randomized clinical trials (RCT) on the efficiency (with respect to prevention of thyroid cancer) and side effects of ITB in the case of a nuclear emergency are not feasible.
- This leads to a low or very low quality of evidence according to the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) system.

Hypothyroidism and benign thyroid nodules

- None of the studies investigated the effects of stable iodine administration on hypothyroidism and benign thyroid nodules

Recommendation and public health recommendations

Recommendation
During a radiological or nuclear emergency, provision of iodine thyroid blocking (ITB) to people who are at risk of being exposed to radioiodine should be implemented as an urgent protective action, within the frame of a justified and optimized protection strategy.
Quality of evidence: very low *Strength of the recommendation:* conditional

ITB

- The effectiveness of stable iodine in blocking thyroid uptake of radioactive iodine has been firmly established in studies.

- Benefits of the intervention outweigh the disadvantages and costs.

- The use of ITB, if carefully planned and administered properly, has a low potential to cause harm.

ITB (false reassurance)

- ITB should not be considered a stand-alone protective action.
- A comprehensive public protection strategy covering all urgent and early protective actions, as well as other response actions, including evacuation and sheltering, restriction on consuming contaminated food, milk and drinking water.

IBT Time

- ITB is a protective action that is implemented only in the urgent phase (hours to one day after the onset of the emergency).

- Regarding the early phase (days to weeks) the effective way to limit the ingestion of radioiodine (as shown by the experience of Fukushima) and the most important method of limiting thyroid doses, especially to children, is to restrict the consumption of contaminated food, drinking water and fresh milk.

Chemical form, storage, and packaging

- The agent most commonly used for protecting the thyroid from radioactive iodine is potassium iodide (KI).
- (KIO_3).
- If storage conditions are adequate, tablets packed in a hermetic packaging and kept in a dry and cool place fully preserve their iodine content for five years.
- After five years, the iodine content may be checked and the shelf life extended, if needed.

Chemical form, storage, and packaging

- The shelf life is much more limited if stable iodine is in powder form or an aqueous solution.
- Stable iodine can be given in either double scored tablet or liquid form.
- Tablets have the advantage of easy storage and distribution, including pre-distribution, less gastrointestinal irritation, crushed and mixed with fruit juice, jam, milk or similar substance,

Dosage

- Dosage information has remained unchanged since it was published in the 1999 WHO guidelines.

Table 2. Recommended single dosage of stable iodine according to age group (*6*)

Age group	Mass of iodine, mg	Mass of KI, mg	Mass of KIO_3, mg	Fraction of a tablet containing 100 mg of iodine	Fraction of a tablet containing 50 mg of iodine
Neonates (birth to 1 month)	12.5	16	21	1/8	1/4
Infants (1 month to 3 years)	25	32	42	1/4	1/2
Children (3 to 12 years)	50	65	85	1/2	1
Adults and adolescents (over 12 years)	100	130	170	1	2

Adverse effects of stable iodine

- Adverse reactions to stable iodine are rare and include iodine-induced transient hyper or hypothyroidism, and allergic reactions .
- Reported severe clinically relevant reactions include: sialadenitis gastrointestinal disturbances and minor rashes.
- There are some rare but clinically relevant reactions, e.g. in patients with dermatitis herpetiformis or hypocomplementemic vasculitis.
- Risk groups for such reactions include those with pre-existing thyroid disorders and iodine hypersensitivity

- In case of hypersensitivity to iodine, use of potassium perchlorate can be considered to supress iodine uptake by the thyroid gland during the time of potential exposure .

- The use of additives, such as colorants, should be avoided as far as possible since they may cause adverse effects (e.g. allergies).

Timing of administration

- The optimal period of administration of stable iodine is less than 24 hours prior to, and up to two hours after, the expected onset of exposure.
- It would still be reasonable to administer ITB up to eight hours after the estimated onset of exposure.
- ITB later than 24 hours following the exposure may do more harm than benefit (by prolonging the biological half-life of radioactive iodine that has already accumulated in the thyroid)

Exposure?

- Radiologic Experts
- Contaminated Areas
- Wind

Repeat dose?

- A single administration of stable iodine is usually sufficient.
- In case of prolonged (beyond 24 hours) or repeated exposure, unavoidable ingestion of contaminated food and drinking water, and where evacuation is not feasible, repeated administration of stable may be necessary .
- Neonates, pregnant and breastfeeding women and older adults (over 60 years), should not receive repeated ITB.

Pre-distribution and distribution

- In the vicinity of nuclear reactors, pre-distribution of stable iodine to households should be considered, taking into account plans for evacuation and sheltering.

- Clear instructions should be issued with the tablets, and public awareness of the procedures should be monitored on a regular basis.

- In areas further away from the sites of release there is likely to be more time available for decision-making

- If pre-distribution to households is not considered feasible, stocks of stable iodine should be stored strategically at, for example, schools, hospitals, pharmacies, fire stations, police stations and civil defense centers.

voluntary purchase

- National authorities are advised that, because of the benefits of ITB and the generally minimal risks of side effects, voluntary purchase of iodine tablets by the general public should be allowed.

Special consideration groups of the population

- The groups most likely to benefit from ITB are children, adolescents, pregnant and breastfeeding women, whereas individuals over 40 years of age are less likely to benefit from ITB.

- Priority should be given to the children and younger adults.

Special consideration groups of the population

- Neonates and people older than 60 years are at higher risk of adverse health effects if they receive repeated doses of stable iodine.

- People living in iodine deficient areas are more likely to be affected by exposure to radioactive iodine . In such places, national or regional programmes targeting iodine deficiency should be considered .

- Individuals at risk of exposure to high doses of radioactive iodine (e.g. emergency workers involved in rescue or clean-up operations) are likely to benefit from ITB irrespective of their age and should be given priority.

Conclusion

- Studies of the Chernobyl accident have found no association between thyroid tumors and radioactive iodine in adults.

- Therefore, individuals over 40 years of age are less likely to benefit from ITB.

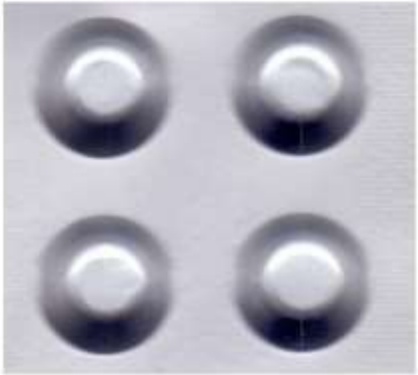
- Some studies of atomic bomb survivors reported an indication of increased risk for thyroid cancer in people over 40 years of age, the exposure was external, and the risk estimates were not statistically significant.

سازمان پدافند غیرعامل کشور - قرارگاه پدافند پرتوی (رافع)

معاونت بهداشت و درمان

مهرماه ۱۳۹۴


Tehran-IRAN
Sc. Tablet
شرکت داروسازی
۶۵ یدید پتاسیم




Potassium Iodide 130
Sc. Tablet
تهران-ایران
۱۳۰ یدید پتاسیم
Tehran-IRAN

Radioactive Accidents

- Atomic Bombs
- Reactores (Chernobyle, Fukioshima)

Radioisotope	Half-life	Origin
Krypton-85m	4.5 hours	noble gas (fission)
Xenon-135	9 hours	noble gas (fission)
Sodium-24	15 hours	activation
Zirconium-97	17 hours	fission
Iodine-133	21 hours	fission
Cerium-143	33 hours	fission
Rhenium-105	35 hours	fission
Xenon-133m	2 days	noble gas (fission)
Neptunium-239	2.4 days	activation
Molybdenum-99	2.9 days	fission
Xenon-133	5 days	noble gas (fission)
Uranium-237	7 days	activation
Iodine-131	8 days	fission
Neodymium-147	11 days	fission
Xenon-131m	12 days	noble gas (fission)
Barium-140	13 days	fission
Cerium-141	33 days	fission
Tellurium-129m	34 days	fission
Niobium-95	35 days	fission
Ruthenium-103	39 days	fission
Iron-59	45 days	activation
Strontium-89	54 days	fission
Yttrium-91	59 days	fission
Zirconium-95	64 days	fission

Iron-59	45 days	activation
Strontium-89	54 days	fission
Yttrium-91	59 days	fission
Zirconium-95	64 days	fission
Cerium-144	285 days	fission
Manganese-54	313 days	activation
Ruthenium-106	372 days	fission
Antimony-125	2.7 years	fission
Iron-55	2.7 years	activation
Europium-155	4.8 years	fission
Cobalt-60	5 years	activation
Krypton-85	10.8 years	noble gas (fission)
Tritium	12 years	fission, fusion, activation
Plutonium-241	15 years	weapon, activation
Strontium-90	29 years	fission
Caesium-137	30 years	fission
Plutonium-238	86 years	activation
Americium-241	433 years	weapon
Plutonium-240	6540 years	weapon, activation
Plutonium-239	24.000 years	weapon
Technetium-99	210.000 years	fission
Chlorine-36	300.000 years	activation
Neptunium-237	2 million years	activation
Caesium-135	3 million years	fission
Iodine-129	16 million years	fission
Uranium-235	700 million years	weapon
Uranium-238	4.5 billion years	weapon

Radioactive Weapons

- **Atomic bombs**, such as those dropped over Japan in World War II, involve nuclear reactions and produce a sudden intense radiation exposure and large amounts of radiation contamination.
- "**Dirty bombs**" are regular bombs which do not involve nuclear reactions, but contain radioactive material which can be dispersed by the explosion of the bomb.

RADIATION

Atomic Bombs

- Large lethal Radiation Zone(miles)
- Atmospheric fallout (global)
- High Risk

Dirty Bombs

- Very small lethal radiation zone (ft)
- Limited fallout (local)
- Minimal Risk

DON'T Panic

- Dose decreases rapidly with time and distance from the bomb- leave the area quickly
- Shielding is an effective protection- take cover and cover as much of your skin as possible.

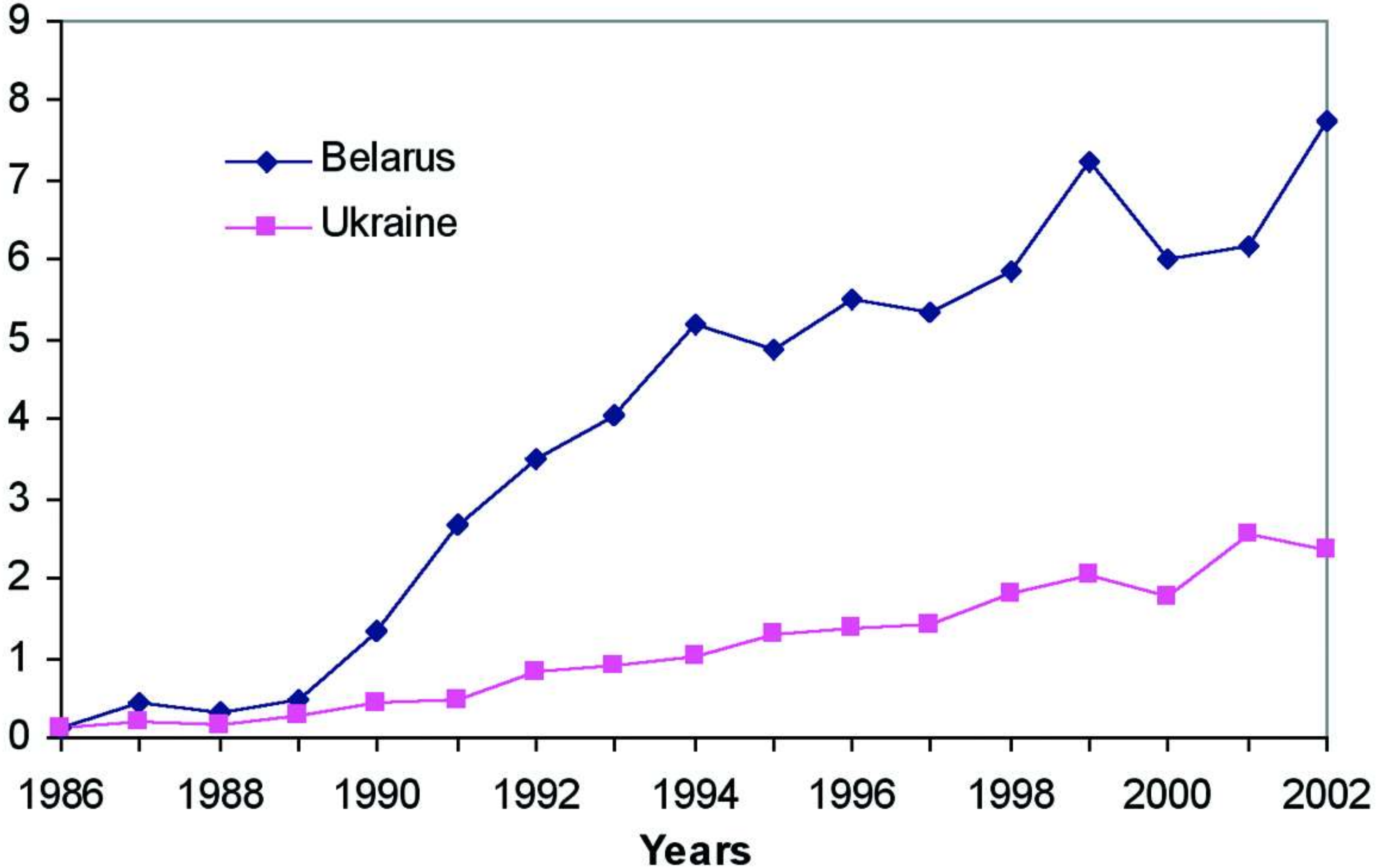
- No health effects have been seen up to 30 times background level .
- The contamination site is limited, and could be cleaned up to near background level.

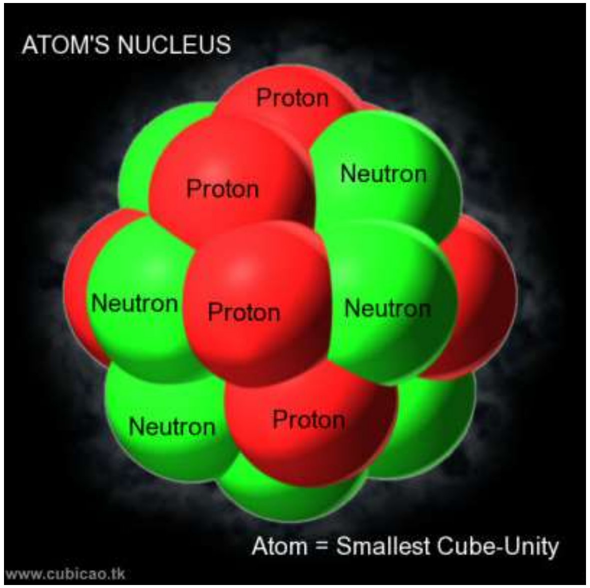
"Radiation Pill!!!!"

Potassium Iodide "pills" offer partial protection against thyroid cancer if given very early in the exposure. They limit the amount of radioactive Iodine that can be deposited in the thyroid gland.

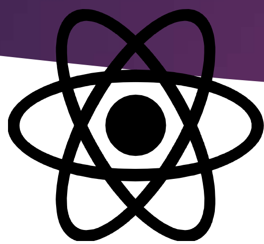
- Doesn't protect from blast
- Doesn't protect from external exposure
- Doesn't protect from other radioactive material
- Doesn't protect from other cancers
- There is no effective "radiation pill"

Incidence Rate of Thyroid Cancer per 100,000 Children and Adolescents as of 1986



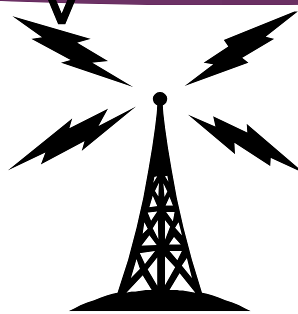

ATOM'S NUCLEUS
Proton
Proton
Neutron
Neutron
Proton
Neutron
Neutron
Proton
Atom = Smallest Cube-Unity
www.cubicao.tk

Radiation

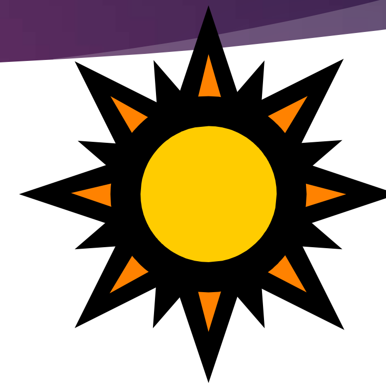


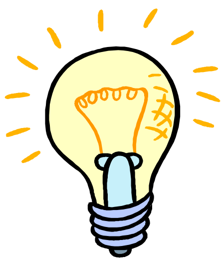
Nuclear

Radio/T
V



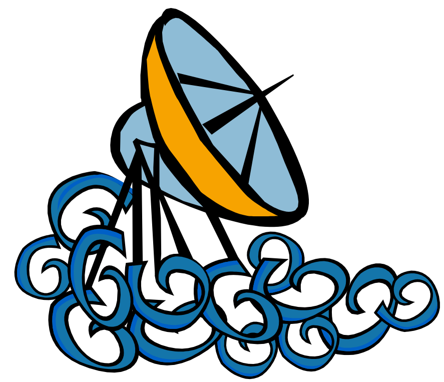
Sun





Ligh
t

Heat



Microwave

Energy →

Electrical Power

Microwave

Radio/TV

Light

UV

X-ray

Gamma

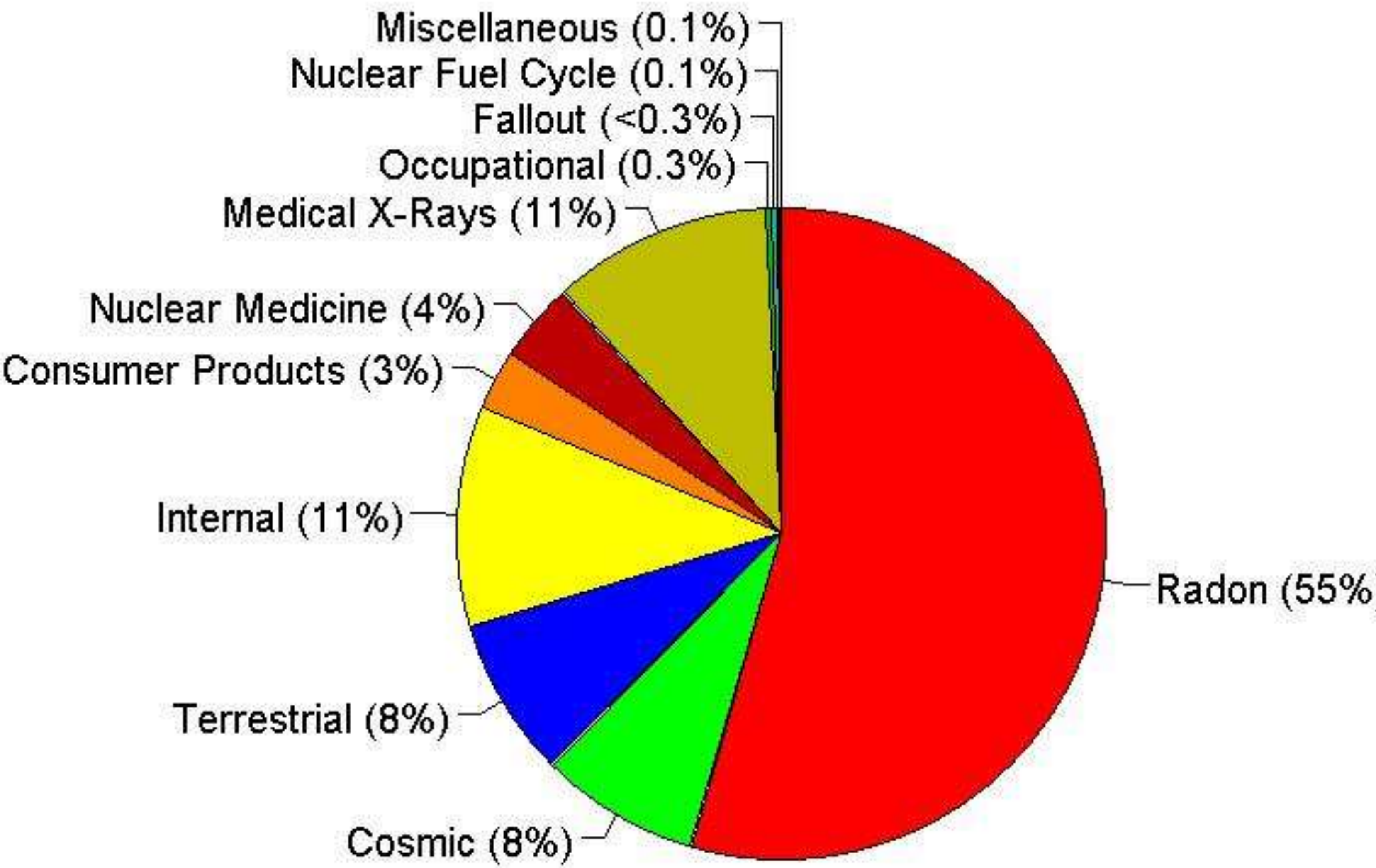
NON-IONIZING RADIATION

IONIZING RADIATION

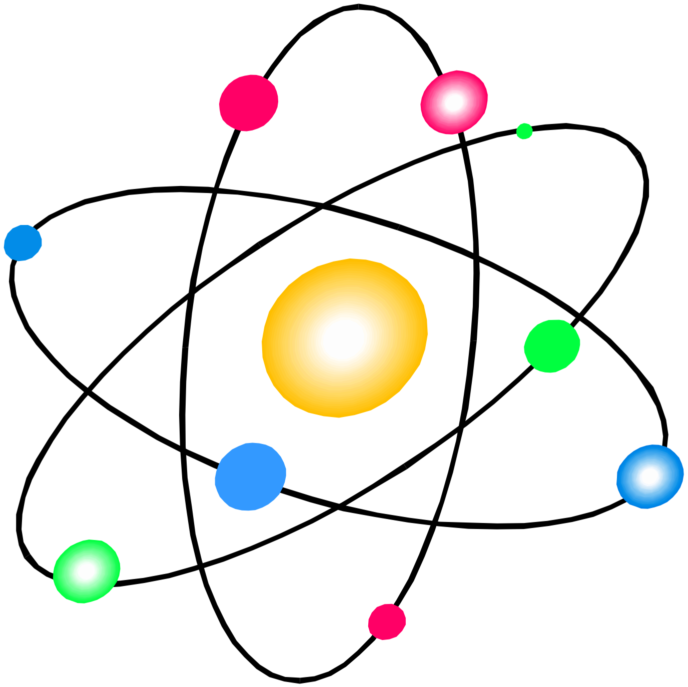
Frequency →

Percentage of Contributions

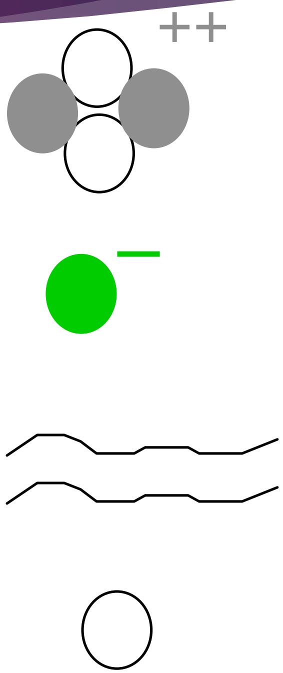
Sources of Background Radiation



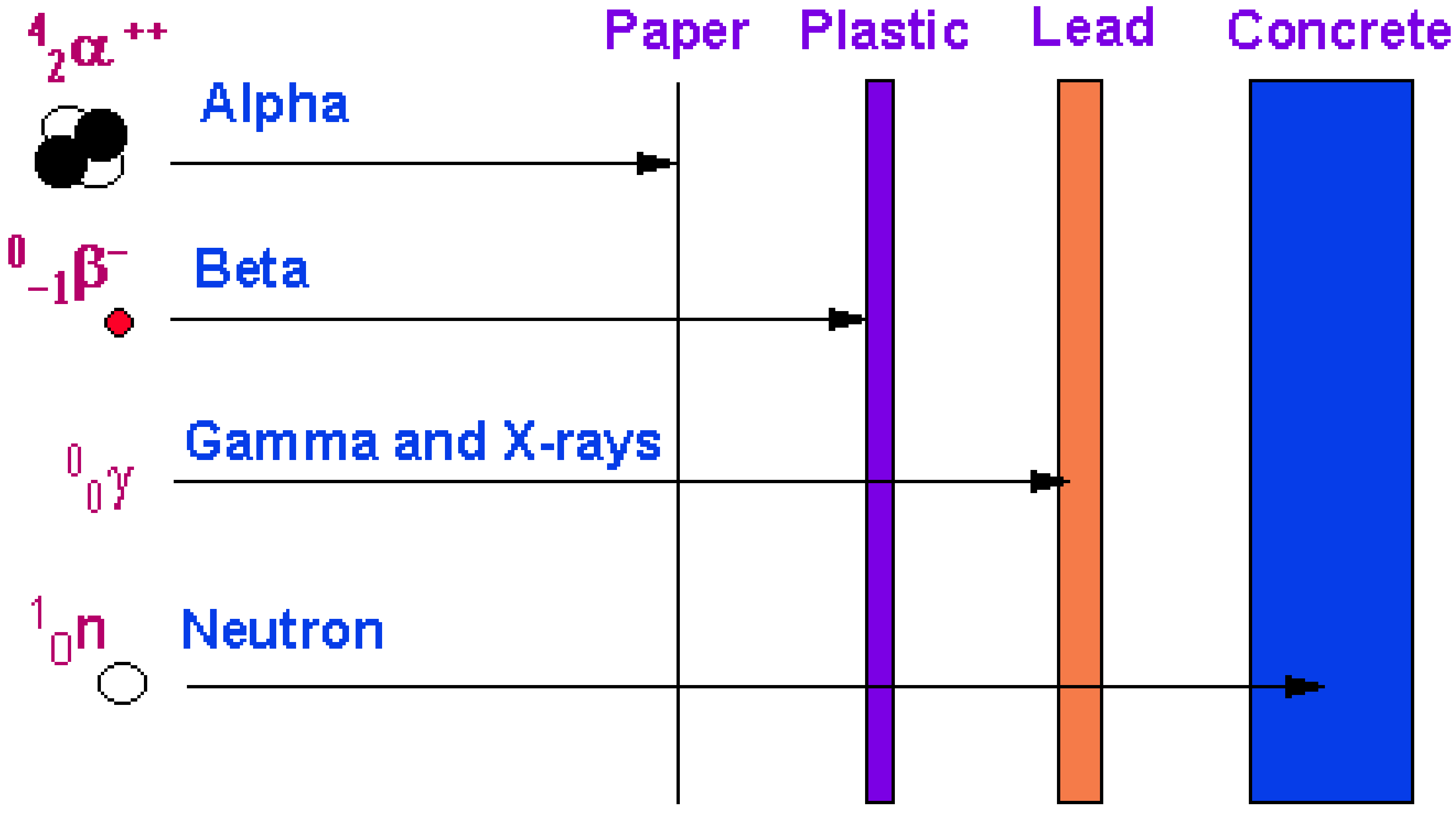
Ionizing Radiation

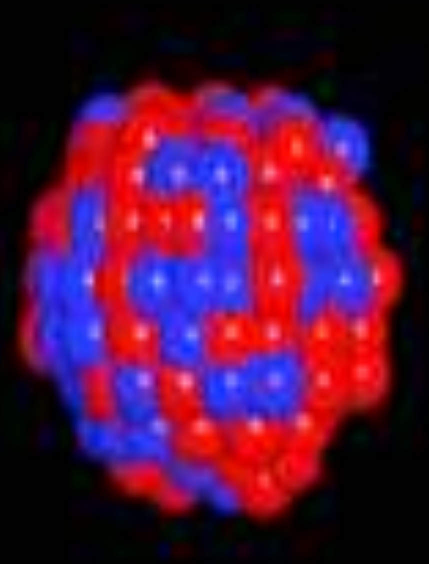


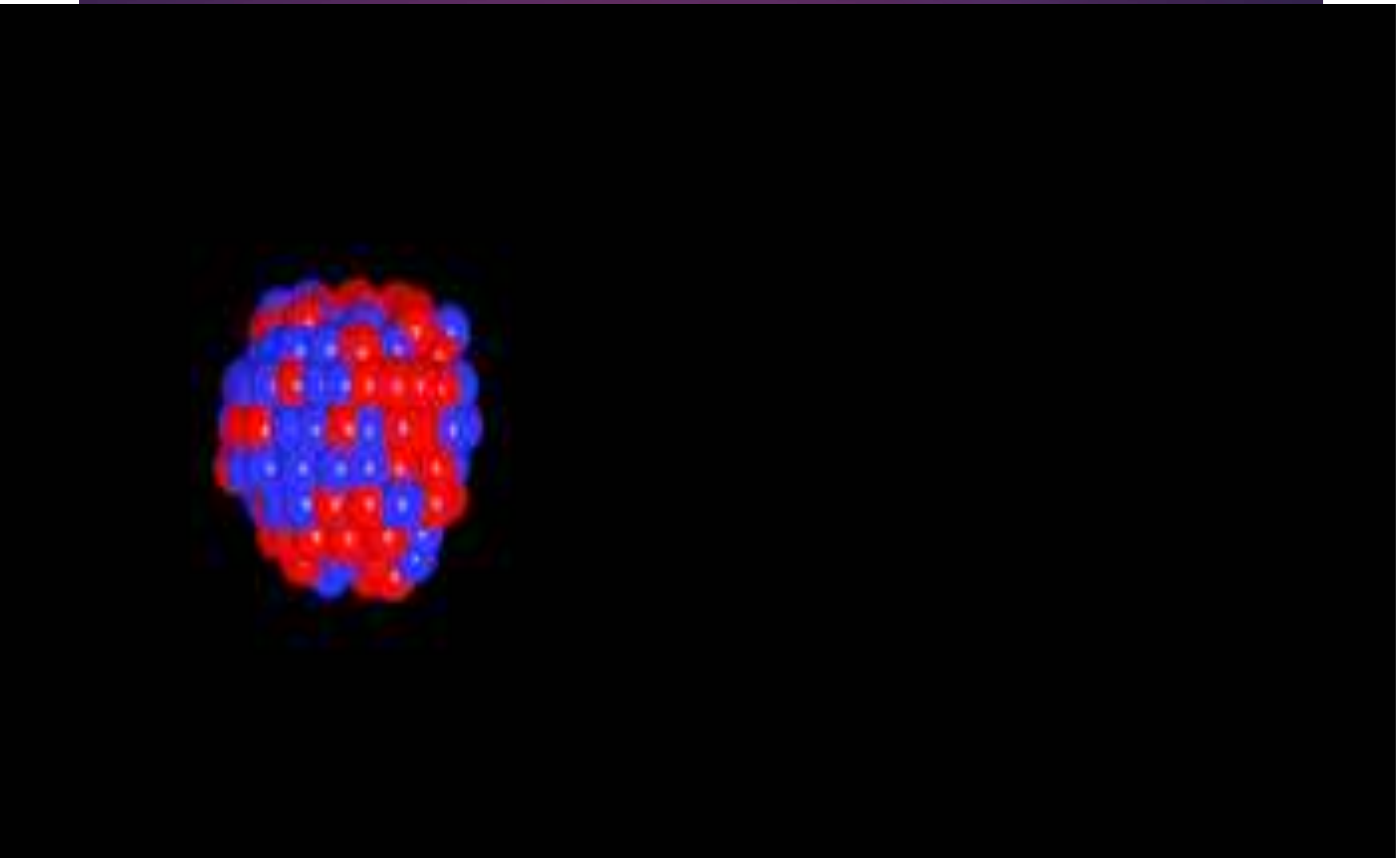
- Alpha particles
- Beta particles
- Gamma rays
- Neutrons

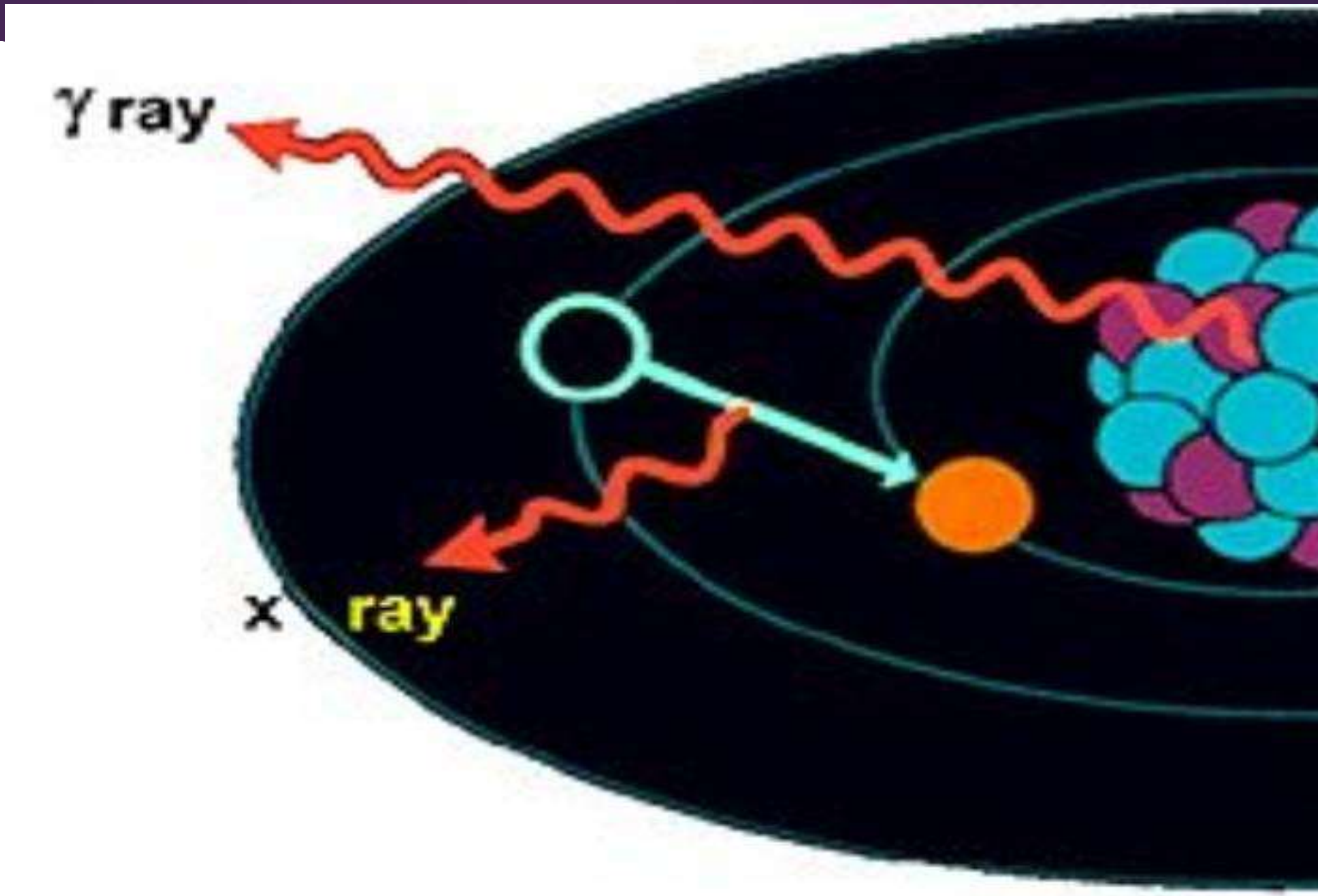


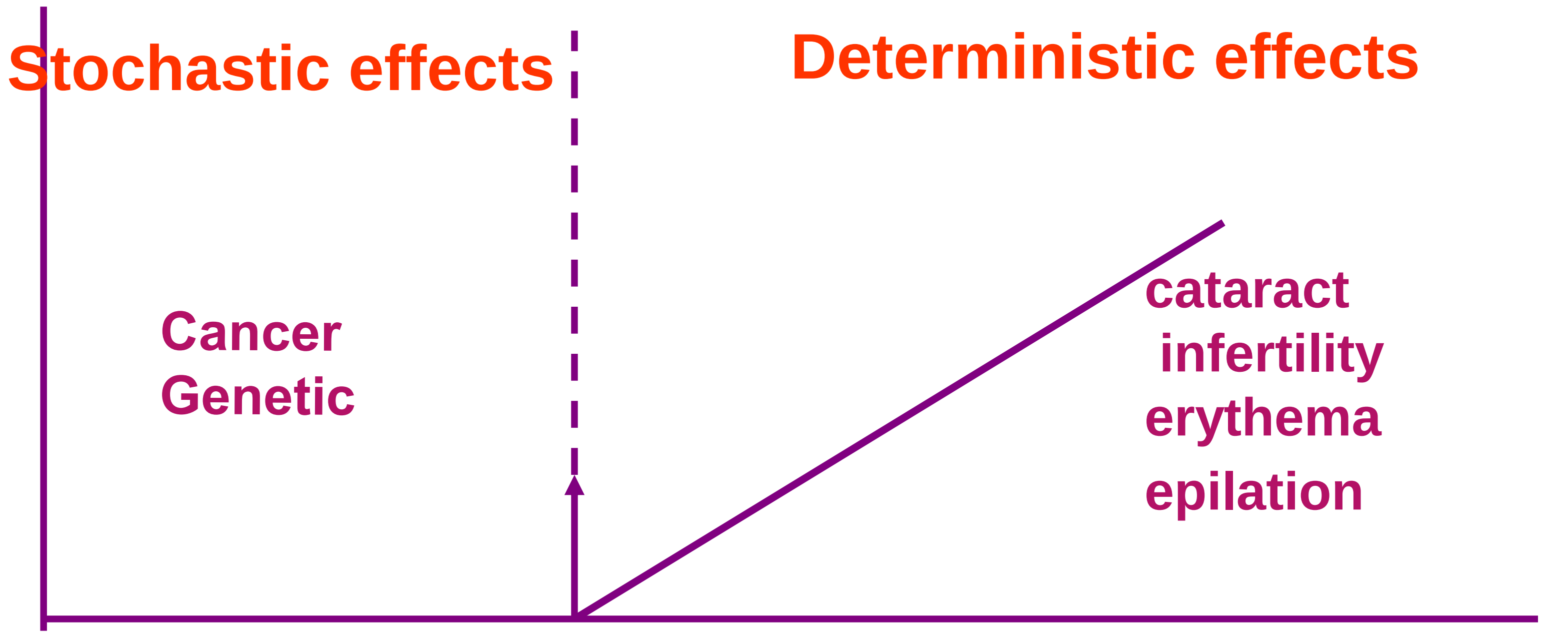
Penetrating Distances





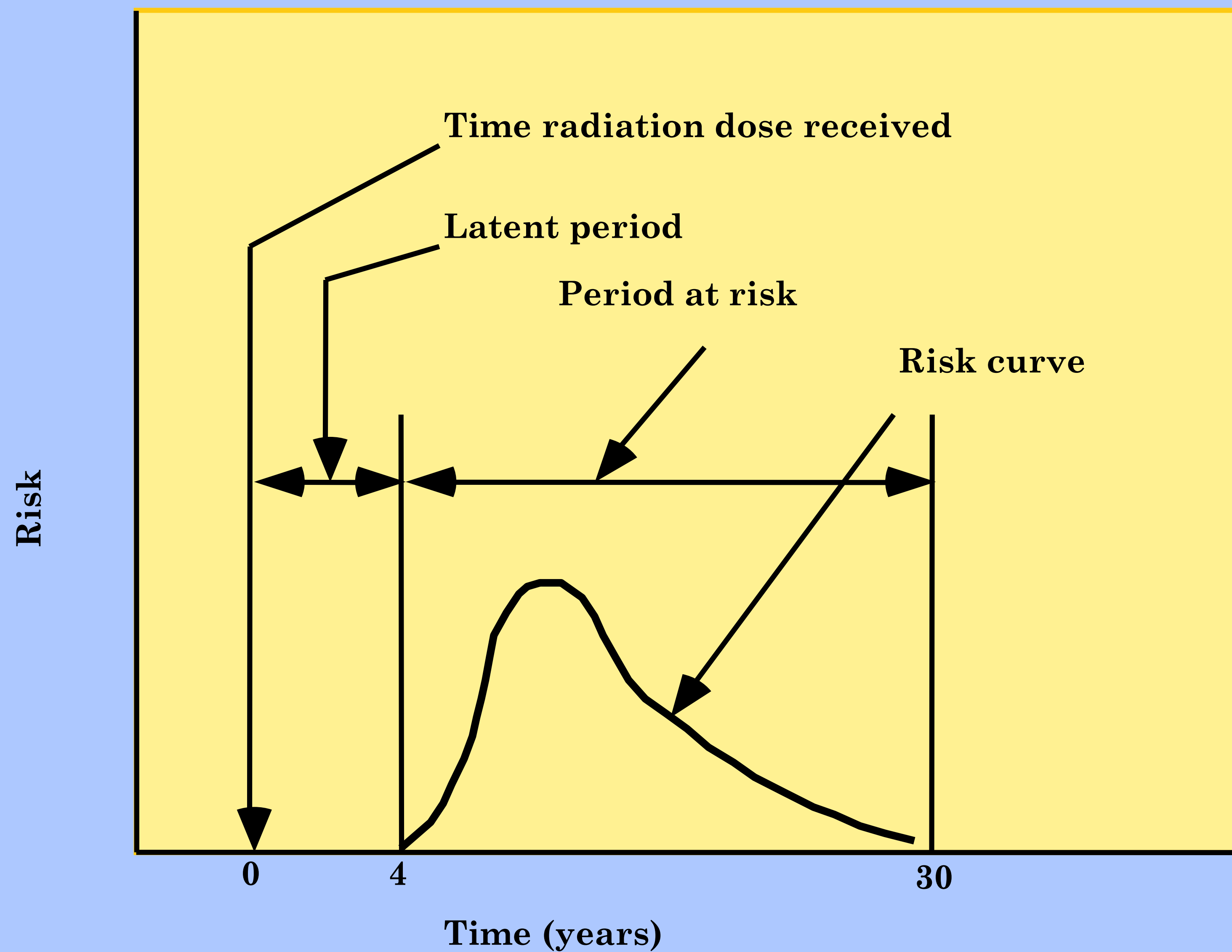



γ ray
X ray

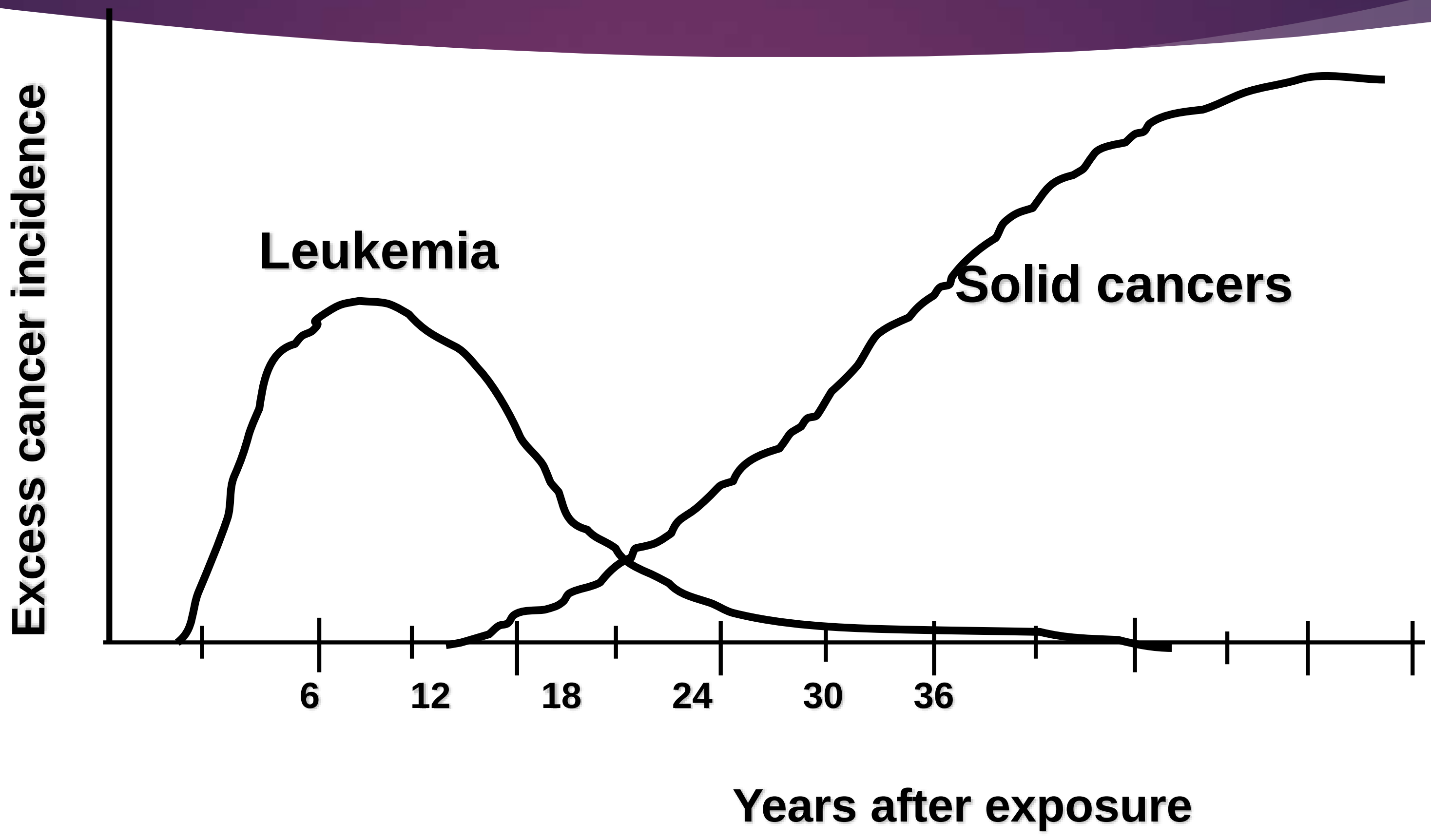


DOSE

500 mSv cataract
150 mSv for sterility (temporary-males)
2500 mSv for ovarian


Time radiation dose received
Latent period
Period at risk
Risk curve
Risk
0
4
30
Time (years)

Latent period for radiation-induced cancers



Radiation-induced cancer:

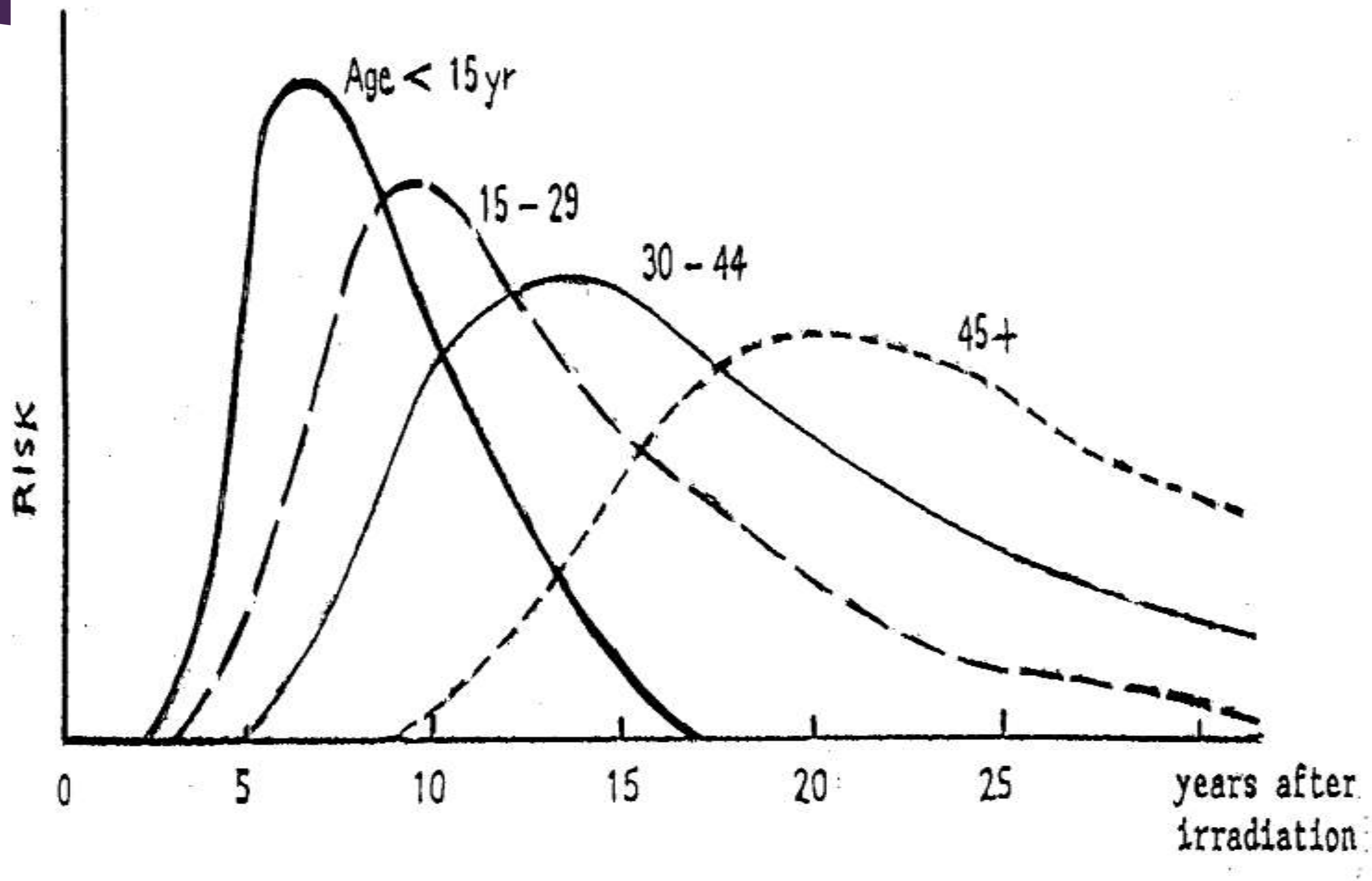
Type or localization of cancer						
Population groups	Leuke-mia	Thyroid gland	Lung	Breast	Bone	Skin
A-bomb survivors	+	+	+	+		
Ra-dial painters					+	
Early radiologists						+
U-miners			+			
Exposed in a nuclear accident		+				

Cancer deaths attributable to A-bombs

In 86572 survivors **of Hiroshima and Nagasaki A-bombing** 7827 persons died of cancer in 1950-90:

	Observed	Expected	Excess	(%)
All tumors	7578	7244	334	(4.4)
Leukaemia	249	162	87	(35.0)
All cancers	7827	7406	421	(5.4)

Risk of Leukemia Depending on the Age at Exposure to A-bombs



- Lymphocytes
- Spermatogonia
- Hematopoietic (Blood Forming)
- Intestinal Epithelium
- Skin
- Nerve Cells
- Muscle Tissue
- Bone
- Collagen

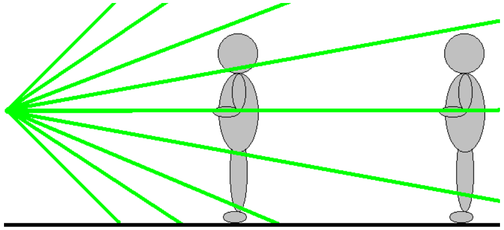
MOST SENSITIVE

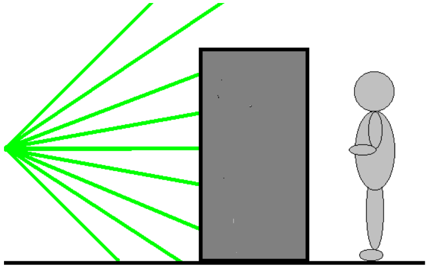
LEAST SENSITIVE

Radiation Protection

- Time

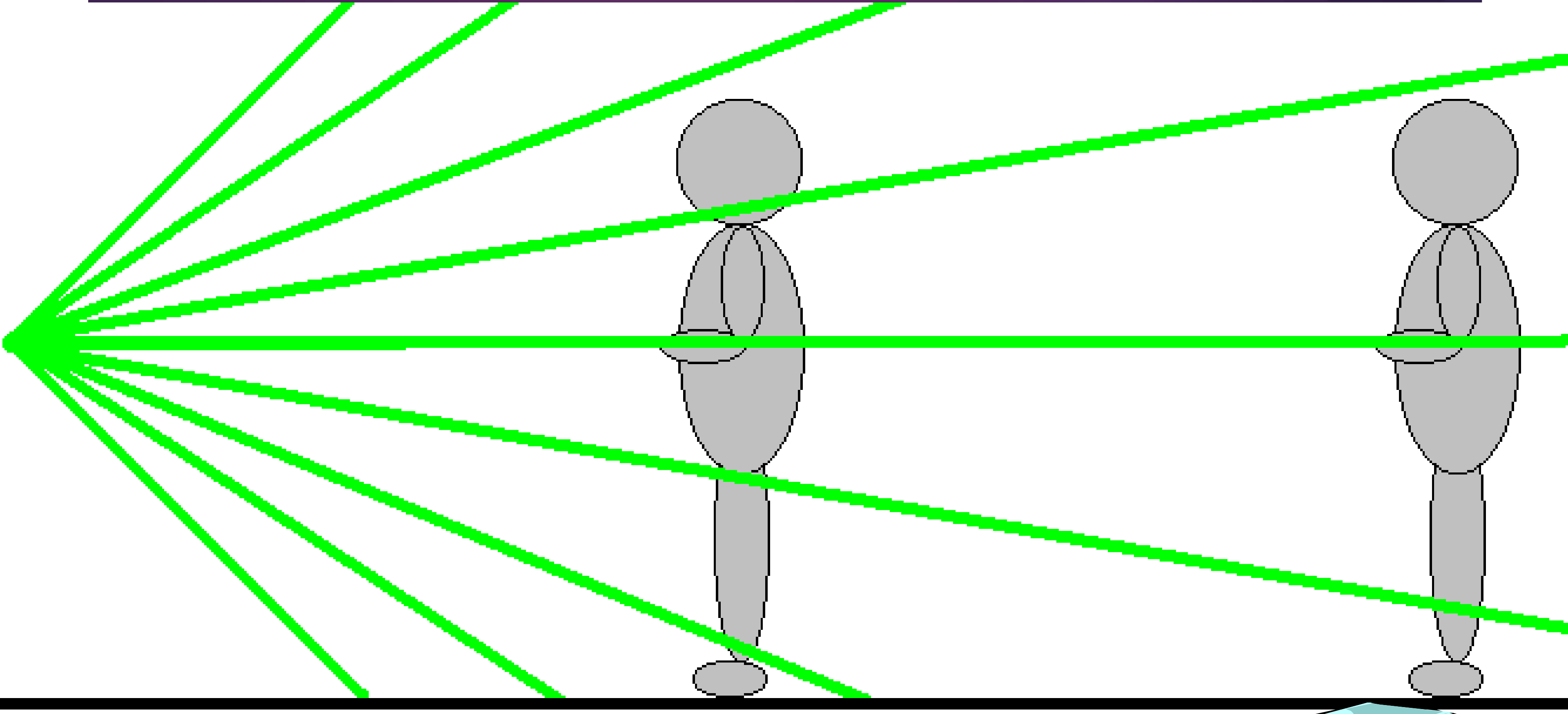
- Distance



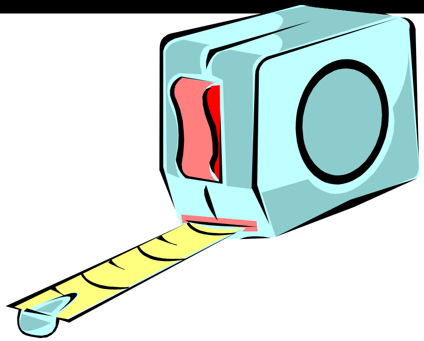


- Shielding

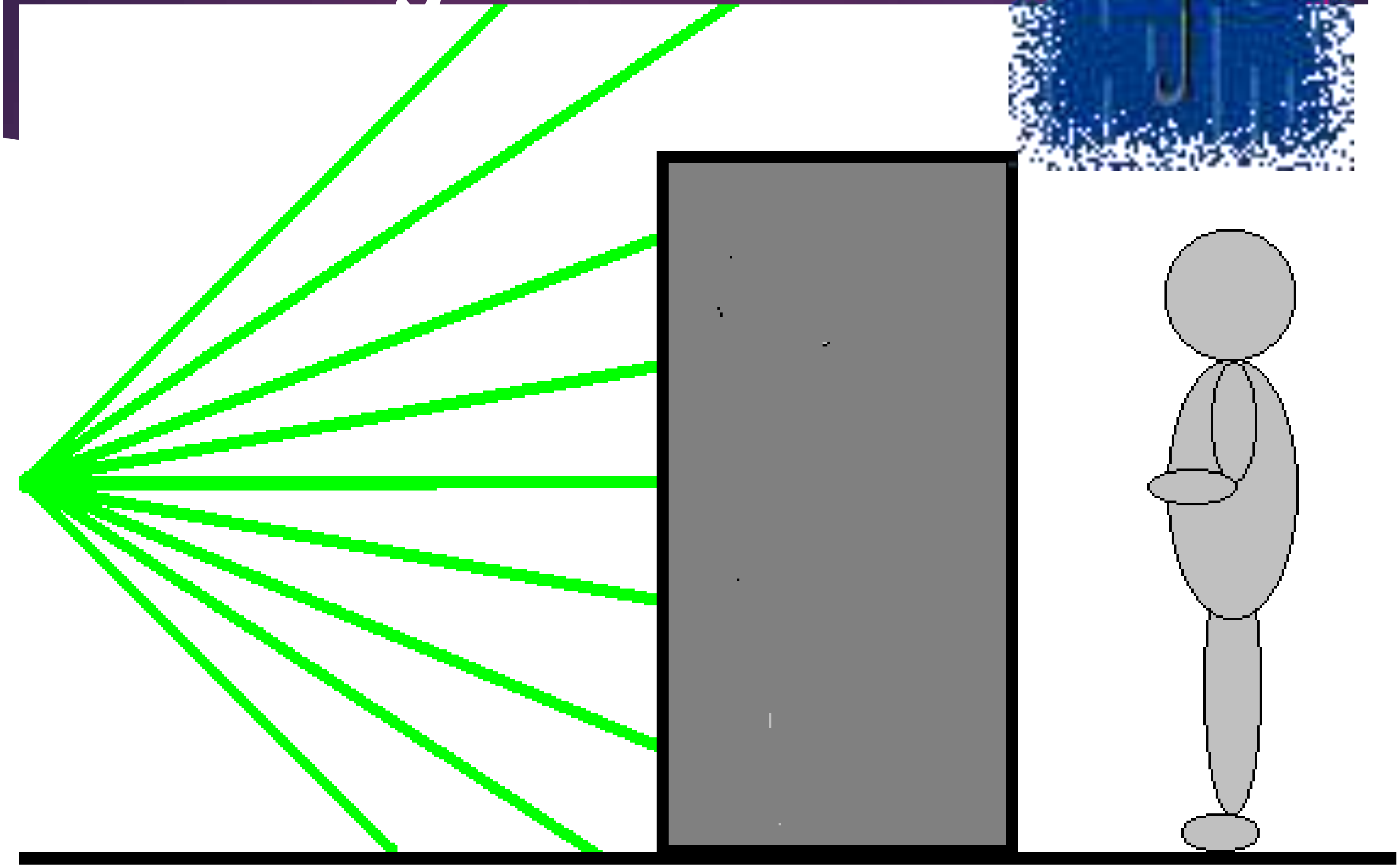
Distance



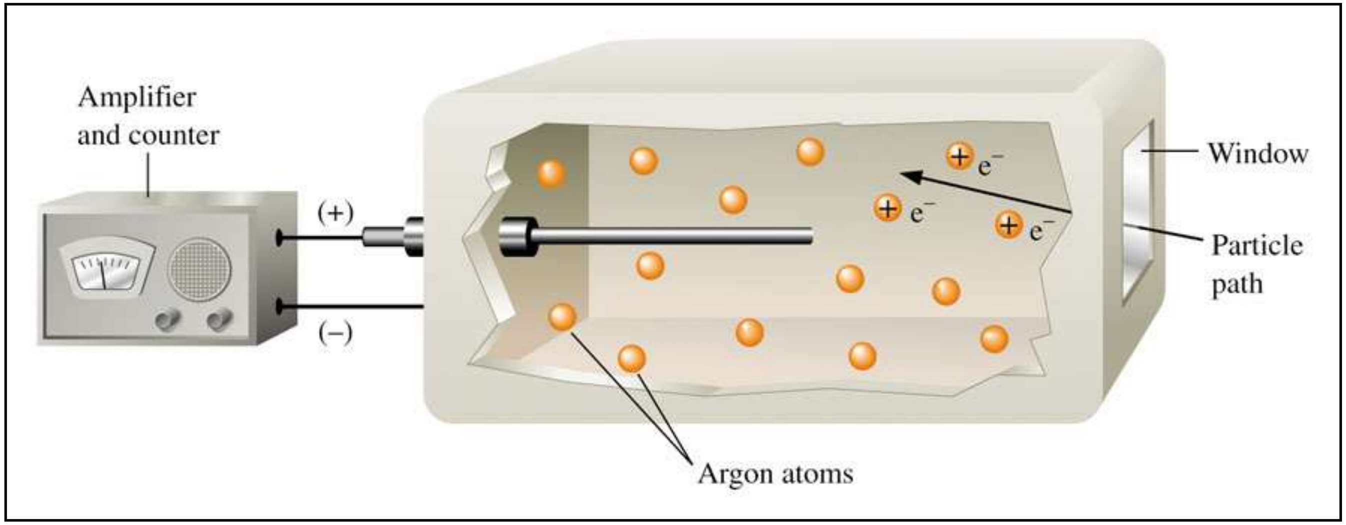
- Double distance = $^{1}/_{4}$ dose
- Triple distance = $^{1}/_{9}{}^{th}$ dose.



Shielding



Geiger Muller



ACUTE RADIATION SYNDROME (ARS)

- The radiation dose must be large (i.e., greater than 0.7 Gray or 70 rads.
- External .
- The entire body.
- In a short time (usually a matter of minutes).

THE THREE CLASSIC ARS SYNDROM ARE:

- **Bone marrow syndrome**: 0.7 Gy (70 rads),
- **Gastrointestinal (GI) syndrome**: 10 Gy (1000 rads).
- **Cardiovascular (CV)/ Central Nervous System (CNS) syndrome**: 50 Gy (5000 rads)

Bone marrow syndrome

- 0.7 Gy (70 rads).
- The primary cause of death is the destruction of the bone marrow, resulting in infection and hemorrhage.

Gastrointestinal (GI) syndrome

- 10 Gy (1000 rads
- Infection, dehydration, and electrolyte imbalance.
- Death usually occurs within 2 weeks.

Cardiovascular (CV)/ Central Nervous System (CNS)

- 50 Gy (5000 rads)
- Death within 3 days.
- Death likely is due to collapse of the circulatory system as well as increased pressure in the confining cranial vault as the result of increased fluid content caused by edema, vasculitis, and meningitis.

THE FOUR STAGES OF ARS ARE:

- Prodromal stage
- Latent stage
- Manifest illness stage
- Recovery or death

Prodromal stage

- The classic symptoms for this stage are nausea, vomiting, as well as anorexia and possibly diarrhea (depending on dose).
- occur from minutes to days following exposure.
- The symptoms may last (episodically) for minutes up to several days

Latent stage:

- In this stage, the patient looks and feels generally healthy for a few hours or even up to a few weeks

Manifest illness stage

- In this stage, the symptoms depend on the specific syndrome and last from hours up to several months.

Recovery or death

- Most patients who do not recover will die within several months of exposure. The recovery process lasts from several weeks up to two years

Acute radiation syndrome prodrome

Vomiting Post Incident	Degree of ARS
> 2 hours after	Mild
1-2 hours	Moderate
< 1 hour	Severe
10 – 30 minutes	Very Severe
< 10 minutes	Rapidly Lethal

SYNDROME	DOSE*	PRODROMAL STAGE	LATENT STAGE	MANIFEST ILLNESS STAGE	RECOVERY
Hematopoietic (Bone Marrow)	> 0.7 Gy (> 70 rads) (mild symptoms may occur as low as 0.3 Gy or 30 rads)	•Symptoms are anorexia, nausea and vomiting. •Onset occurs 1 hour to 2 days after exposure. •Stage lasts for minutes to days.	•Stem cells in bone marrow are dying, although patient may appear and feel well. •Stage lasts 1 to 6 weeks.	•Symptoms are anorexia, fever, and malaise. •Drop in all blood cell counts occurs for several weeks. •Primary cause of death is infection and hemorrhage. •Survival decreases with increasing dose. •Most deaths occur within a few months after exposure.	•In most cases, bone marrow cells will begin to repopulate the marrow. •There should be full recovery for a large percentage of individuals from a few weeks up to two years after exposure. •death may occur in some individuals at 1.2 Gy (120 rads). •the LD50/60† is about 2.5 to 5 Gy (250 to 500 rads)
Gastrointestinal (GI)	> 10 Gy (> 1000 rads) (some symptoms may occur as low as 6 Gy or 600 rads)	•Symptoms are anorexia, severe nausea, vomiting, cramps, and diarrhea. •Onset occurs within a few hours after exposure. •Stage lasts about 2 days.	•Stem cells in bone marrow and cells lining GI tract are dying, although patient may appear and feel well. •Stage lasts less than 1 week.	•Symptoms are malaise, anorexia, severe diarrhea, fever, dehydration, and electrolyte imbalance. •Death is due to infection, dehydration, and electrolyte imbalance. •Death occurs within 2 weeks of exposure.	•the LD100‡ is about 10 Gy (1000 rads)
Cardiovascular (CV)/ Central Nervous System (CNS)	> 50 Gy (5000 rads) (some symptoms may occur as low as 20 Gy or 2000 rads)	•Symptoms are extreme nervousness and confusion; severe nausea, vomiting, and watery diarrhea; loss of consciousness; and burning sensations of the skin. •Onset occurs within minutes of exposure. •Stage lasts for minutes to hours.	•Patient may return to partial functionality. •Stage may last for hours but often is less.	•Symptoms are return of watery diarrhea, convulsions, and coma. •Onset occurs 5 to 6 hours after exposure. •Death occurs within 3 days of exposure.	•No recovery is expected.

* The absorbed doses quoted here are "gamma equivalent" values. Neutrons or protons generally produce the same effects as gamma, beta, or X-rays but at lower doses. If the patient has been exposed to neutrons or protons, consult radiation experts on how to interpret the dose.

† The LD50/60 is the dose necessary to kill 50% of the exposed population in 60 days.

‡ The LD100 is the dose necessary to kill 100% of the exposed population

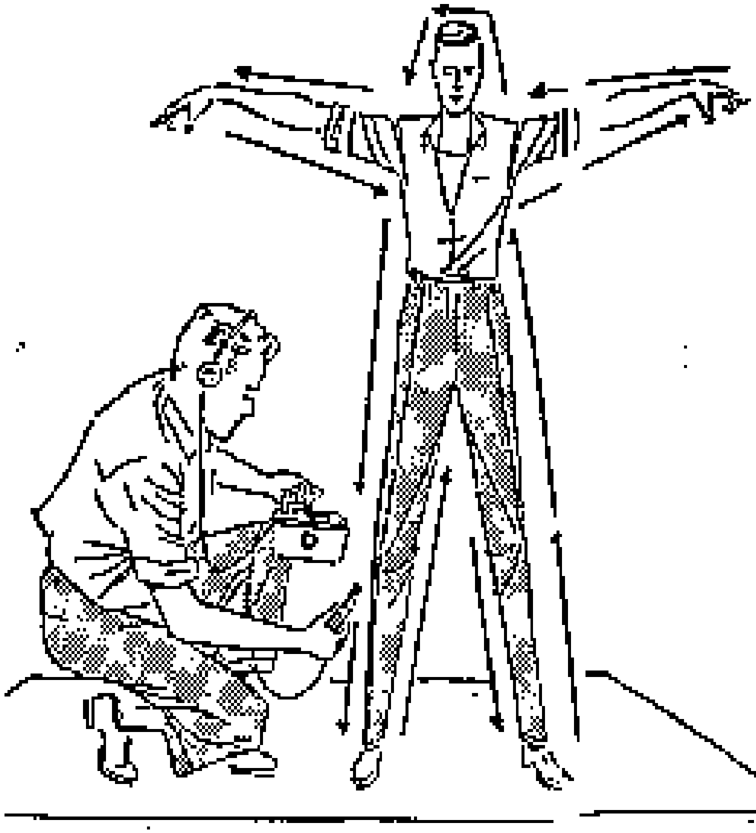
PATIENT MANAGEMENT Triage:

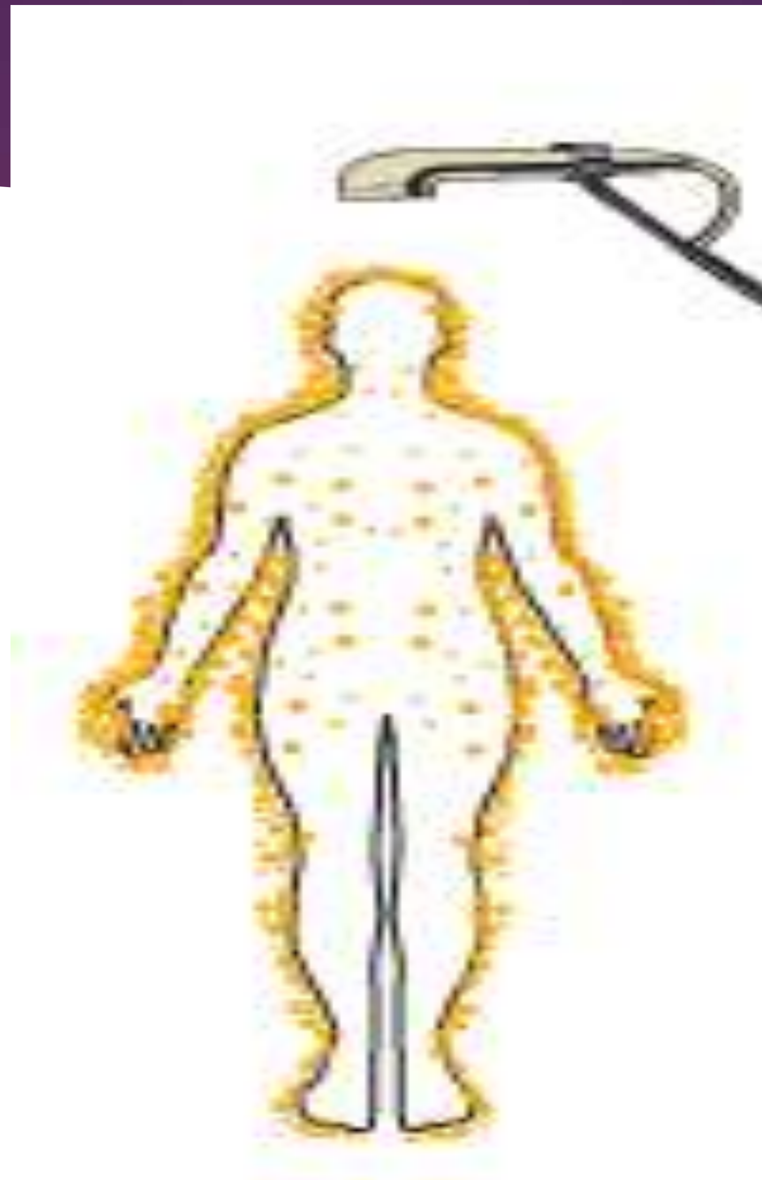
- Secure ABCs
- Treat major trauma, burns, and respiratory injury if evident.
- In addition to the blood samples required to address the trauma, obtain blood samples for CBC with attention to lymphocyte count, and HLA (human leukocyte antigen) prior to any initial transfusion and at periodic intervals following transfusion.

PATIENT MANAGEMENT Triage:

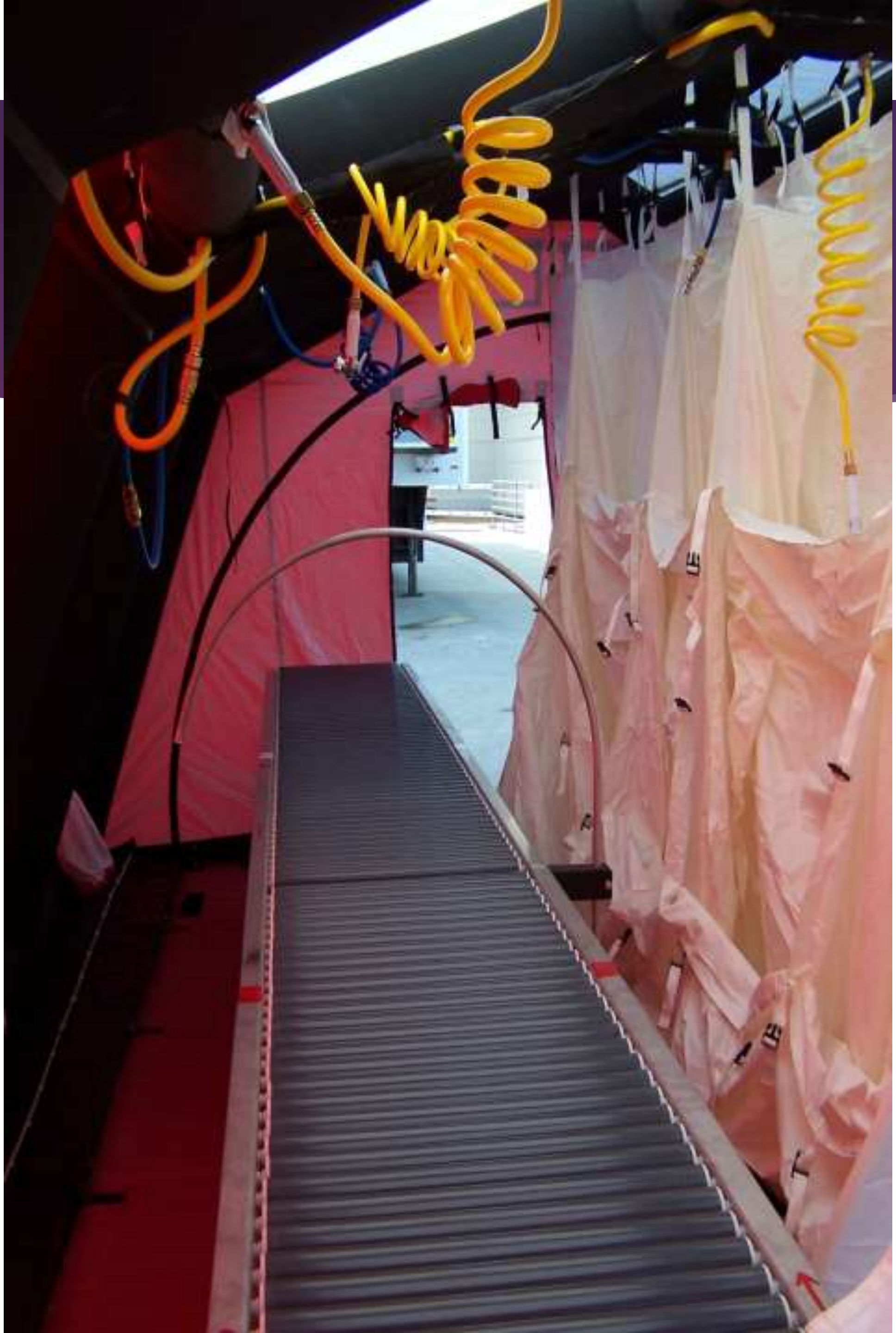
- Treat contamination as needed.
- If exposure occurred within 8 to 12 hours, repeat CBC, with attention to lymphocyte count, 2 or 3 more times (approximately every 2 to 3 hours) to assess lymphocyte depletion.

Radiological Triage



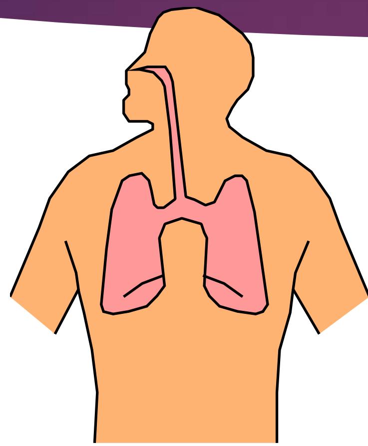


Wound contamination

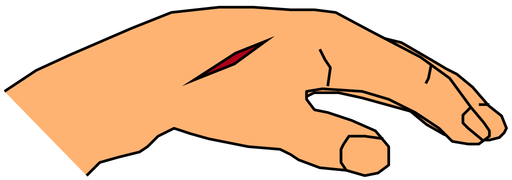


Inhalation

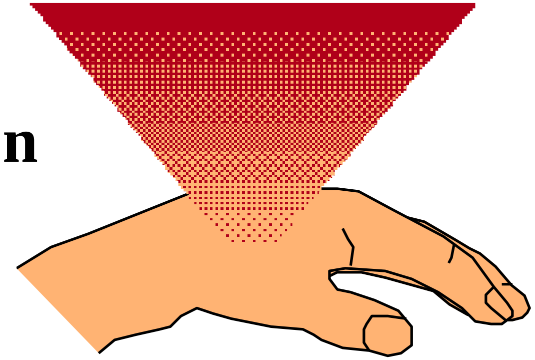
- Breathing



Wound or Cut

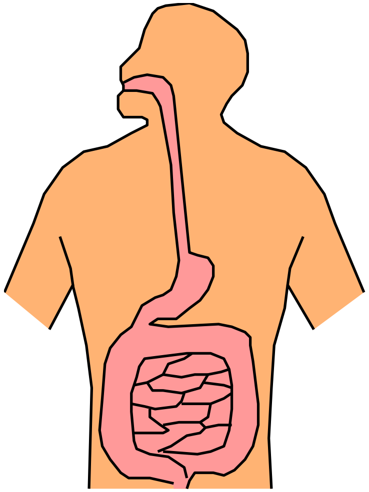


Absorption



Ingestion

- Eating
- Drinking
- Chewing



TRIAGE

- Nasal and mouth Swab : Contamination?
- Gastric lavage.
- Laxative?

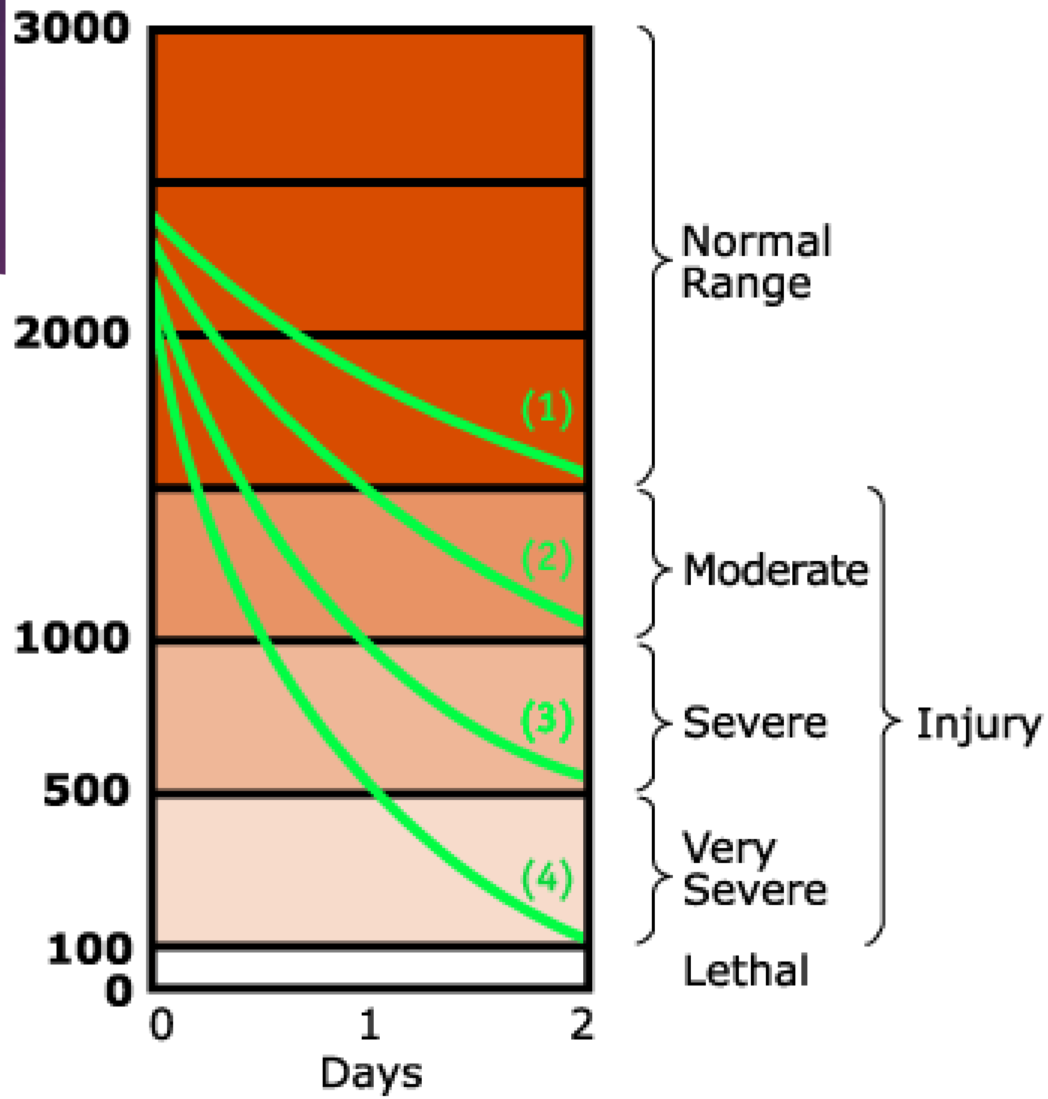
Diagnosis

- The diagnosis of ARS can be difficult to make because ARS causes no unique disease.
- Also, depending on the dose, the prodromal stage may not occur for hours or days after exposure.
- Patient may already be in the latent stage by the time they receive treatment, in which case the patient may appear and feel well when first assessed

Diagnosis

- Serial CBC every 4-6 hours lymphocyte count.
- History of nausea and vomiting.
- Bleeding.
- Epilation

Patterns of early lymphocyte response in relation to dose.



treatment

- Supportive care in a clean environment ((if available, the use of a burn unit may be quite effective).
- Prevention and treatment of infections.
- stimulation of hematopoiesis by use of growth factors .
- stem cell transfusions or platelet transfusions (if platelet count is too low.

treatment

- Psychological support °
- careful observation for erythema (document locations), hair loss, skin injury, mucositis, parotitis, weight loss, or fever.


I-131 released
Traveled away on wind
Fell with rain, landing on grasses and pastures
Grazing animals (cows or goats) ate the grass
I-131 collected in the animals' milk
Humans (often children) drank the milk
Some I-131 in milk collected in thyroid gland

Drugs

Radionuclide	**Treatment**	**Route**
Cesium-137	Prussian blue	Oral
Iodine-125/131	Potassium iodide	Oral
Strontium-90	Aluminum phosphate	Oral
Americium-241/ Plutonium-239/ Cobalt-60	Ca- and Zn-DTPA	IV