DRAFT AGENDA
FULL BOARD MEETING
Stoller-Navarro, 7710 W. Cheyenne, Conference Room 130
April 11, 2007 - 5:00 p.m.
CALL-IN NUMBER: 702-295-3007

I.	Chair's Opening Remarks	David Hermann
	• Agenda Approval	
II.	Public Comment	
III.	"Radiation 101" Briefing / Demo	Tom Enyeart
IV.	Committee Updates	
	• Transportation/Waste	Ted Oom
	• EMPIRE	Jan Spinato
	• UGTA	Engelbrecht von Tiesenhausen
V.	Other CAB Business	
	• Approval of January 10, 2007 Minutes	All
	• SSAB Meeting Recap	Dave Hermann
	• May 9, 2007 Agenda Discussion – NDEP Portion	Kelly Snyder
	• DOE News o FY 2008 EM Budget	Kelly Snyder
VI.	March State of Nevada Notification	Facilitator
	• CAU No. 124 – Storage Tanks (SAFER Plan) Approximate Submittal Date: April 20, 2007	
VII.	Meeting Wrap-Up / Assessment	All

Meeting: Full Board Meeting

Date: January 10, 2007

CAB Members Present: David Hermann, Chair; Walter Wegst, Ph.D., Vice Chair; Paul Adras, Bill Aldrich, Bob Gatliff, Marian Lawrence, Vernell McNeal, Ted Oom, Warren Pawliuk, Kathleen Peterson, Charles Phillips, Jack Ramsey, Ph.D., David Rosin, M.D., Jan Spinato, Engelbrecht von Tiesenhausen, Stacy Standley, James Weeks

CAB Members Participating via Teleconference: Robert Johnson

CAB Members Not Present: Steven Hopkins, Genne Nelson, Harold Sullivan

Liaisons Present: Tiffany Lantow, Defense Reduction Threat Agency; Tim Murphy, NDEP

Liaisons Not Present: Steve Mellington, David Ek, David Swanson

UNLV Technical Support: Dr. Helen Neill

U.S. Department of Energy: Kelly Snyder, DDFO

Facilitator: Carla Sanda, Consensus by Design

Administrative Support Staff: Cheryl Duncan-Olague, Stoller-Navarro Joint Venture

Public: Chris Andres, NDEP

Agenda

- Approval of Agenda
- Public Comment
- Committee Reports
- Other Business
  - FFACO Public Involvement Plan
  - Meeting Report: Intergovernmental Meeting
  - SSAB National Meeting
  - DOE News
  - Thank You: Kathleen Peterson and Marian Lawrence
- Notification for Closed in Place Corrective Actions
  - CAU 145 Waste Disposal Sites (CADD)

Approval of Agenda

A CAB member moved and seconded the motion to approve the Agenda with no changes. Motion passed unanimously.

Public Comment

No public comments were given.

Transportation/Waste Committee
Ted Oom provided a brief overview of recent briefings provided to the Committee (Transuranic Waste in the Trenches, Transportation of Low-Level Radioactive Waste, Soils Sub-Project Update). The Transportation/Waste Committee is nearing completion of its review of the U.S. Department of Energy's National Low-Level Waste Disposition Strategy document and will provide formal comments.

Environmental Management Public Information Review Effort (EMPIRE) Committee
Both Jan Spinato and Stacey Standley advised the CAB that the committee has reviewed and commented on eight fact sheets. They are working on prioritizing all of the facts sheets; reviewing contents to ensure that information is consistent; and will prioritize for future production and distribution.

Underground Test Area (UGTA) Committee
Engelbrecht von Tiesenhausen stated that Dr. Helen Neill is editing and finalizing the comprehensive well recommendation report. Upon completion of the final draft, the committee will meet with Dr. Neill for review and completion.

Engelbrecht von Tiesenhausen will provide recommendations to support staff related to the annual UGTA Kick-Off.

Budget Committee
Jackson Ramsey, Committee Chair, provided a brief overview of the Budget Committee's annual approach to the budget review, prioritization, and recommendations to the U.S. Department of Energy-Nevada Site Office. Kelly Snyder stated that the CAB should have its recommendations to the FY 2009 budget finalized and submitted by mid-April. Support staff will work with the Federal Sub-Project Directors to schedule full-day briefings with the Budget Committee in mid-February.

Federal Facility Agreement and Consent Order (FFACO) Public Involvement Plan (PIP)
An electronic copy of the PIP was previously distributed to the CAB for their review, with the request that comments be provided at this meeting. Kelly Snyder, Carla Sanda, and Tim Murphy provided background information related to the PIP, including its initial development and ongoing objectives. Ms. Snyder further explained that the document is really in place to ensure that the public is provided opportunities for information-sharing and involvement in issues related to the FFACO. Numerous comments were discussed and provided to Ms. Snyder. Dr. David Rosen moved to approve the comments. CAB members approved the motion, with the action that the comments would be provided in a formal recommendation letter to DOE.

CAB members also requested that Kelly Snyder provide a recap of any future inquiries or interaction with the public to ensure that the CAB has a better perspective of community concerns, interest, and requests. Ms. Snyder agreed to include this as part of the ongoing EM program updates.

Approval of November 8, 2006 meeting minutes
Jan Spinato requested that beginning time of the March 14, 2007, EMPIRE Committee meeting be corrected, the time should state 3:30 – 5p.m. instead of 4-5p.m. Walt Wegst moved that the minutes be approved with the noted correction.

Meeting Report: Intergovernmental Meeting
Dave Hermann attended the Intergovernmental Meeting held in Alexandria, VA. Numerous discussions focused on environmental management topics, including a briefing provided by James Rispoli, Assistant Secretary of Energy – EM; an update on the National Low-Level Waste Disposition Strategy; and a tutorial on EM's performance-based project management activities. Mr. Hermann noted that although the Yucca Mountain project is not within the CAB's purview, he found discussions related to water rights and future drilling for underground to be of interest simply due to the UGTA Committee's groundwater focus.

Site-Specific Advisory Board (SSAB) National Chairs Meeting
The SSAB National Chairs Meeting will be held March 28 – 30, 2007 at the Suncoast Hotel and Casino, Las Vegas. A Steering Committee conference call is scheduled next week to finalize the agenda and confirm logistics.

FY 2007 EM Budget
Kelly Snyder spoke to the committee regarding the status of the FY 2007 budget. At this time the EM program is operating under a Congressional continuing resolution until February 15, 2007. The budget roll-out for FY 2008 is expected in mid –February.

Thank you: Kathleen Peterson and Marian Lawrence
David Hermann offered his appreciation to both Kathleen Peterson and Marian Lawrence for their years of service on the CAB, as this is their last official CAB meeting as members. Kelly Snyder thanked both ladies on behalf of the DOE for their years of dedication, support and many hours of effort that they put in to the CAB. Carla Sanda also expressed appreciation to Kathleen for accomplishments on the UGTA committee, and to Marian for the positive voice she has provided for the Nevada's stakeholders.

January Notification of Close in Place Corrective Action Units
CAB members were invited to read and comment on the upcoming Close in Place Corrective Action Documents for CAU 538 – Spill Sites (CADD), expected to be available for review and comment at the CAB office on February 27, 2007

Action Items
- Schedule meeting in early February with the Federal Managers
- Provide budget input to DOE by mid-April
- Include public queries/activities on monthly DOE updates
- Request that the Mobile Decontamination Trailer be brought from Sunrise Hospital for the SSAB meeting. In the event that it cannot be brought to the Suncoast, can the CAB go there for a tour?
- Draft CAB's recommendation letter to the PIP for DOE
- UGTA Committee provide comments to staff for UGTA kick off letter
- On January 24, 2007, the Nuclear Waste Technical Review Board is having a meeting at the Atrium Suites Hotel, 4255 S. Paradise, Las Vegas, from 8 am - 6 pm. This meeting is open to the public.

Notification for
Closed in Place Corrective Actions
April 11, 2007
Las Vegas, Nevada

During the next 30 days, the Department of Energy (DOE) will be submitting Corrective Action Decision Document Closure Report (CADD/CR) to the Nevada Division of Environmental Protection (NDEP) for the following Corrective Action Units (CAU). This document will recommend that engineering and/or administrative controls be used to close the sites although contamination remains.

When submitting this document to NDEP, copies will be supplied to the Community Advisory Board and the Las Vegas and Carson City Public Reading Rooms for review. Submit comments regarding this decision document to Tim Murphy (NDEP) within 30 days of the document's release. Contact addresses listed below.

CAU Number	CAU Description	Approximate Submittal Date
542	Disposal Holes (CADD/CR)	April 30, 2007

Southern Nevada Public Reading Facility

c/o Nuclear Testing Archive

775 East Flamingo Road

Las Vegas, NV 89119

Northern Nevada Public Reading Facility

Nevada State Library and Archives

100 N. Stewart Street

Carson City, NV 89701-4285

TMurphy@ndep.nv.gov

Department of Energy
National Nuclear Security Administration
Nevada Site Office
P.O. Box 98518
Las Vegas, NV 89193-8518

February 1, 2007

David Hermann, Chair
Community Advisory Board for Nevada Test Site Programs
7710 W. Cheyenne, Building 3
Las Vegas, NV 89129

RESPONSE TO NOVEMBER 7, 2006 LETTER REGARDING THE ENVIRONMENTAL MANAGEMENT PUBLIC INFORMATION REVIEW EFFORT (EMPIRE) COMMITTEE RECOMMENDATIONS FOR REGULATORY REQUIREMENTS, BUDGET AND PLANNING, WASTE MANAGEMENT AND ENVIRONMENTAL RESTORATION FACT SHEETS

In response to the EMPIRE committee's letter, I have reviewed their recommendations and am currently in the process of revising the four fact sheets to include as many recommendations as possible. The nine general suggestions will be incorporated into all Environmental Management fact sheets. However, when implementing the suggestion of creating a glossary and increasing the font size on each fact sheet, it became clear that some reduction in the verbiage was needed to ensure that the number of printed pages and associated printing costs were within reason.

Below is a listing of the recommendations that will not be incorporated and the specific reason for not being included in the revised version:

Waste Management Fact Sheet

Recommendation: Page 2, Paragraph 4 - Insert this sentence at the end of the paragraph: This sub-project is scheduled to close at the end of fiscal year 2007.

Action: Recommendation will not be included. Including the requested verbiage in the fact sheet would prematurely date the publication if the Transuranic Sub-Project does not close in fiscal year 2007. This would require a costly reprint of the fact sheets.

Regulatory Requirements Fact Sheet

Recommendation: Incorporate rewritten and reorganized text.

Action: Recommendation will be partially accepted. The amount of verbiage that was submitted would cause the fact sheet to be 6 or more pages. The verbiage will be minimized to ensure a cost efficient and concise publication.

Thank you for the extensive effort and time that these recommendations required. As the Environmental Management Public Affairs Task Manager, my ultimate goal is to provide information that is inviting, readable, and understandable to our stakeholders. The EMPIRE Committee's approach and feedback has been tremendously helpful and will result in materials that are certainly more user-friendly to the general public.

I look forward to receiving additional recommendations on other Environmental Management publications.

Kelly K. Snyder
Deputy Designated Federal Officer

PSG:2785.KKS

cc via e-mail:
Melissa Nielson, DOE/HQ (EM-13) FORS
Kay Planamento, NREI, Las Vegas, NV

Community Advisory Board for Nevada Test Site Programs

March 12, 2007

Kelly Snyder, DDFO
U.S. Department of Energy – Nevada Site Office
PO Box 98518
Las Vegas, NV 89193-8518

SUBJECT: Environmental Management Public Information Review Effort Committee (EMPIRE)

Following is a compilation of our recommendations for the following four fact sheets given to our committee for review.

First, the EMPIRE Committee again reiterates the same general suggestions for all of the fact sheets:

1. Define unfamiliar terms and acronyms before they are used in a sentence.
2. Bold the definitions so that they are easily referenced.
3. When doing several definitions together, bullet the definitions, rather than listing them in the sentence.
4. Include a key and/or glossary on each fact sheet for unfamiliar terms and acronyms.
5. Reference on each fact sheet that other fact sheets are available.
6. In general, increase font point size for easier reading.
7. Try to keep fact sheets at an eighth grade reading level.
8. Update all references to off-site locations to comply with current transition status.
9. Distribute fact sheets to libraries, city halls, Nuclear Testing Archive, Legislator offices, environmental groups, UNLV and senior centers.

Now, for specific suggestions on each fact sheet:

Environmental Management Public Involvement

Page 1 (front of brochure)

1. Lower right hand corner – Change tag line to eliminate first person. Be consistent with tag line on all handouts.

Page 2 (first column on inside)

1. Paragraph 1 – Line 3: At end of line – confirm from Associate Press Guide whether the word should be in or of.
2. Paragraph 2 – Line 4: Capitalize the word Program.
3. Paragraph 2 – Line 7: Remove the last two words: are offered and replace with: have been put in place.

Page 3 (second column on inside)

1. Paragraph 1 - Line 1: Remove the first word (Because), and begin the sentence with EM.
   Line 2: Put a period after leaders and begin a new sentence with: The office assists . . .

2. Paragraph 3 - Line 1: Change the number of volunteer citizens to 15-20.
   Line 3: After the sentence ending with: rural and urban areas, list the locations by saying: Included but not limited to the following:
   Line 5: Remove the sentence that begins: The CAB meets . . . and replace with: The CAB meets on a regular basis. All CAB meetings are open to the public.

Page 4 (third column on inside)

1. Paragraph 1 - Line 1: Change the word provide to the word give.
2. Paragraph 2 - End of paragraph. Add this sentence to the end of the paragraph: Listings of events are available on the web site.
3. Paragraph 4 - Delete the first six lines in their entirety and replace with: The public is invited to visit: Change the information below the addresses to the following: To be added to the list to receive meeting notices and information on projects and activities contact us at: then put the contact box from the back page.

   Move this entire paragraph to the back of the brochure to replace what is there now.

   Corrections for the entire inside of the brochure: add captions to all pictures.

Page 6 (second column from left on outside)

1. Paragraph 2 - Place a colon after the last word in the paragraph (components:).
2. Paragraph 3 - Line 3: Remove the word weapons
   Line 7: Remove the last sentence and replace with the following: In addition, long-term surveillance and monitoring techniques are used to make sure the health and safety of workers, the public and the environment are not put at risk.
3. Paragraph 4 - Line 1: After the word disposes, add the word of.
   Line 4: Delete the word: also, and after the word disposes add the words: of that.

Page 7 (back of brochure)

1. Eliminate all the current information now on the back of the brochure and replace with the **For More Information:** section from the inside of the brochure (bottom of column 3).

   Corrections for column of pictures on the outside of the brochure: add captions.

Environmental Management Speakers Bureau

1. Paragraph 3 - Line 7: Put a comma after the word Range and a period after Tonopah Test Range. Delete the words: and at nine off-site test locations in five states, including Nevada.

Federal Facility Agreement and Consent Order

Page 1 - Move Heading up and change font size so it all fits on one line.

1. Paragraph 1 - Delete the bolded heading (same as at the top of the page) and start paragraph closer to top of the page.

Line 1: Delete the word: hosted. Replace with: was the scene of.
Line 6: Delete the words: other locations in Nevada. Replace with: portions of the Nevada Test and Training Range.

2. Paragraph 2
Eliminate last sentence and replace with: How are these corrective actions overseen and enforced?
Paragraph 3 - Line 3: Place a period after the (FFACO). Eliminate the rest of the paragraph and replace with: The Agreement was signed in May 1996 by DOE, the state of Nevada's Division of Environmental Protection, and the U. S. Department of Defense (DoD). The agreement is designed to improve the environmental restoration process for local residents, the state of Nevada and the DOE.
3. Paragraph 4 - Line 1: Delete the entire first paragraph.
Line 5: Delete the word: will
Line 6: Place a period after the word: state. Delete the remainder of that sentence.
Line 7: Place a period after the word: sites. Delete the remainder of the sentence.

Page 2 - Remove the entire section that lists the five locations (total of six lines).
1. Last Paragraph - Line 1: Change the first sentence to read: the Federal Facility Agreement and Consent Order, with its six appendices, is a legally binding document.
Line 2: Delete the s on the second word (describes).
Change the map to reflect current locations.

Page 3
1. Paragraph 2 - Line 1: Change the word: four to the word: three.
Line 4: Change the two words: in directly to the correct: indirectly.
Line 8: Eliminate the entire two lines in reference to the offsites.
2. Paragraph 3 - Line 1: Delete the word: will
Line 2: Change the second sentence to read: the recommendations are presented for review by the public and the Community Advisory Board for Nevada Test Site Programs.
Line 4: Delete the word: will.

Page 4
1. Paragraph 1 - Line 6: Remove the s from the word state.
Line 7: Change the line to read: which is then posted in the reading facility.
2. Paragraph 2 - Line 4: After the word: Management, delete the rest of the sentence. Follow the word Management with: Distribution List.
Line 5: Delete the first word in the sentence: Quarterly.

Add to the caption of the photo: - located at: (then list address of the DOE's Public Reading Facility).

Environmental Management
Page 1 - Line 4: After the word: initiatives add the following: (between 1950 and 1992).

Page 2
1. Paragraph 1 - Line 4: Change the words: Nevada Test Site to: NTS.
2. Paragraph 2 - Line 2: Change the end of the sentence to read: news releases, exhibits, the CAB Roadshow and CAB public meetings.
Line 5: Change number of citizen volunteers to 15-20.
Line 6: Add to the end of the paragraph: The CAB meets monthly and the public is invited. **(or semi-monthly if that schedule remains)**

Page 3

1. Our first recommendation on this page and the ones remaining is to change the font on the headings. It is **extremely** difficult to read.
2. Paragraph 1 - Reverse the order of the first two sentences in this paragraph.
   Line 5: Make a bulleted list of:
   - Underground Test Area
   - Soils
   - Industrial Sites
   - Offsites
3. Paragraph 2 - State what happens if groundwater contamination is found. Also make sure it is noted that this is an area where the CAB is actively involved.
4. Paragraph 3 – Line 3: Remove the word: resides and replace with the word: remains.

Page 4

1. Paragraph 2 - The portion of the paragraph that speaks about management of transportation is confusing. It leads one to think that program activities include more than they do. It needs to be rewritten. Also, the mention of coordination of rural county emergency response efforts gives the wrong impression. This reference makes a reader think that program activities include helping local municipalities with their emer gency response efforts. It needs to be rewritten.

Page 5

1. Paragraph 1 - Line 2: Change Environmental Protection Agency to: EPA.
2. Paragraph 4 - Add this sentence to the end of the paragraph: The last of the stored transuranic waste will be transported off NTS by (and insert appropriate date).

Page 6

1. Change Heading to read: How is Low-Level and Mixed Low-Level Waste Safely Disposed at NTS?
2. Underline and bold the following:
   Line 2: **The Radioactive Waste Acceptance Program**
   Line 4: **Risk Assessments**
   Line 12: **The Closure Program**
3. On line 7 change the sentence to read: Continuous monitoring of air, groundwater, and soil serves as an early detection system . . . .

Our overall recommendation in relation to this handout is to change the graphics. The graphics make it very hard to read throughout, and they distort the photos. All photos should be replaced and include captions.

Attached is a copy of our committee work on these handouts.

Thank you for the opportunity to review these fact sheets.

Sincerely,

Jan Spinato, Chairperson
CAB EMPIRE Committee

March 30, 2007

Assistant Secretary James A. Rispoli
EM-1/DOE-HQ Forrestal Building
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

Dear Mr. Rispoli:

The Environmental Management (EM) Site Specific Advisory Boards (SSAB) Chairs wish to commend the Department of Energy (DOE) on the release of the 2007 EM Engineering and Technology Program Plan, October 2006 Preliminary Draft Pre-decisional and the associated DOE-EM Engineering and Technology Roadmap, earlier this year for comment. This action demonstrates the Department's commitment to engage us early in public policy issues involving decisions protecting health, safety, and the environment now and in the future.

Further, the EM SSAB Chairs commend the DOE on the application of standard engineering project management tools for all EM projects. The incorporation of total lifecycle cost evaluations in developing validated baselines that are comprehensive will be beneficial for future planning. We look forward to continued status reports on the successful application of these tools.

These actions demonstrate a commitment to openness and a willingness to engage us, collaboratively, in charting the course for what will be the cornerstone of efforts to reduce technical uncertainty and risk in legacy waste and environmental cleanup through out the DOE complex.

Once again, thank you.

Susan Leckband, Chair
Hanford Advisory Board

Bill Flanery, Co-Chair
Idaho National Laboratory Site EM Citizens' Advisory Board

Richard L. Buxton, Co-Chair, Idaho National Laboratory Site EM Citizens' Advisory Board

David Hermann, Chair
Nevada Test Site Advisory Board

J.D. Campbell, Chair
Northern New Mexico Citizens' Advisory Board

Lance Mezga, Chair
Oak Ridge Site Specific Advisory Board

Allen Burnett, Chair
Paducah Gaseous Diffusion Plant Advisory Board

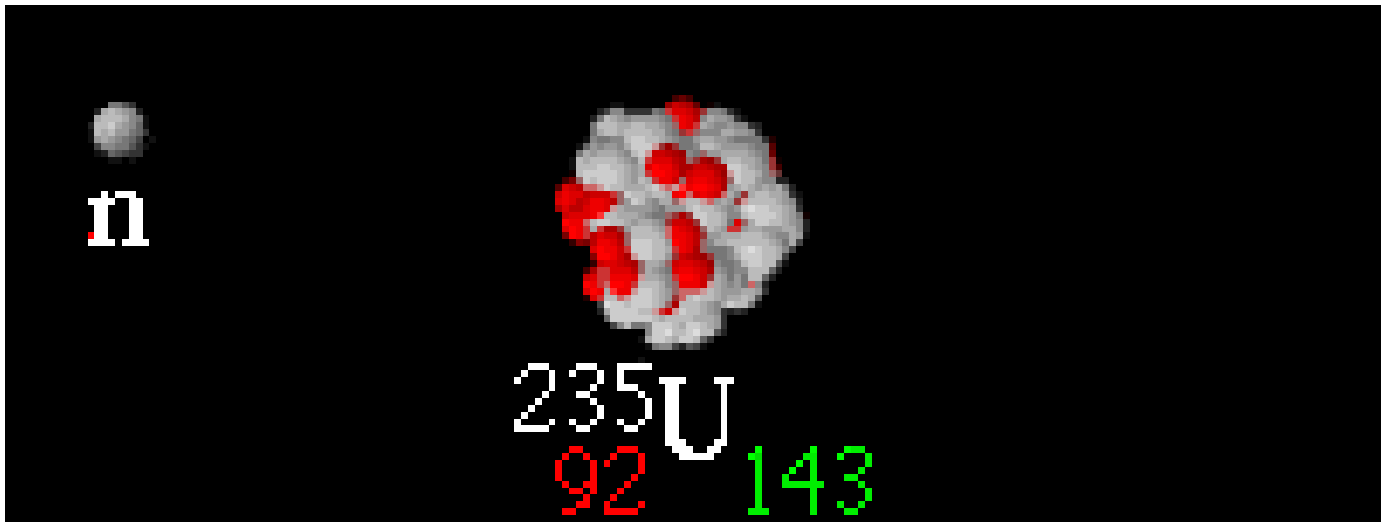
Karen Patterson, Chair
Savannah River Site Citizens' Advisory Board

FY 2008 Congressional Budget
NNSA NSO EM Program
Breakout by Sub-Project

PBS	Sub-Project	Budget ($K)
VL-NV-0013	TRU/MTRU	0
VL-NV-0030	Soils	2,677
	UGTA	21,282
	Industrial Sites	21,392
	Program Integration	11,443
	Total	56,794
VL-NV-0080	LLW/MLLW (includes Generator funds)	21,767
VL-NV-0100	AIPs/Grants	2,545
NEVADA SITE OFFICE TOTAL		81,106

Per the February 5, 2007, Budget Roll-Out

Fundamental Principles of Radiation



April 11, 2007

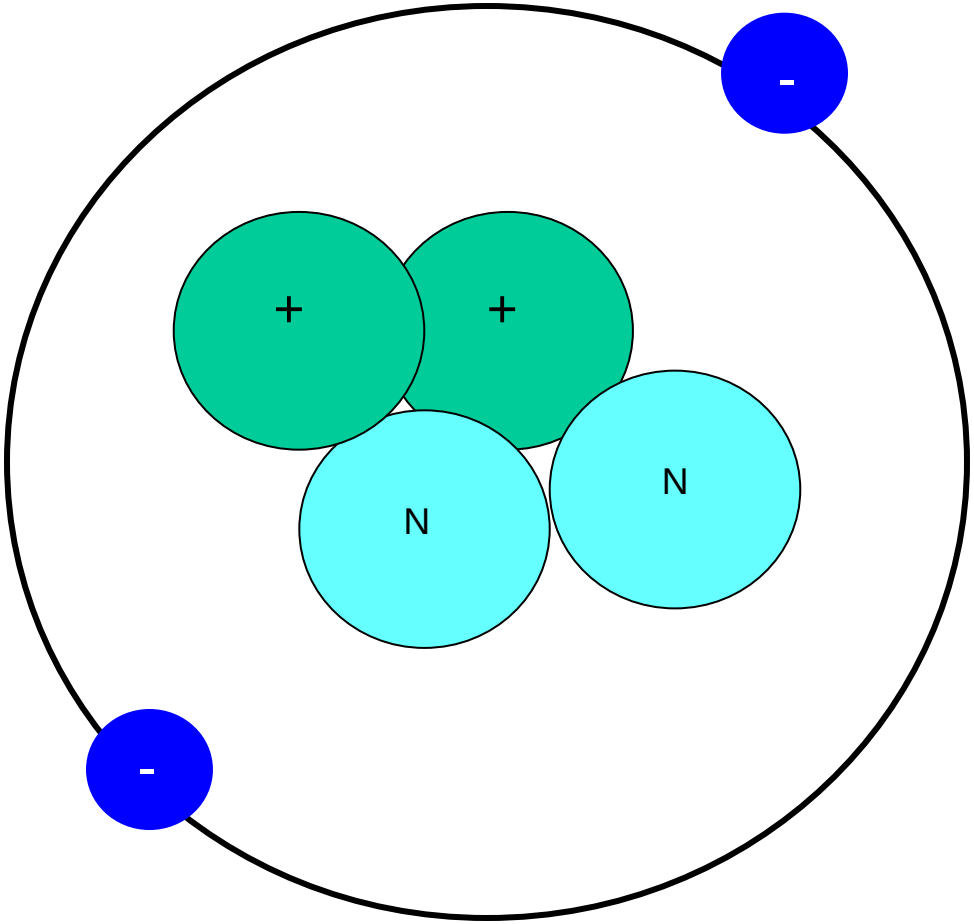
Instructor: Tom Enyeart, CHP

National Nuclear Security Administration
Nevada Site Office

FUNDAMENTALS OF IONIZING RADIATION

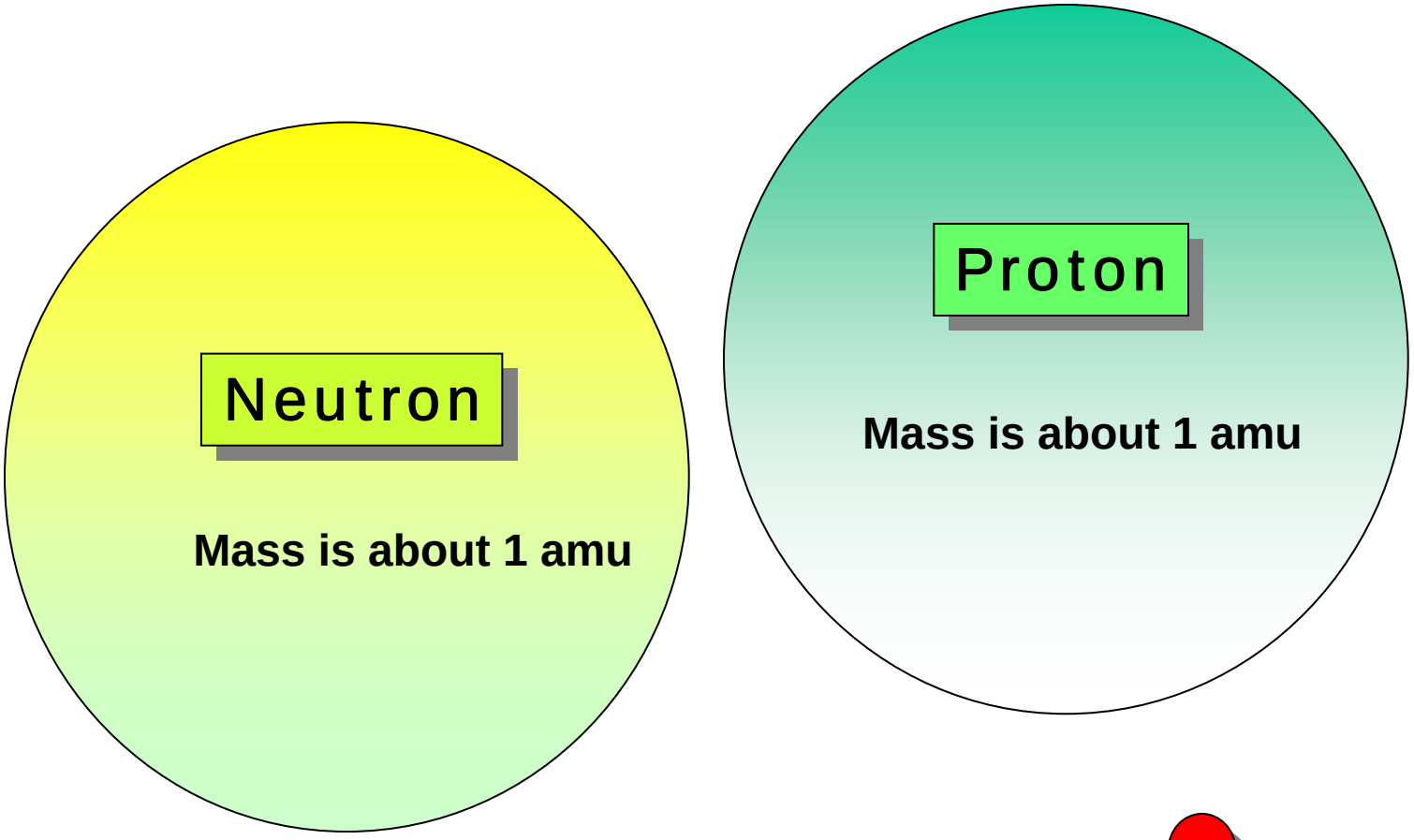
Atoms

Atoms are the building blocks of ALL matter

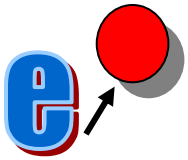


A Helium atom is used in this example

Nucleons



1 amu = 1.66 x 10^{-24} gram



Mass is about 0.0005 amu

Atoms

- **Nuclear particles form atoms**
- **Similar atoms combine to form elements**
- **Elements combine to form molecules**
- **Molecules combine to form compounds**

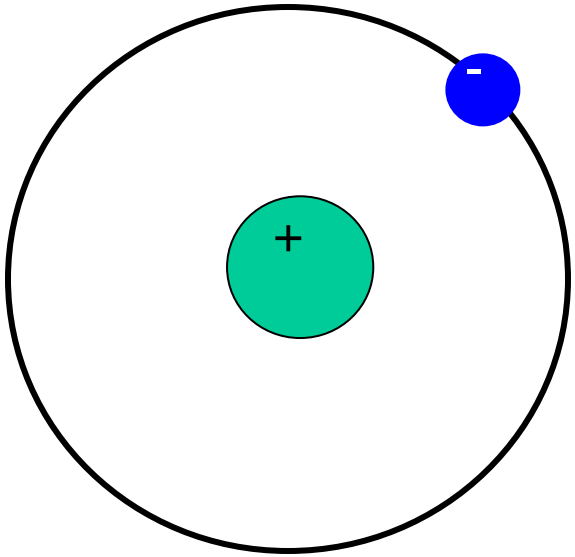
Isotopes

- **The number of PROTONS defines the ELEMENT**
- **The number of NEUTRONS defines the ISOTOPE**
- **The isotopes of an element have similar chemical properties but different nuclear properties**
  - **Some isotopes are stable**
  - **Some isotopes are radioactive**

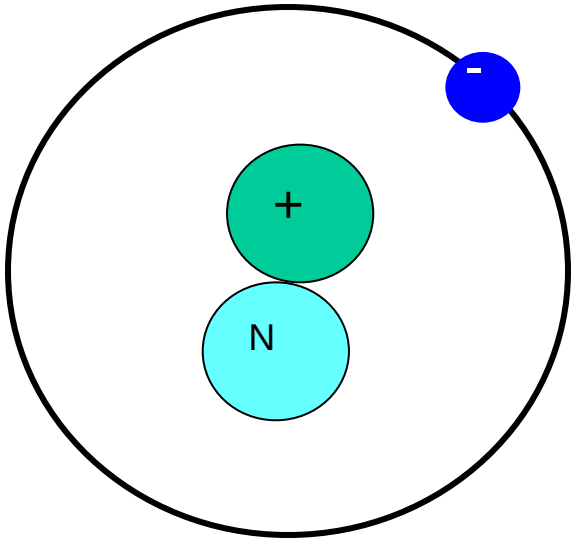
Isotopes

Different Isotopes of Hydrogen

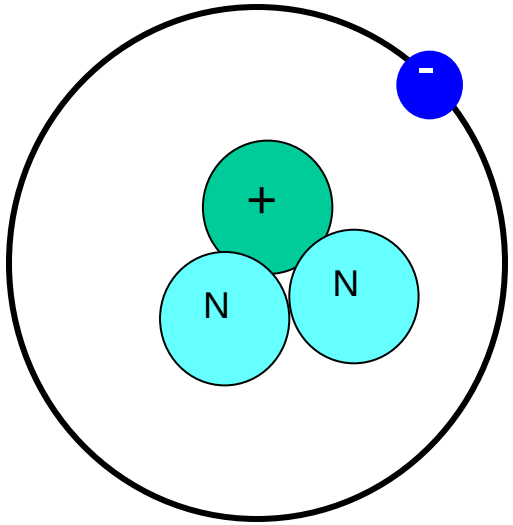
“Normal” Hydrogen or Protium
1 proton
0 neutron
1 electron
$_1H^1$



Deuterium
1 proton
1 neutron
1 electron
$_1H^2$



Tritium
1 proton
2 neutrons
1 electron
$_1H^3$



Isotopes & Atomic Notation

X = The symbol of the element

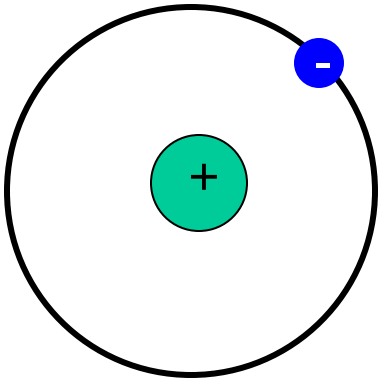
Z = The atomic number (# of protons)

$_{Z}X^{A}$

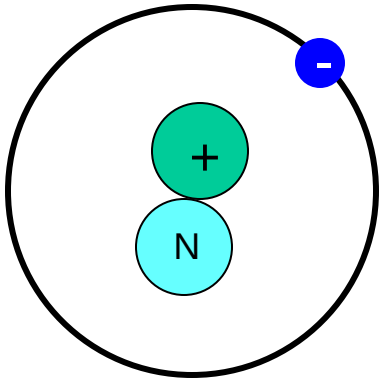
A = The atomic mass number (# of protons + neutrons)

Different Isotopes of Hydrogen

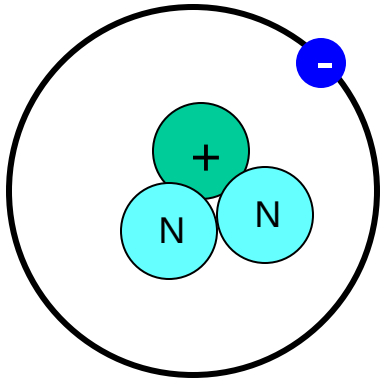
"Normal" Hydrogen or Protium
1 proton
0 neutrons
1 electron
$_{1}H^{1}$



Deuterium
1 proton
1 neutron
1 electron
$_{1}H^{2}$



Tritium
1 proton
2 neutrons
1 electron
$_{1}H^{3}$



IONIZING RADIATION

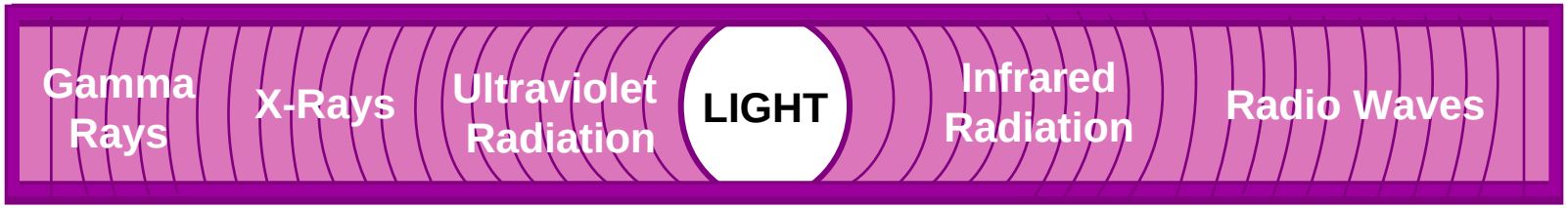
Two Types of Radiation

- **Non-Ionizing**
- **Ionizing**

Non-Ionizing

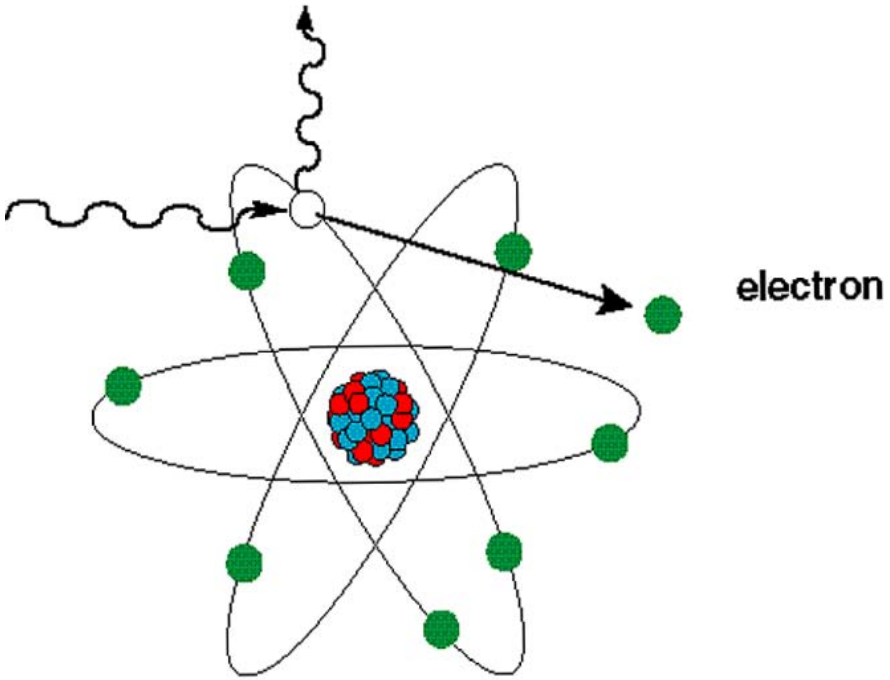
- **Radiation that doesn't have enough energy to form ions:**
  - **Radar Waves**
  - **Microwaves**
  - **Laser**
  - **Visible Light**

The Electromagnetic Spectrum is a large family of radiation that includes light, infrared, ultraviolet, X-rays, radio waves, and gamma rays



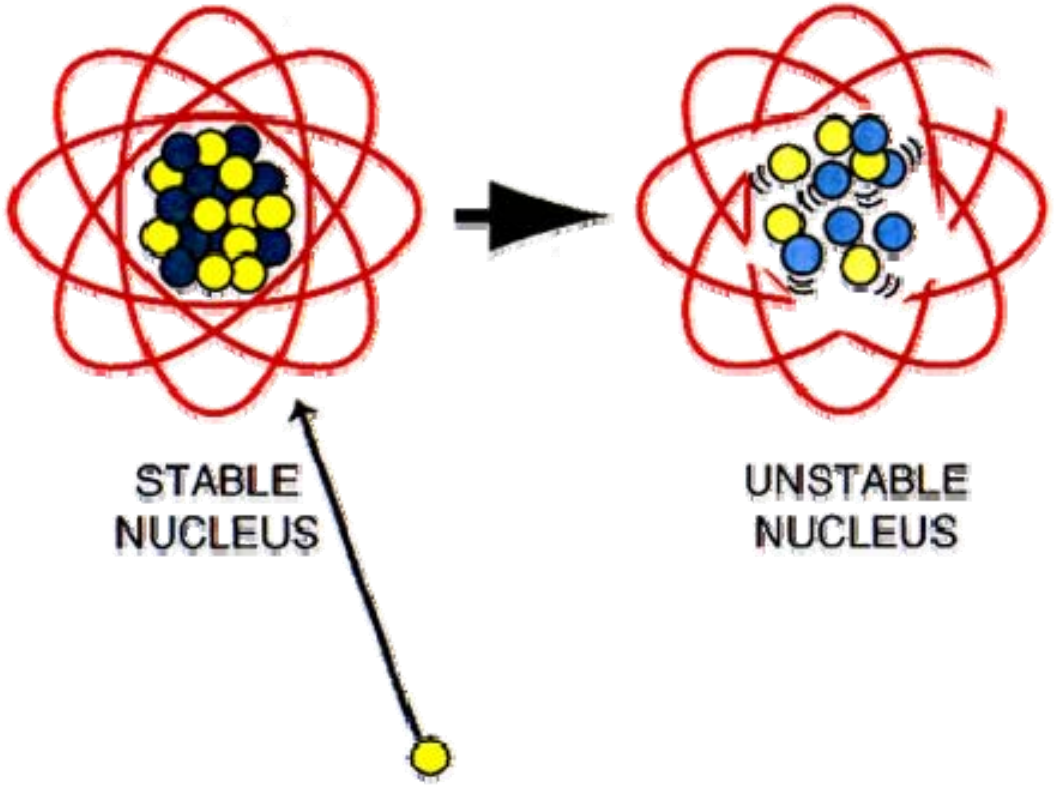
Ionizing Radiation

Excess energy (from unstable atoms) capable of removing orbiting electrons from an atom, producing electrically-charged particles called ions. The "free" electron (- charge) and the remaining atom (+ charge) are the ions.



Stability of Nucleus

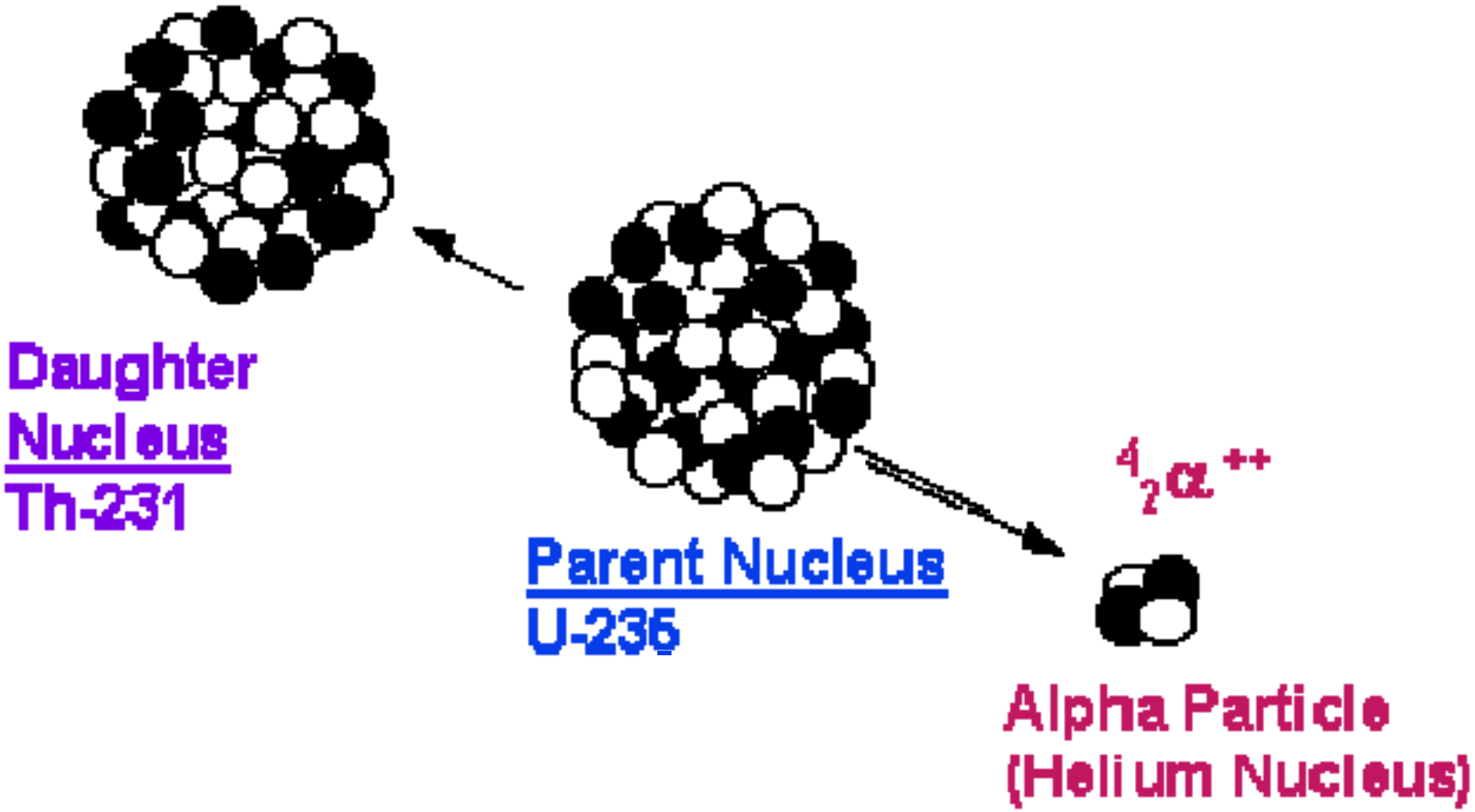
NUCLEI MAY BE STABLE OR UNSTABLE



Do any or all of the following:

- **Emit particle**
  - Alpha (α)
  - Beta (β)
  - **Positron**
  - **Neutron**
- **Emit EM radiation**
  - Gamma (γ)
- **Grab electron**
- **Split (fission)**

Alpha Particle Radiation

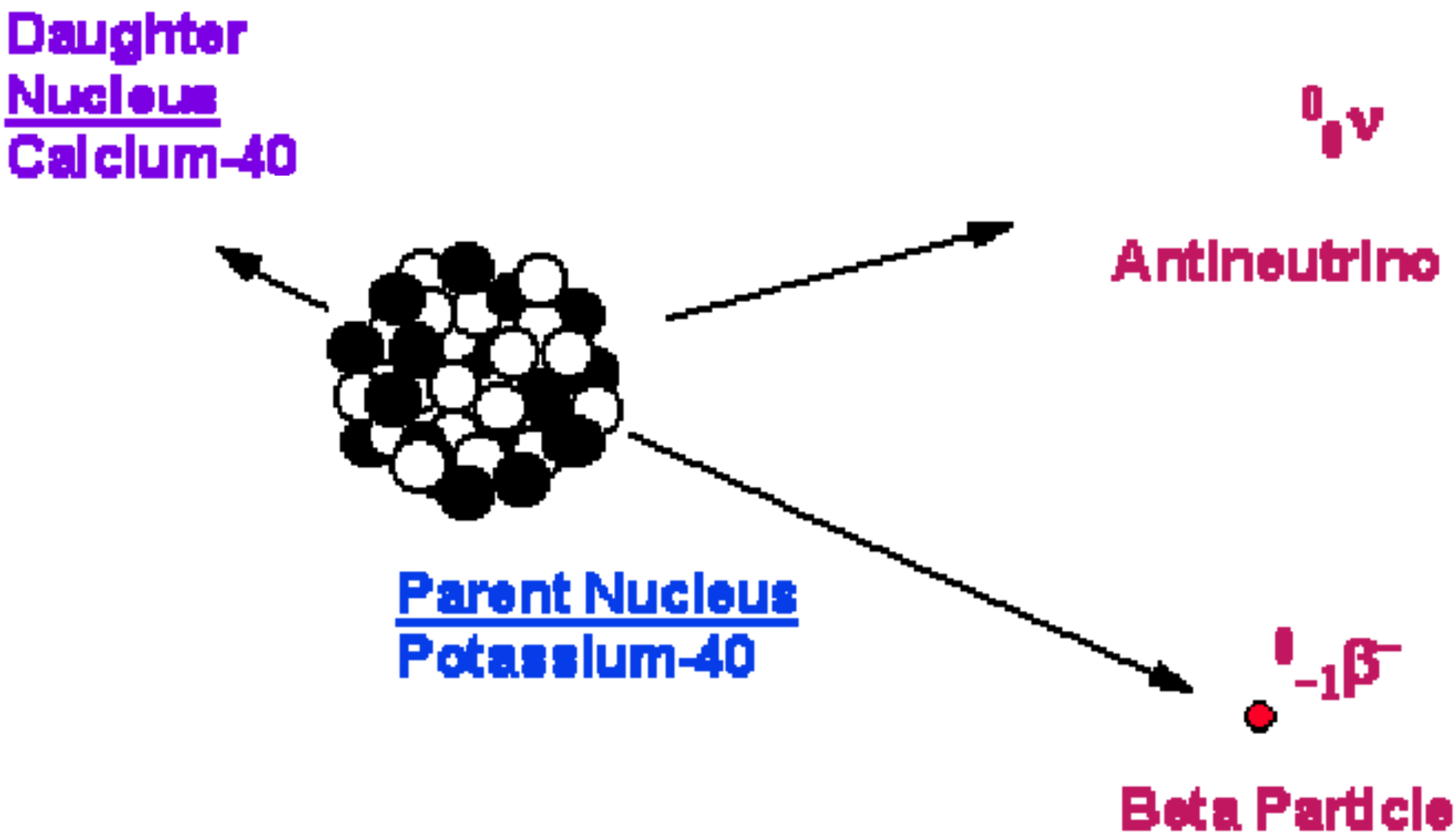


Alpha Particle Radiation

Alpha

- **Large, highly positive charged particle**
- **Range in air about 1 - 2 inches**
- **Shielding can be a piece of paper, clothing or even the dead outer layer of skin**
- **Biological hazard is inhalation or ingestion**

Beta Particle Radiation

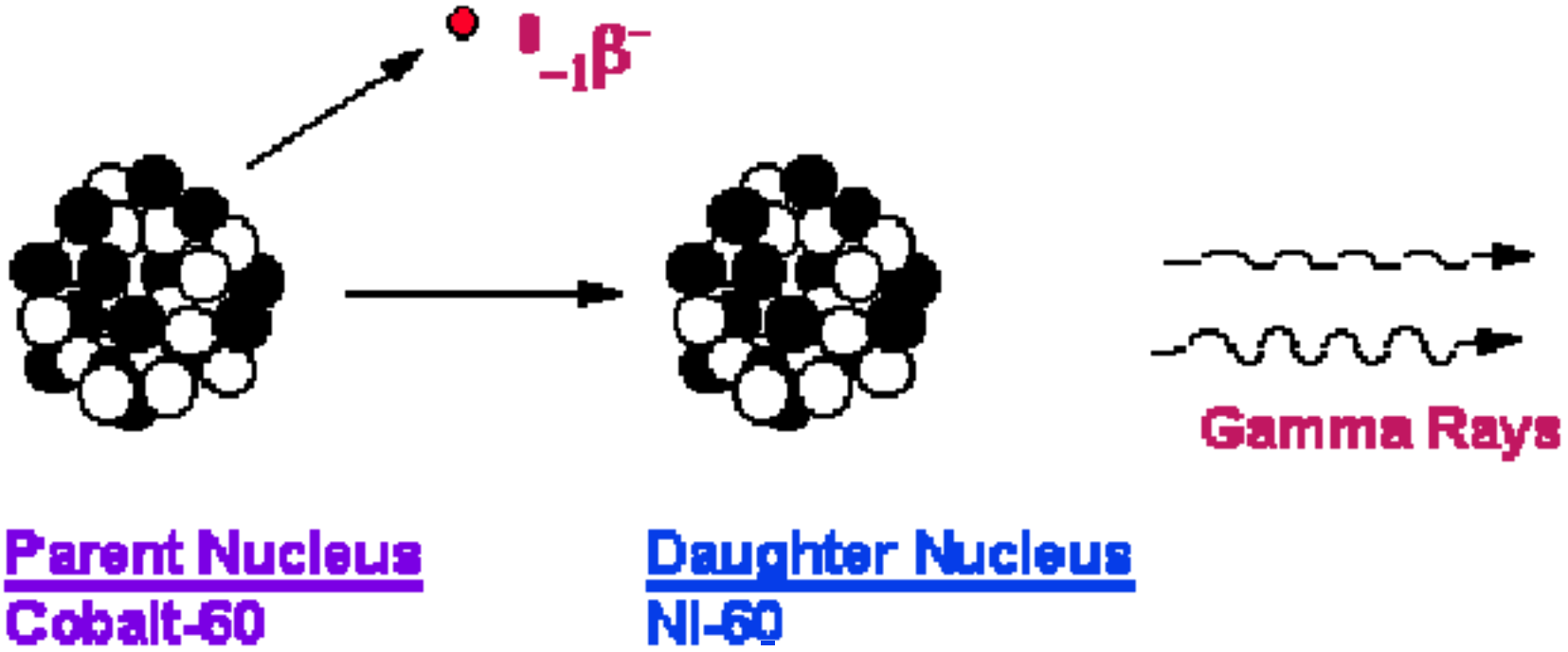


Beta Particle Radiation

Beta

- **Small, negative charged particle**
- **Range in air is about 10 feet**
- **Shielding can be plastic, glass, metal foil, or safety glasses**
- **Biological hazard is inhalation or ingestion**
- **Externally, the eyes and skin are at risk**

Gamma-Ray Radiation



Gamma-Ray Radiation

Gamma

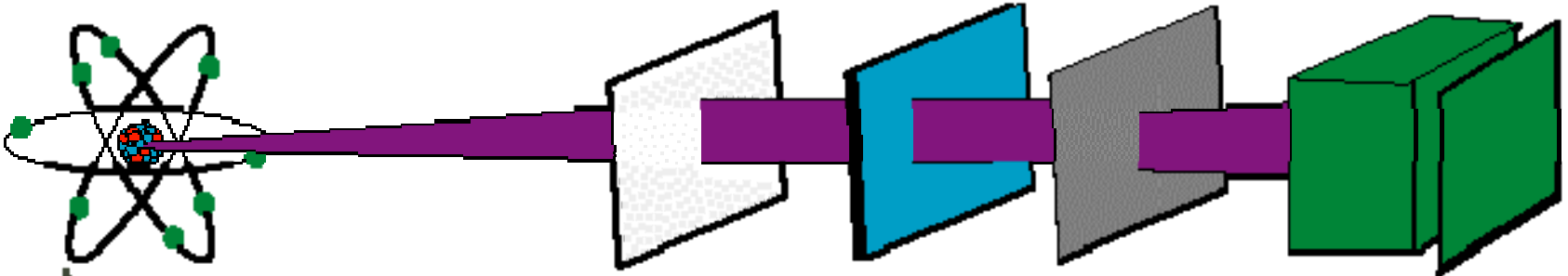
- **Electromagnetic waves or photons that have no charge, similar to X-rays**
- **Range in air is several hundred feet**
- **Shielding is more difficult due to high penetrating power - dense materials (high Z number) such as concrete, lead, steel**
- **Biological hazard is whole body**

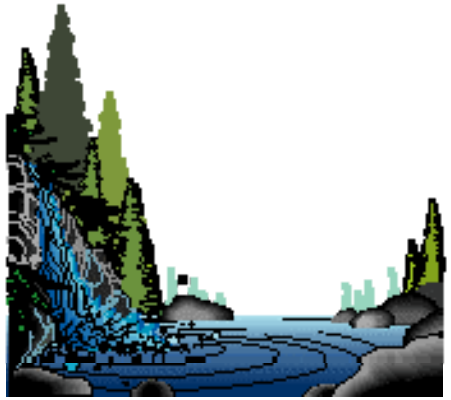
Neutron Radiation

are very penetrating;
therefore, they can affect all organs.

eyes are the most susceptible

slowed by hydrogenous materials and then absorbed by cadmium or boron





few natural emitters

reactors,
research accelerators

Neutron Radiation

Neutron

- **Neutral particle ejected from nucleus**
- **Range in air is several hundred feet**
- **Shielding is better with materials that have high hydrogen content - water, plastic, boron, and even paraffin (low Z number)**
- **Biological hazard is whole body due to high penetrating power**

Half-Life

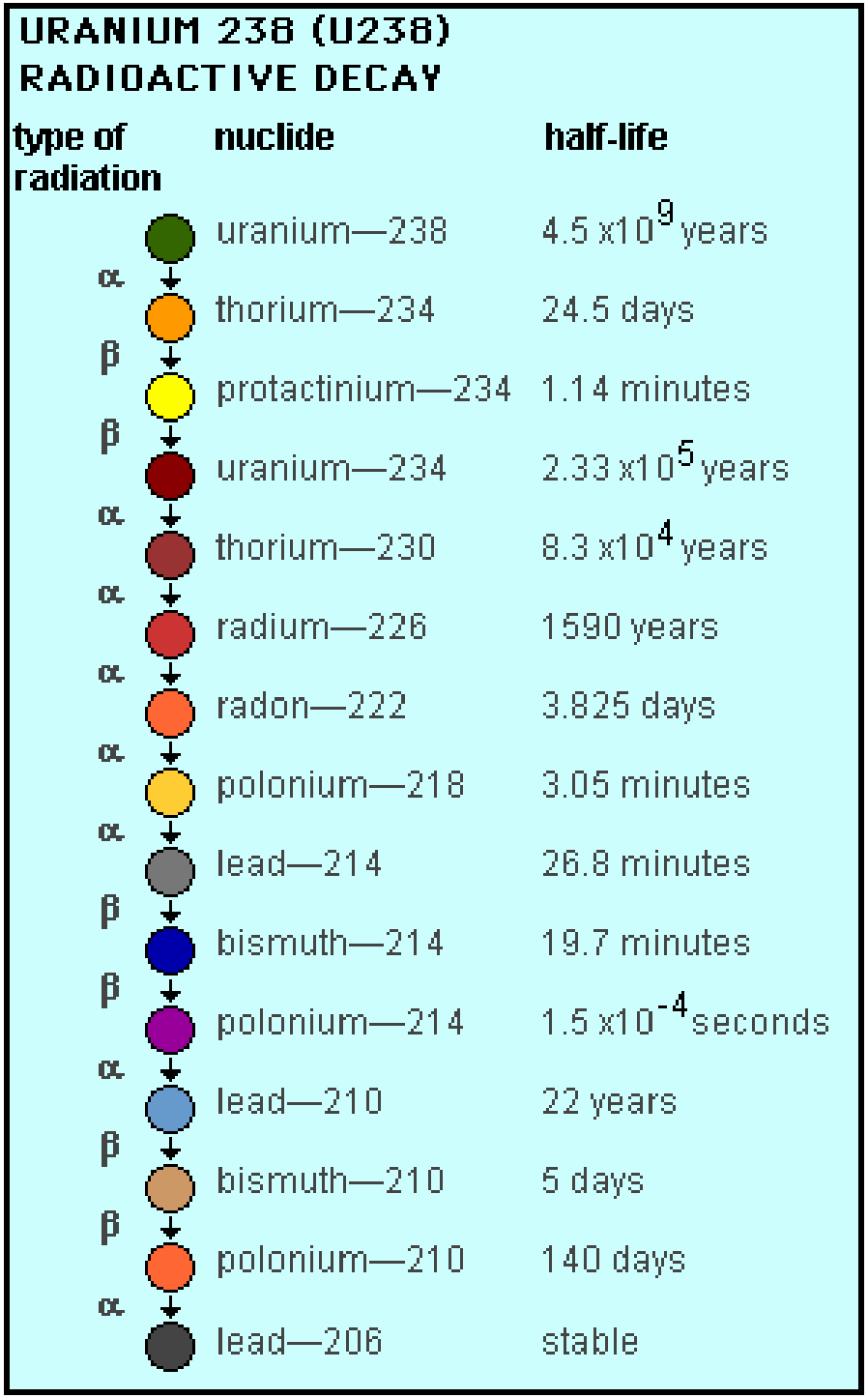
- **Radioactive Decay:**

The process of radioactive materials releasing their energy over a period of time to become stable.

- **Radioactive Half-Life:**
  - **The time it takes for one-half of the material to decay**
  - **After seven half-lives, the activity will be less than 1% of the original activity**

Half-Life


daughter
parent
daughter
parent
One half-life
Two half-lives


URANIUM 238 (U238)
RADIOACTIVE DECAY
type of radiation
nuclide
half-life
uranium—238
4.5 x10^9 years
α
thorium—234
24.5 days
β
protactinium—234
1.14 minutes
β
uranium—234
2.33 x10^5 years
α
thorium—230
8.3 x10^4 years
α
radium—226
1590 years
α
radon—222
3.825 days
α
polonium—218
3.05 minutes
α
lead—214
26.8 minutes
β
bismuth—214
19.7 minutes
β
polonium—214
1.5 x10^-4 seconds
α
lead—210
22 years
β
bismuth—210
5 days
β
polonium—210
140 days
α
lead—206
stable

UNITS OF MEASURE

Units for Radiation Dose and Exposure

Roentgen (R)
Unit for measuring exposure
Defined only for effect on air
Applies only to gamma and X-ray radiation
Does not relate biological effects of radiation to the human body

Units for Radiation Dose and Exposure

Rad (Radiation Absorbed Dose)
Unit for measuring absorbed dose in any material
Defined for any material.
Applies to all types of radiation
Does not take into account the potential effect that different types of radiation have on the body

Units for Radiation Dose and Exposure

Rem (Roentgen Equivalent Man)
Unit for measuring effective dose equivalence (most commonly used unit)
Pertains to human body
Applies to all types of radiation
Takes into account the energy absorbed (dose) and the biological effect on the body due to the different types of radiation

Units for Radiation Dose and Exposure

Roentgen (R)	**Rad (Radiation Absorbed Dose)**	**Rem (Roentgen Equivalent Man)**
Unit for measuring exposure.	Unit for measuring absorbed dose in any material.	Unit for measuring dose equivalence (most commonly used unit)
Defined only for effect on air.	Defined for any material.	Pertains to human body.
Applies only to gamma and X-ray radiation.	Applies to all types of radiation.	Applies to all types of radiation.
Does not relate biological effects of radiation to the human body.	Does not take into account the potential effect that different types of radiation have on the body.	Takes into account the energy absorbed (dose) and the biological effect on the body due to the different types of radiation.

Rem = Rad x QF

Not All Radiation Is The Same

- **Different radiation has different biological effects**
- **Biological QUALITY FACTORS**
  - **Alpha = 20** α
  - **Neutron = 10** η
  - **Beta = 1** β
  - **Gamma = 1** γ

Prefixes for Units

PREFIX	FACTOR	SYMBOL	PREFIX	FACTOR	SYMBOL
yotta	10^{24}	Y	deci	10^{-1}	d
zetta	10^{21}	Z	centi	10^{-2}	c
exa	10^{18}	E	**milli**	$\mathbf{10^{-3}}$	**m**
peta	10^{15}	P	**micro**	$\mathbf{10^{-6}}$	**μ**
tera	$\mathbf{10^{12}}$	**T**	**nano**	$\mathbf{10^{-9}}$	**n**
giga	$\mathbf{10^{9}}$	**G**	**pico**	$\mathbf{10^{-12}}$	**p**
mega	$\mathbf{10^{6}}$	**M**	femto	10^{-15}	f
kilo	$\mathbf{10^{3}}$	**k**	atto	10^{-18}	a
hecto	10^{2}	h	zepto	10^{-21}	z
deka	10^{1}	da	yocto	10^{-24}	y

Prefixes for Units

1 rem = 1,000 mrem (millirem)

1 mrem = 1,000 µrem (microrem)

1 µrem = 1,000 nrem (nanorem)

The same holds true for the new SI units, i.e.,

1 Sievert (Sv) = 1,000 mSv (millisieverts)

1 mSv = 1,000 µSv (microsieverts)

Unit Conversions

	Source Activity (disintegrations per unit time)	Exposure	Dose
Old Units	**Curie (Ci) = 37×10^9 dps dps = disintegrations per second**	**Roentgen (R). RAD or rad: radiation absorbed dose**	**Rem – roentgen equivalent man**
New SI Units	**Becquerel (Bq) 1 Bq = 1 dps 1 Ci = 37 GBq**	**Gray (Gy) 1 Gy = 100 rad 1 rad = 1 cGy**	**Sievert (Sv) 1 Sv = 100 rem 1 rem = 10 mSv**

For gamma and x-ray radiation, a common "conversion factor" between exposure, absorbed dose, and dose equivalent is:

1 R = 1 rad = 1 rem

SOURCES OF RADIATION

Natural Sources of Radiation

- **Cosmic radiation**
- **Terrestrial radiation**
- **Radon**
- **Human body**

Man-made Sources of Radiation

- **Medical radiation**
- **Building materials**
- **Consumer products**
- **Domestic water**
- **Other minor sources**

Average Annual Dose

Cosmic radiation – 26 mrem/yr @ sea level

Terrestrial radiation – 28 mrem/yr

Radon – 200 mrem/yr

Human body – 40 mrem/yr

Medical radiation – 54 mrem/yr

Building materials – 7 mrem/yr

Domestic water – 5 mrem/yr

Average Annual Total – 360 mrem/yr

BIOLOGICAL EFFECTS OF RADIATION EXPOSURE

Two Categories of Radiation Dose

- **Acute**
- **Chronic**

Acute Radiation Doses

- **An acute effect is a physical reaction due to massive cell damage.**

- **Damage caused by a large amount of radiation in a short period of time.**

Acute Radiation Dose Effects

Blood changes	**25 – 100 Rad**
Anorexia (loss of appetite)	**150 Rad**
Nausea	**200 Rad**
Fatigue	**220 Rad**
Vomiting	**280 Rad**
Epilation	**300 Rad**
Diarrhea	**350 Rad**
Mortality (w/o supportive care)	**350 Rad**
Mortality (with supportive care)	**500 Rad**

Chronic Radiation Doses

- **Chronic radiation dose is typically a small amount of radiation received over a long period of time.**

- **Example: the dose we receive from natural background radiation every day of our lives.**

Chronic Radiation Dose Effects

- **The principal effect of chronic radiation dose is increased risk of contracting cancer.**

- **No increased risk of cancer has been observed in individuals who receive radiation dose at occupational levels (500 – 5,000 mrem/yr).**

- **No observable radiation effects in humans below a one-time dose of about 10,000 mrem.**

Possible Effects of Radiation on Cells

When a cell is exposed to ionizing radiation, several things can happen:

- **No damage**
- **Cells repair the damage and operate normally**
- **Cells are damaged and operate abnormally**
- **Cells die as a result of the damage**

Factors Affecting Biological Damage from Radiation

- **Total dose**
- **Dose rate**
- **Type of radiation**
- **Area of the body receiving the dose**
- **Cell sensitivity**
- **Individual sensitivity**

Comparison of Risks

Health Risk	*Estimate of Life Expectancy Lost*
Smoking 20 cigarettes a day	**6 years**
Overweight (by 15%)	**2 years**
Alcohol consumption (U.S. average)	**1 year**
Agricultural accidents	**320 days**
Construction accidents	**227 days**
Automobile accidents	**207 days**
Home accidents	**74 days**
1 rem/yr from age 18 to 65	**51 days**
All natural hazards (earthquake, etc.)	**7 days**
Medical radiation	**6 days**

RADIATION PROTECTION

ALARA

As

Low

As

Reasonably

Achievable

ALARA Exposure Practices

There are three basic practices used to maintain exposures to ALARA:

TIME	Reduce Exposure Time
DISTANCE	Increase Distance
SHIELDING	Use Shielding

TIME

DOSE RATE: Energy per unit time

DOSE: Total energy absorbed

Dose = (Dose rate) x Time

Example of dose rate: 100 mrem/hr

TIME

DOSE RATE: Energy per unit time

DOSE: Total energy absorbed

Dose = (Dose rate) x Time

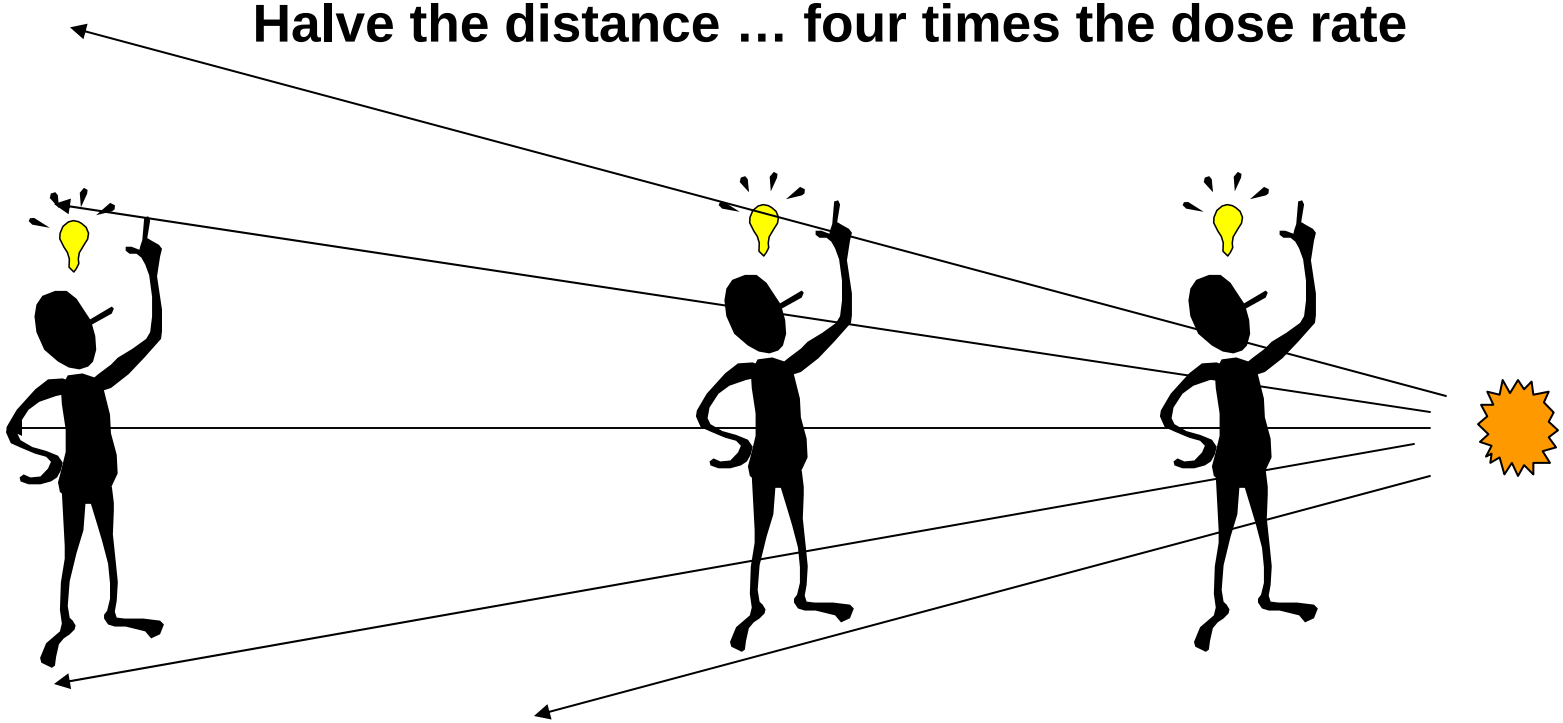
Example of dose rate: 100 mrem/hr

- **If you stayed in this *dose rate* for an hour, what would your *total dose* be ?**
- **What would your *dose* be after 15 minutes ?**
- **If your allowed total dose is 75 mrem, what is your stay time ?**

DISTANCE

Inverse Square Law

Double the distance … ¼ the dose rate
Halve the distance … four times the dose rate



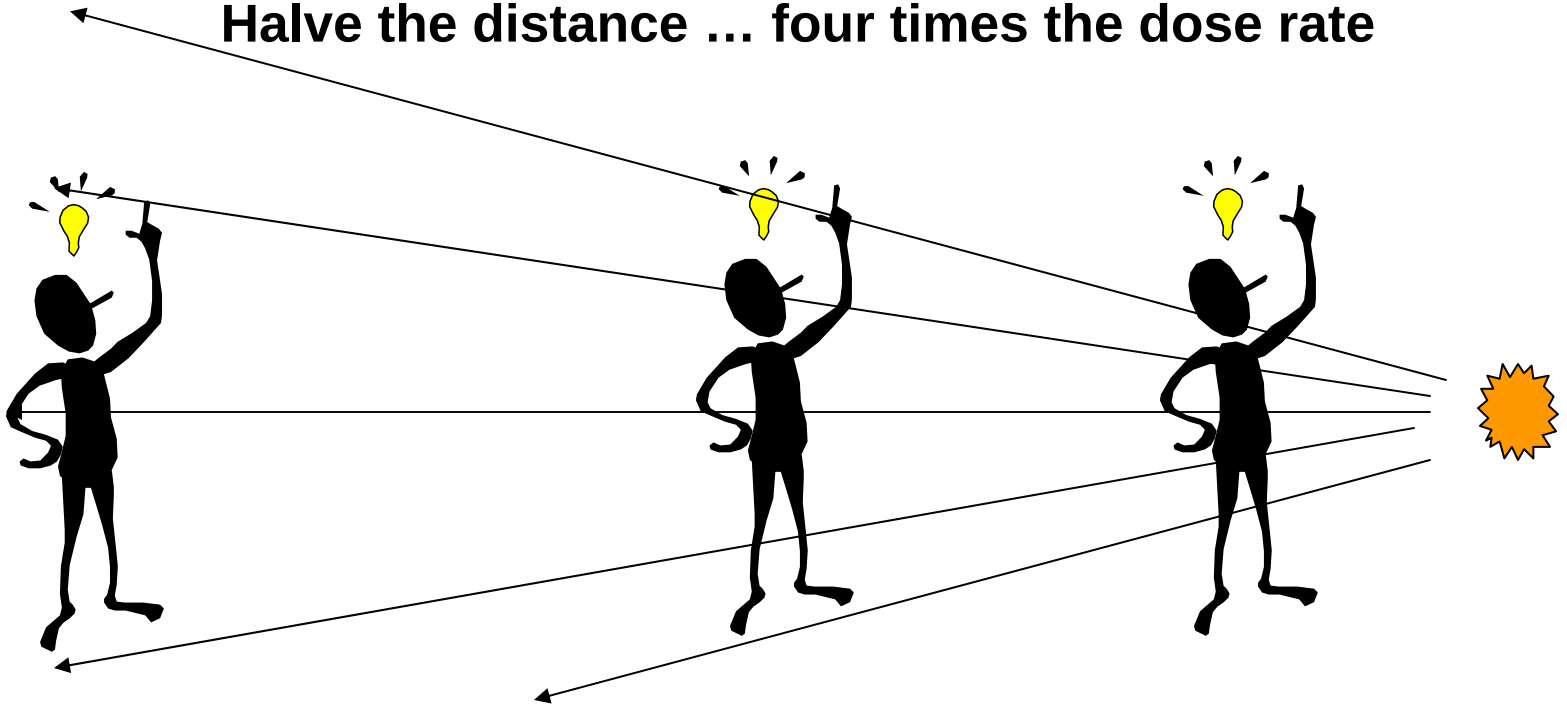
DISTANCE

Inverse Square Law

$$R_1 D_1^2 = R_2 D_2^2$$

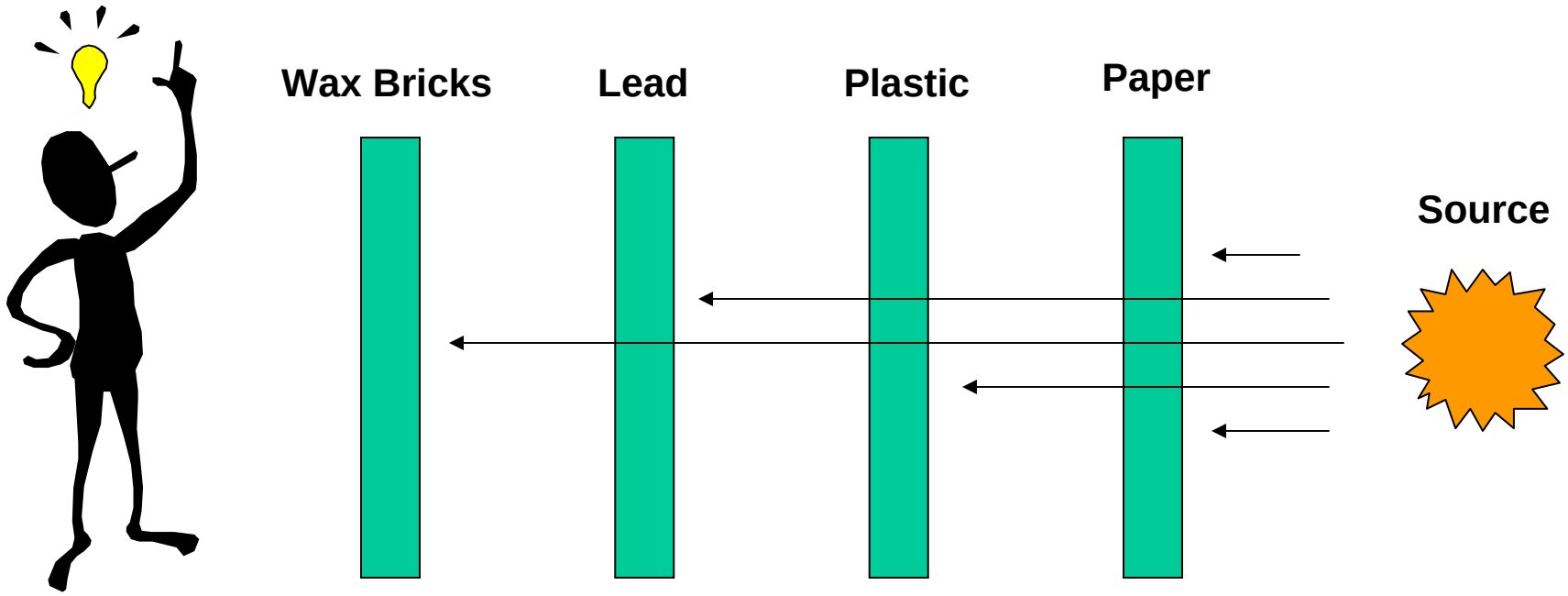
R = Radius, D = Dose Rate

Double the distance … ¼ the dose rate
Halve the distance … four times the dose rate



SHIELDING

Shielding: **Material between you and the source**



Radiation Dose Limits *

	Mrem
Annual limit for occupational workers	**5,000**
Annual limit for member of public	**100**

*** Limits for radiation exposure above background radiation (360 mrem/yr U.S. average)**

ALARA

Radiation exposure to the work force and general public shall be controlled such that exposures are well below regulatory limits and that there is:

- no radiation exposure without an equal benefit.