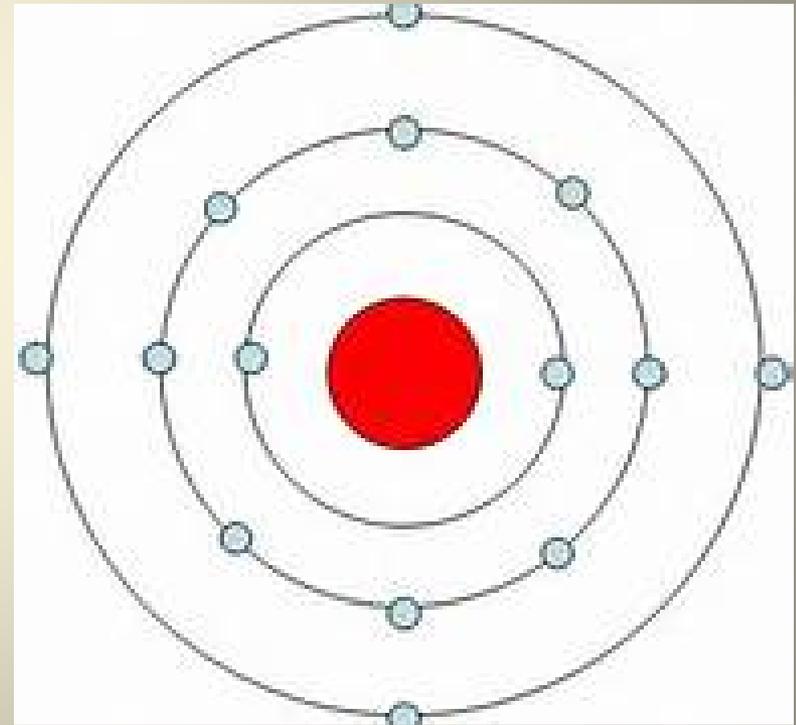


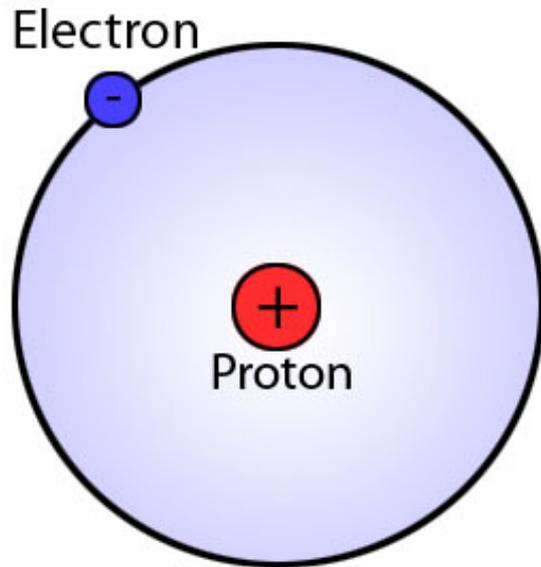
EHS RADIATION SAFETY TRAINING

- This training is required of all persons who work with radioactive materials or radiation producing machines. It should be completed prior to any work with sources. If you need further information or have questions contact EHS at hbarrett@fa.ua.edu or 348-5905. In order to get credit for initial training follow the instructions on the last slide.

The Bohr Model

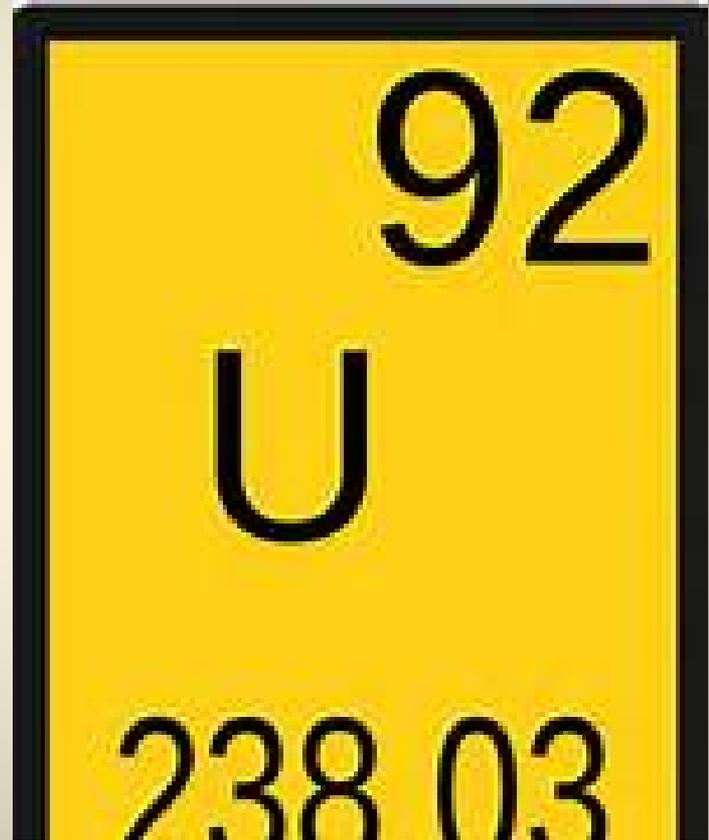
The Bohr atomic model is a central nucleus composed of neutrons and protons surrounded by electrons. The number of electrons and protons are equal.

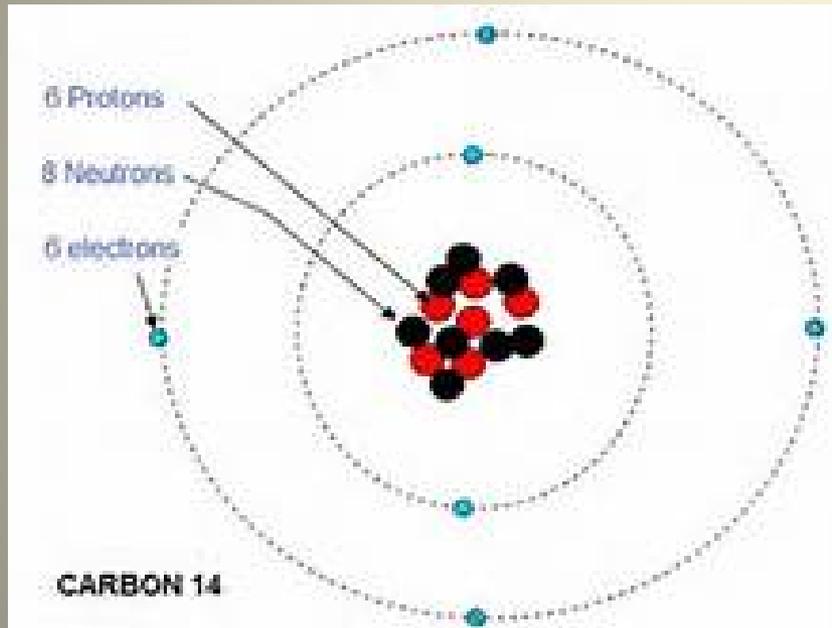




- Protons have a positive charge. Neutrons have no charge. Electrons have a negative charge

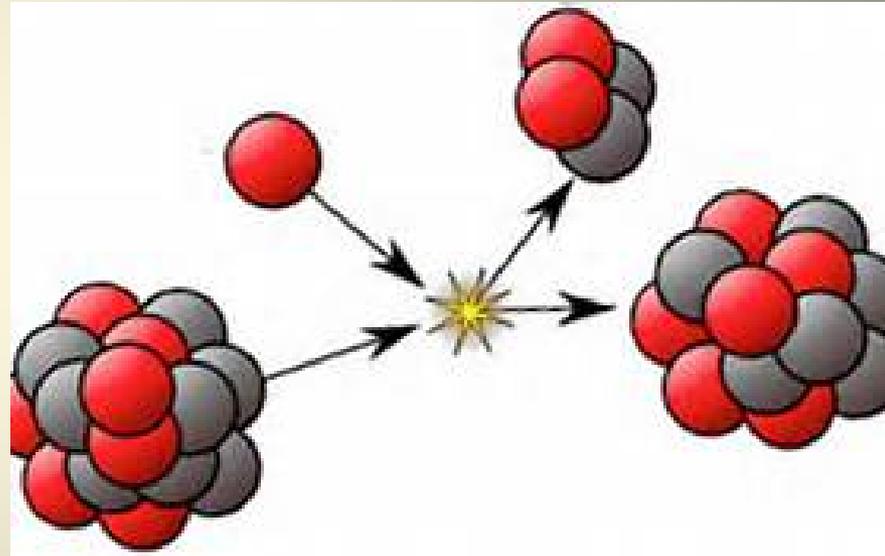
- The atomic number is the number of protons in the nucleus. For example the atomic number for Uranium is 92.

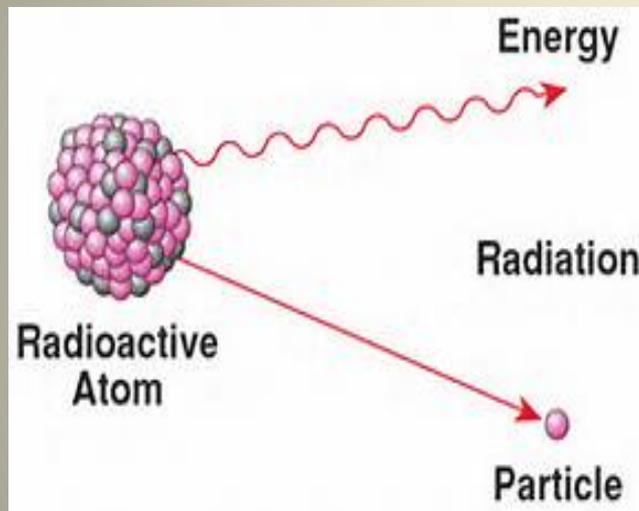




- An element may have several isotopes. An isotope has the same number of protons but a different number of neutrons. C14, S35 and P32 are examples of isotopes.

- Many isotopes are stable. However unstable isotopes release energy by radioactive decay.

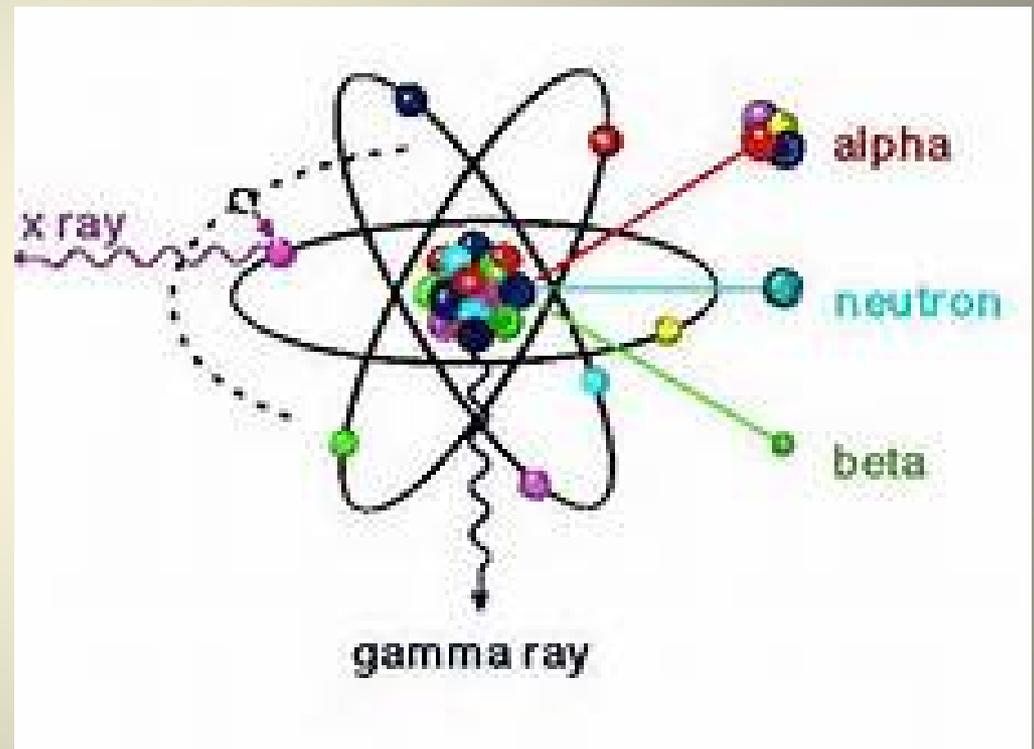




- Radioactivity is the natural and spontaneous process by which an unstable isotope decays to a different state and emits excess energy in the form of particles or waves.

Examples of ionizing radiation

- Alpha particles
- Beta particles
- Gamma rays
- Neutrons
- Xrays

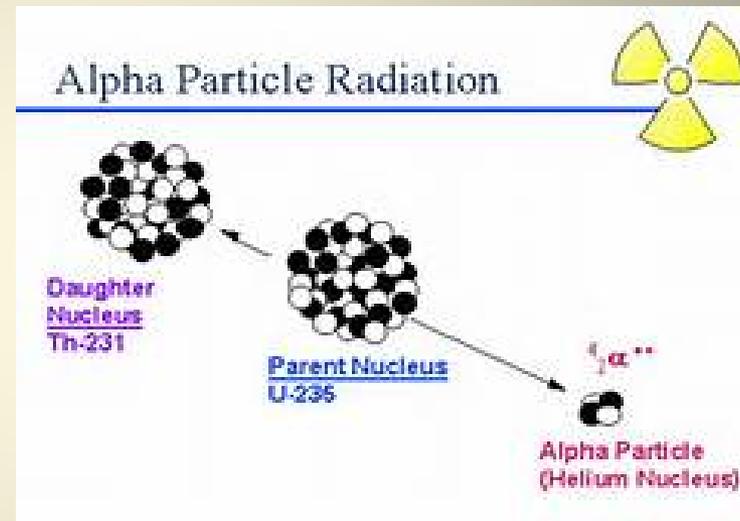


- An isotope decays through a specific set of transformations in an effort to reach stability. For example P32 to S32 is accompanied by the emission of a beta particle.



Alpha particle

- Composed of 2 neutrons and 2 protons. They are relatively heavy and will travel only a short distance.





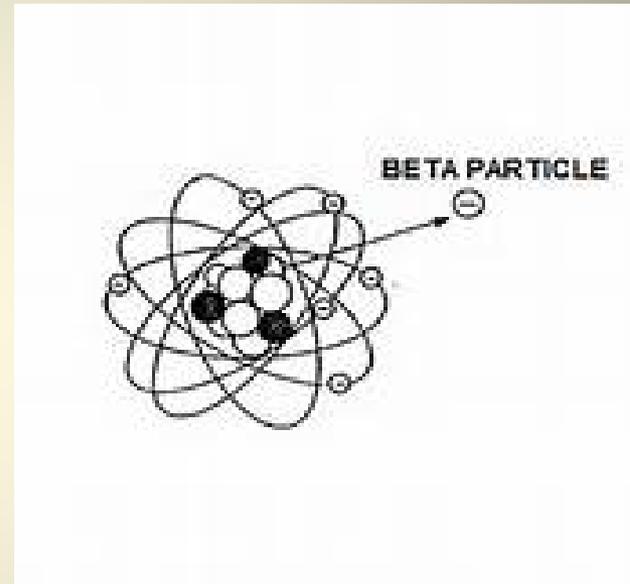
- Alpha particles are easily shielded and cannot penetrate the skin.



- Alpha particles do not present an external exposure hazard. However they can present a serious hazard if inhaled or ingested.

Beta particle

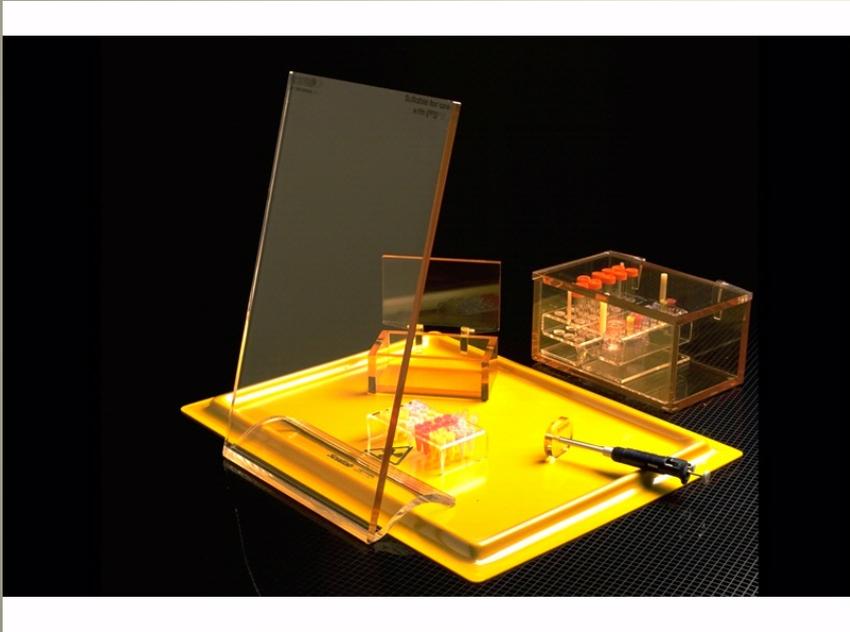
- A beta particle is an electron emitted from an atom. Examples of beta emitters commonly used on campus are H3, C14, P32 and S35.



- Beta particles have a longer range than alphas. High energy betas (P32) can penetrate the skin while low energy betas (H3) cannot.

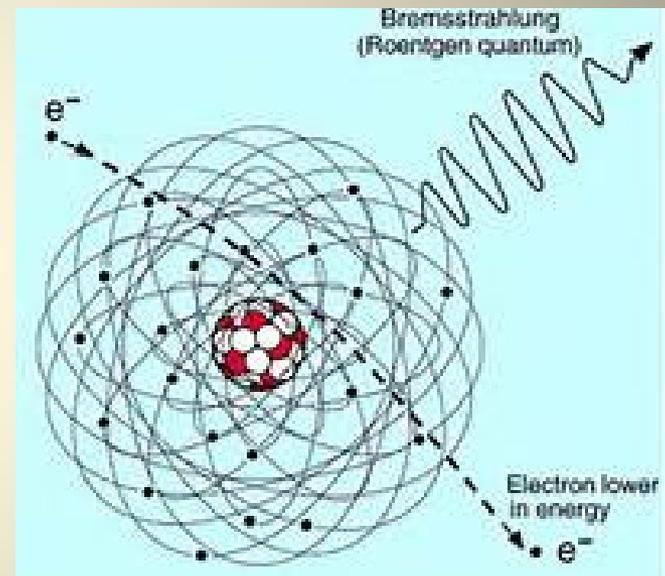


- Beta particles may require shielding. All present a problem if inhaled, absorbed or ingested.



Bremsstrahlung

- A secondary x-ray radiation produced when beta particles pass near the nuclei of atoms. Can be a problem with high energy beta emitters like P32.



- To reduce bremsstrahlung use plexiglass shielding for beta emitters instead of lead.



Gamma Rays

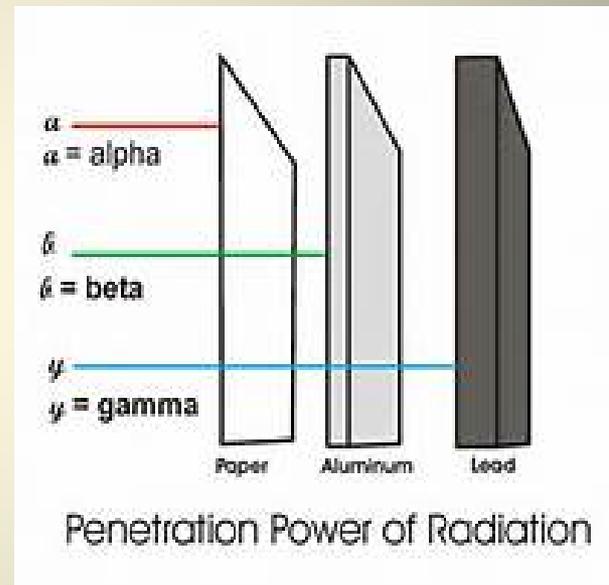
- A gamma ray is a photon of electromagnetic radiation emitted from the nucleus during decay.





- Gamma rays are high energy with no mass or charge and can travel significant distances.

- Gamma radiation is an external hazard. Shielding is typically very dense for example lead.

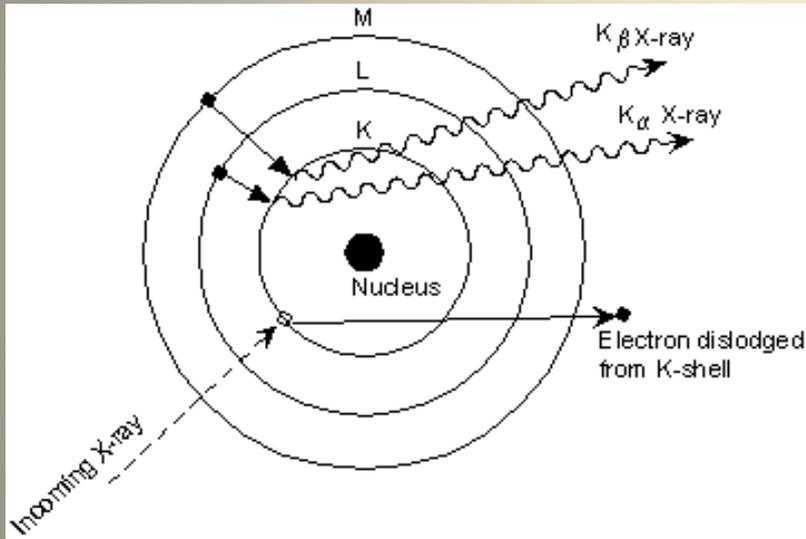


- Gamma emitters commonly used on campus are Co60, Cs137 and Ra226.

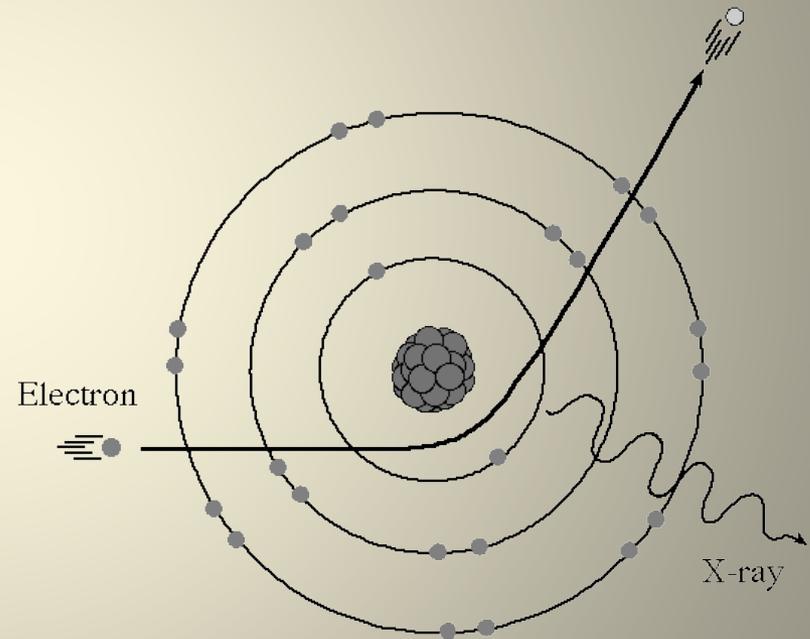


X-rays

- Produced as the result of changes in the positions of electrons as they shift to different energy levels.



- Xrays can be produced as a result of decay or by Bremstrahlung radiation.

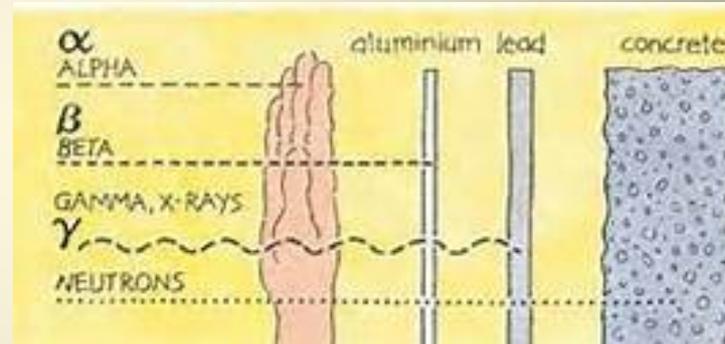


- Sources of x-rays on campus include isotopes such as I125 and I131 and analytical xray machines.



Neutron Radiation

- Neutron radiation was discovered as a result of observing beryllium interacting with an alpha particle and emitting a neutron.



- Neutron radiation normally comes from sources such as nuclear reactors or particle accelerators.



Activity

- Quantities of radioactive material is measured in activity rather than mass. Activity is the number of disintegrations per a given period of time.



- The most common units of activity are the Curie or the Becquerel (SI).



- 1 Curie (Ci) = 3.7×10^{10} disintegrations per sec
- 1 Becquerel (Bq) = 1 disintegration per sec



- Normally at UA millicurie or microcurie amounts are generally used.
- $1 \text{ mCi} = 2.2 \times 10^9$
 $\text{dpm} = 3.7 \times 10^7 \text{ Bq}$
- $1 \text{ uCi} = 2.2 \times 10^6$
 $\text{dpm} = 3.7 \times 10^4$



Intensity

- A more useful way to describe potential hazard than activity.



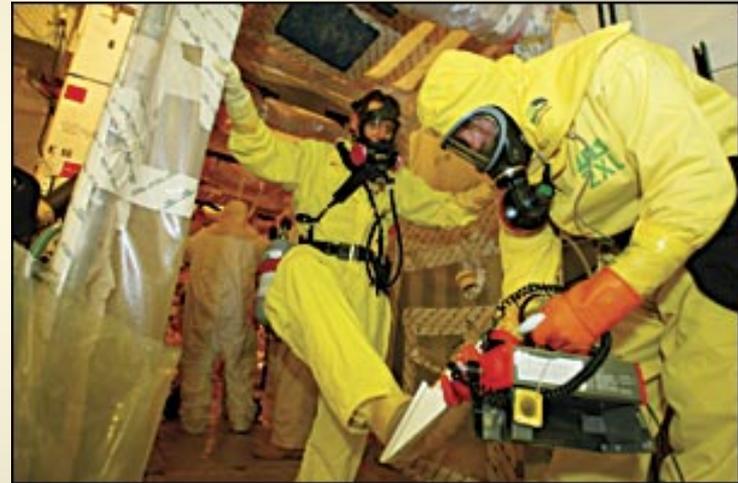
- Exposure, absorbed dose and dose equivalent are the quantities which describe radiation intensity.



- Exposure is expressed in units of Roentgen (R) or Coulombs/kg. It is the amount of charge produced in 1 kg of air by x or gamma rays.
- $1R=2.58 \times 10^{-4} \text{ Cb/kg}$



- Absorbed dose is expressed in units of Rad or Gray. It is the amount of energy absorbed in 1 gram of matter from radiation.
- $1 \text{ rad} = 100 \text{ ergs/gram}$
- $1 \text{ Gray} = 100 \text{ rad}$

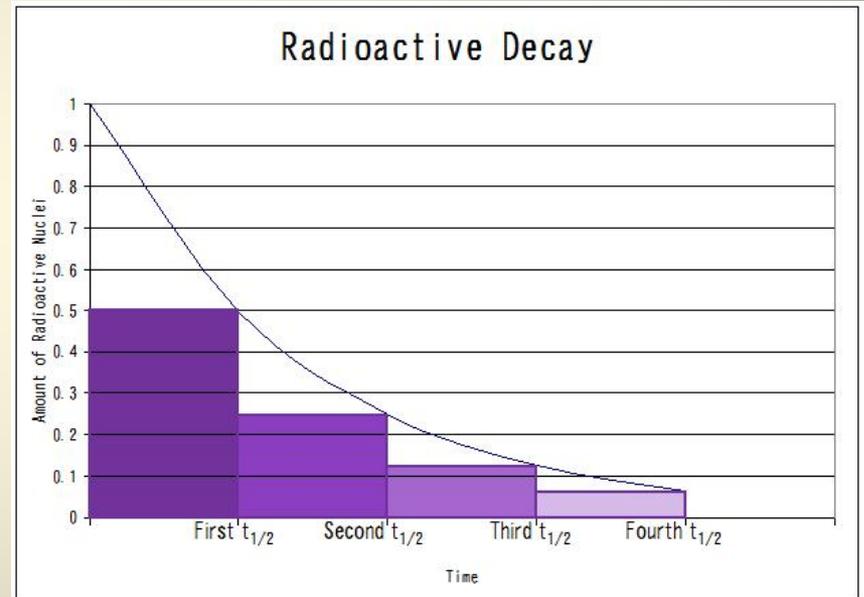




- Dose equivalent is expressed in units of Rem or Seivert. It is absorbed dose modified by the ability of the radiation to cause biological damage.
- $\text{Rem} = \text{rad} \times \text{quality factor}$
- $1 \text{ Sv} = 100 \text{ rem}$

Half Life

- Radioactive materials decay at rates unique to each isotope. The half life is the time required for the material to be reduced to $\frac{1}{2}$ of its original activity.





- Half life of commonly used isotopes:
- H3 12.3 yrs
- C14 5730 yrs
- P32 14.3 days
- S35 87.6 days
- I125 60.1 days



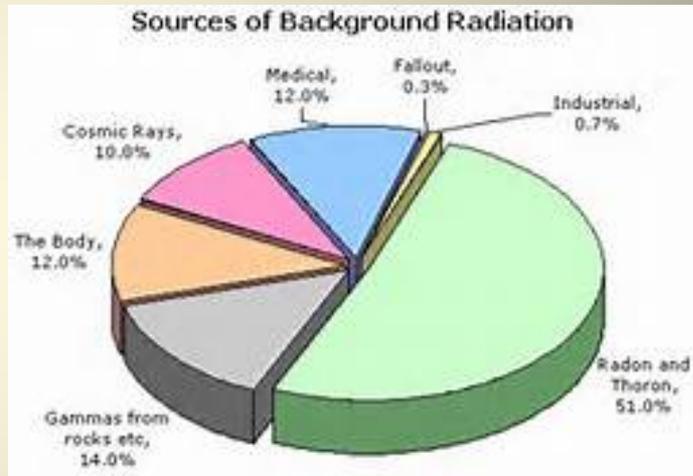
- When a material goes through 10 half lives the activity is considered to be zero.

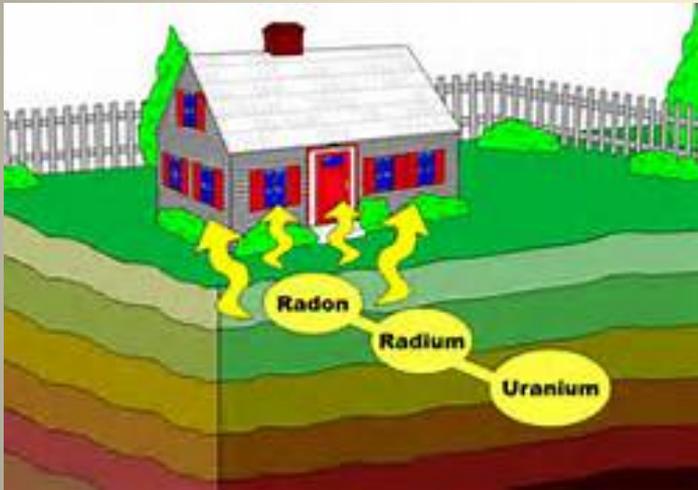
Background Radiation

- We are all exposed to ionizing radiation from natural sources constantly.



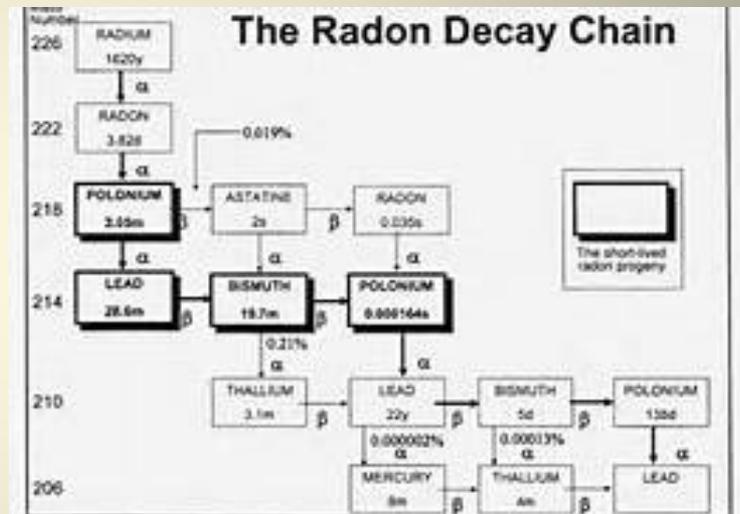
- Sources of background radiation include radioactive material and gasses naturally in the earth, cosmic rays and trace amounts of isotopes present in the body.





- Sources in the earth include long half life isotopes and their decay products for example uranium-thorium-radon.

- Geologically speaking exposure to radon gas is not a problem in the Tuscaloosa area.





- Cosmic rays are high energy particles which originate in stars. Exposures at high altitudes are greater than those at sea level.

- Natural radioactivity in the body comes from isotopes present in our food, water and air we breathe. The most common isotopes are H3, C14 and K40.



- Radiation dose to U.S. population:
- Cosmic 31
- Terrestrial 19
- Radon 229
- Internal 16
- Medical 300
- Others 25
- Avg. annual total 620 mrem/yr.



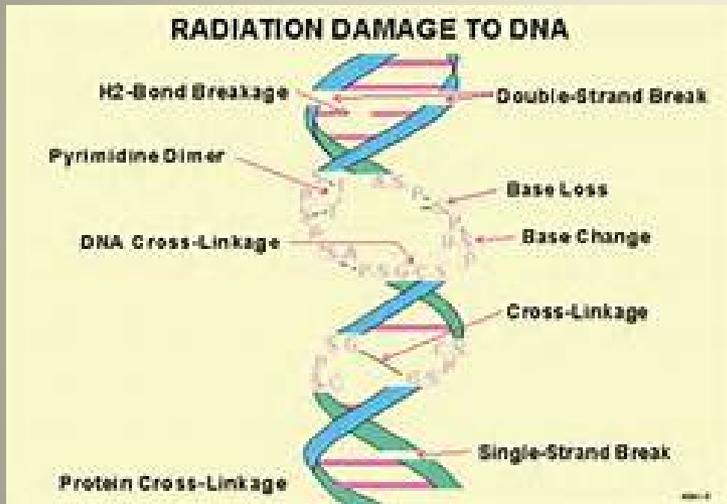
- Average doses from common activities:
- Smoking 280 mrem/yr
- Working in UA lab <1
- X-rays 20
- Drinking water 5
- Cross country flight 5
- Coal burning 0.165



Biological Effects

- Injury to living tissue results from the transfer of energy to atoms and molecules in the cellular structure.





- The mechanisms of damage include:
- Producing free radicals
- Breaking chemical bonds
- Producing new chemical bonds
- Damaging molecules that regulate cell processes (DNA, RNA).

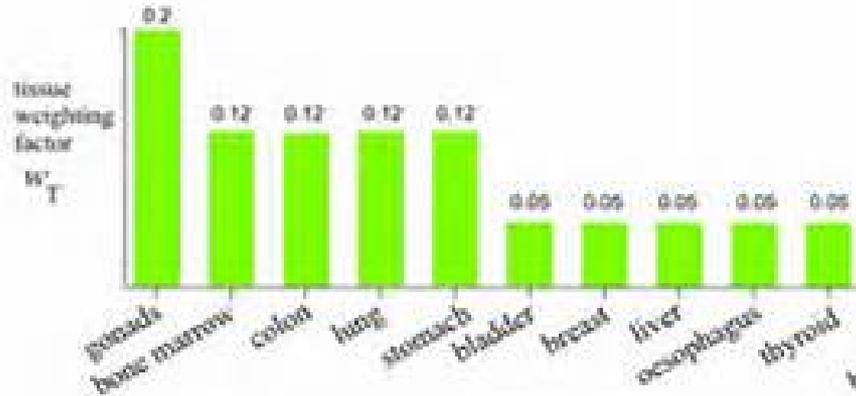
- At low doses cellular damage can be rapidly repaired. At higher doses cell death may result.



- Tissues are not equally sensitive to radioactivity.



Tissue/Organ Sensitivity (currently under review)



- In general tissue sensitivity is proportional to the rate of proliferation of cells and inversely proportional to the degree of cell differentiation.

- The blood forming and reproductive organs are the most sensitive tissues. A developing embryo is at it's most sensitive early in the pregnancy.



- Radiation effects may be prompt or delayed.



- Prompt effects occur after large doses of radiation over a short period of time.



- Delayed effects appear months or years following a radiation exposure.



- Prompt effects:
- Blood count 50 mrem
- Vomiting 100 mrem
- 100% death 800 mrem
- LD 50/60 500 mrem





- Effects can be very different when only portions of the body are irradiated. For example a full body dose of 500 mrem may be fatal. The same dose could be delivered as a medical treatment.



- Leukemia, multiple myeloma, breast and lung cancer may be induced by high doses.

- People associate exposure to radiation with an increased risk of cancer. A dose of 10 mrem creates a risk factor of death from cancer at 1 in 1 million.



- Other activities with a 1 in 1 million risk of death from cancer:
- Smoking 1.4 cigarettes during your life
- Spending 2 days in NY
- Driving 40 miles
- Flying 2500 miles
- Canoeing for 6 minutes





- There is little evidence of radiation induced genetic effects in humans.



- Prenatal exposure can result in low birth weight, mental retardation and other neurological problems.

Regulatory Elements

- The University of Alabama has been issued a license by the Alabama Department of Public Health.



- This license is issued by the State and specifies amounts, locations and conditions under which UA may use isotopes and equipment.





- A copy of The University license is available from EHS



- The State conducts periodic unannounced inspections of UA.



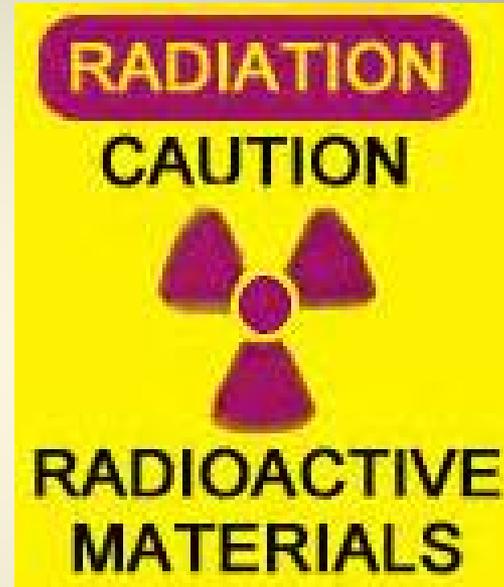
- A major part of this inspection is visiting labs and interviewing sub licensees and users.



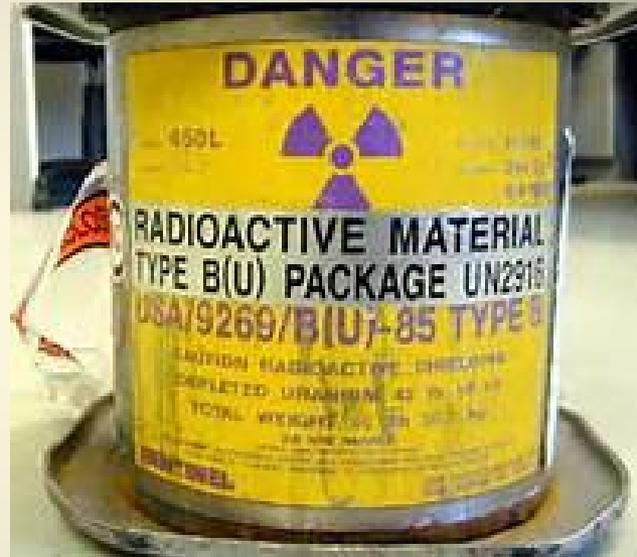
- If an inspector visits your lab answer their questions directly. Do not volunteer information or ramble. Simply wait until the next question is asked.

Radiation Safety Program

- The Radiation safety program is made up of four key elements:
- The RCAC
- EHS
- Sub licensees
- Users.



- The Radiation Control Advisory Committee (RCAC) is responsible for oversight of the program, advises the RSO and authorizes the use of radiation sources.





- The RCAC is made up of faculty and staff who have experience working with radioactive materials or equipment.

- All types of users are represented on the RCAC. This includes sealed sources, unsealed sources and xray producers.



- EHS manages the Radiation safety Program. The Radiation Safety Officer is Hal Barrett Director of EHS.





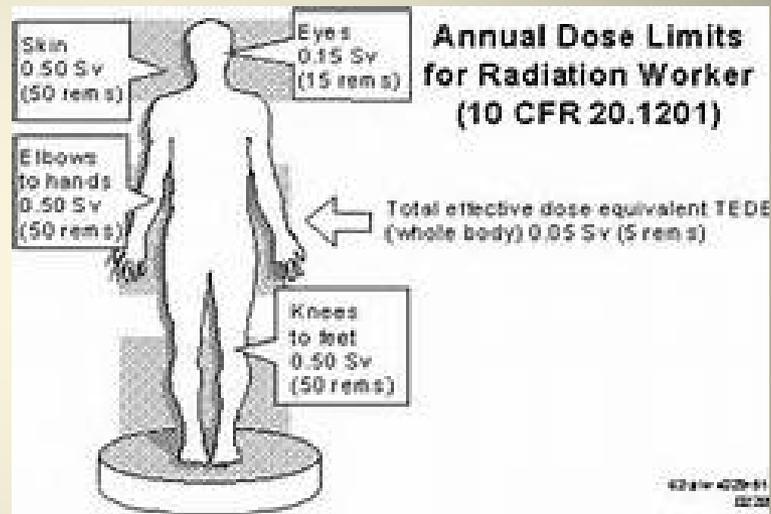
- Sub licensees are faculty or staff who are authorized by the RCAC to supervise labs where radioactive sources or machines are used.

- Users are faculty, staff, students or visitors who work with radioactive materials or machines under the supervision of the sub licensee.



Dose/Exposure Limits

- Dose limits are established by the State:
- Whole body 5 rem/yr
- Lens of eye 15 rem/yr
- Extremities 50 rem/yr
- Skin 50 rem/yr
- Fetus 0.5 rem/9 mo



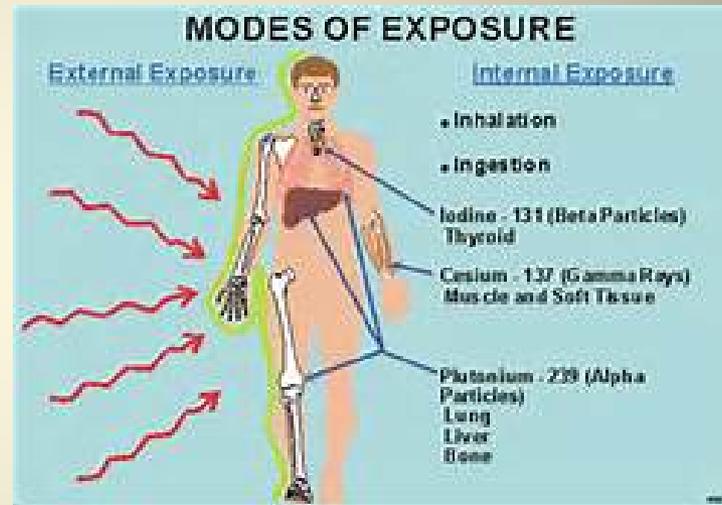


- The exposure limit for a minor is 10% for that of an adult.



- Exposure limit for the general public is 100 mrem/yr.

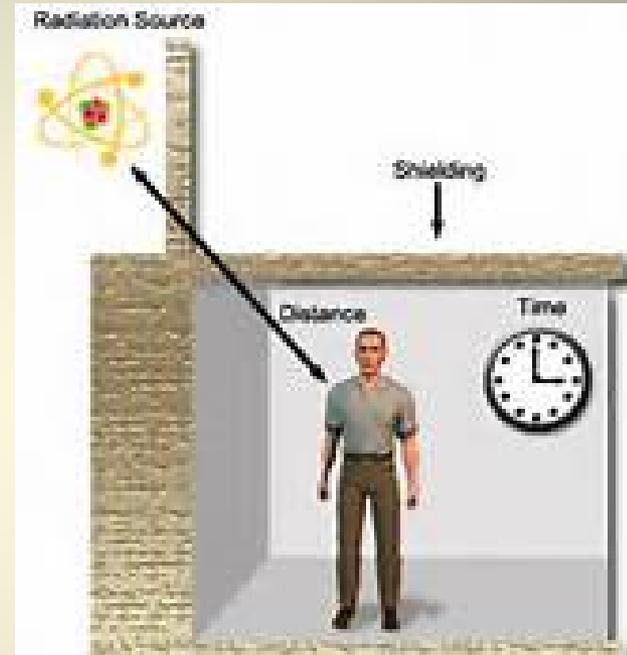
- EHS investigates any quarterly exposures above 100 mrem/quarter. Over the past 10 years there have been no exposures at UA that required investigation.



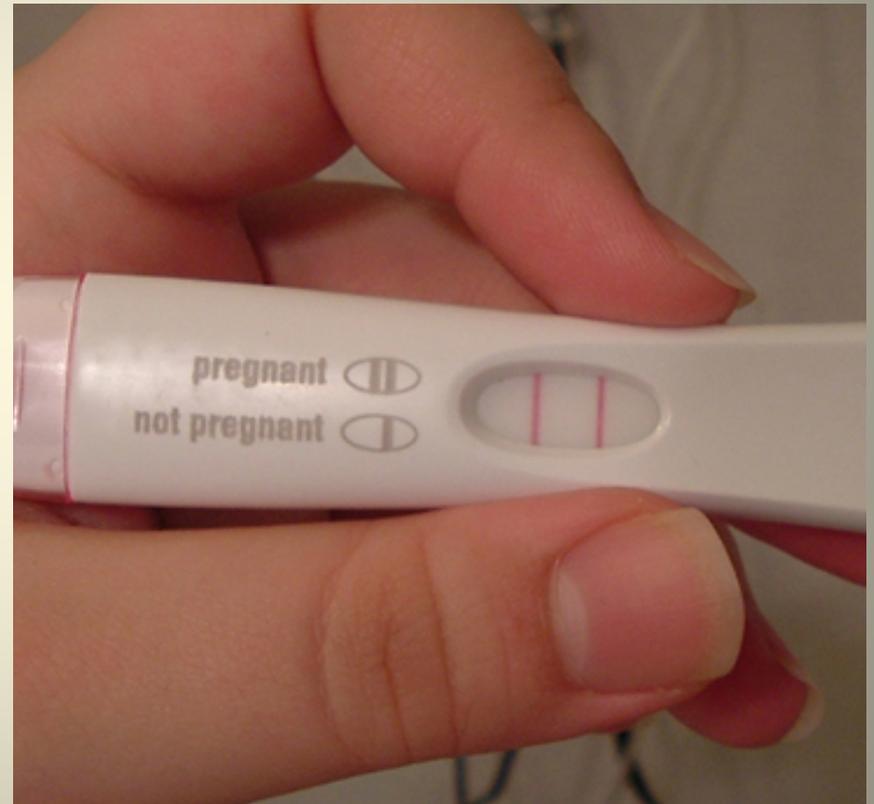
- All radiation work must be done with the ALARA exposure principle in mind.
- A-As
- L-Low
- A-As
- R-Reasonably
- A-Achievable



- Time, distance and shielding are very good ALARA techniques to limit exposures.



- Any sub licensee or user who is pregnant should notify the RSO. The RSO will provide risk information and evaluate potential exposures.



EHS Responsibilities

- EHS is responsible for the management of the radiation safety program and the daily functions that are necessary to support the program.





- The Radiation safety Officer (RSO) is Hal Barrett ,Director of EHS. The RSO position goes through a state approval process.

- Dosimetry is provided by EHS to monitor exposures.





- When new users begin work their sub licensee requests personal dosimetry from EHS if it is appropriate.

- Source labs which only use H3 or C14 are not issued dosimetry. The energy is too low to be detected.



- Analytical x-ray labs are provided with area monitors





- Temporary personal dosimetry may be issued to visitors if necessary.

- EHS changes out dosimetry quarterly.



- Three types of radiation safety training are provided. These are:

- Initial
- Lab Specific
- Annual



- Initial training is provided by EHS prior to working with sources.



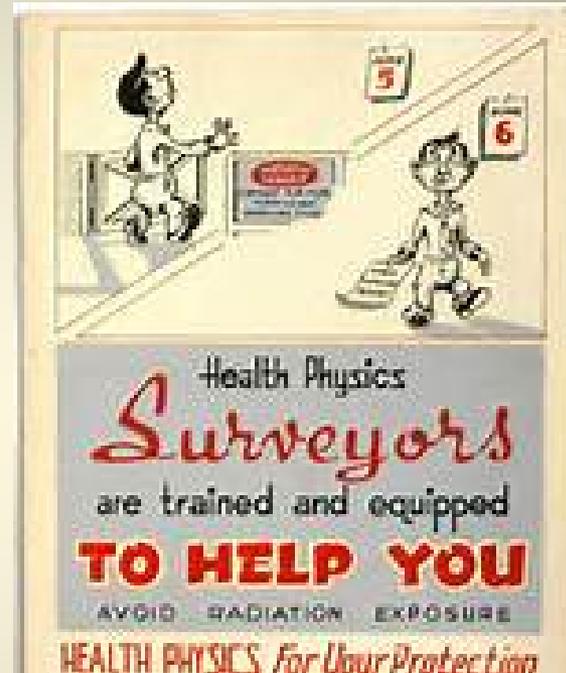


- Lab specific training is provided by the sub licensee to lab users.



- Annual training is provided by EHS. All sub licensees and users are required to complete each year.

- EHS conducts an annual audit of each area approved for work with radiation sources.



- EHS checks security each time the lab is visited. Labs must be locked when no authorized users are present and sources must always be secured.





- EHS conducts monthly contamination surveys of all labs that are sublicensed to use unsealed sources.

- Sealed source inventories are conducted quarterly by EHS. This includes checking for leakage.



- A monthly inventory of all sources is provided by EHS to sub licensees. Each sub licensee should verify the accuracy of their inventory.



- EHS checks meters annually to determine efficiency against a source of known activity.





- Survey meters are not very efficient. Do not look at the readout. Compare the difference in the number of clicks for background versus a source to determine if contamination is present.

- All purchases of radiation sources must be approved by EHS prior to purchase. Obtain an approval number first.





- All purchases of sources must be shipped directly to EHS for processing and contamination testing.

- Once processed and cleared packages will be delivered to the lab by EHS.



- All off campus shipments of radioactive material must be done by EHS. Jeff Hallman has the training to manage these shipments.





- Radioactive waste is picked up , managed and disposed of by EHS.

- The UA Radiation Safety Manual goes into much more detail regarding program requirements. It is available on the EHS web site.



- You have almost completed initial training. To get credit E mail the answers to the following 25 questions to hbarrett@fa.ua.edu you will then be provided annual training.



- 1. An isotope has the same number of _____.
- A. electrons and protons
- B. protons different number of neutrons
- C. protons different number of electrons
- D. protons as neutrons

- 2. Which is not an example of ionizing radiation_____.
- A. x-rays
- B. alpha
- C. gamma
- D. lasers

- 3. A beta particle is _____.
- A. highly charged
- B. an electron emitted from an atom
- C. very small
- D. able to penetrate 1 inch of lead shielding

- 4. Bremsstrahlung may be reduced by_____.
- A. lead shielding
- B. x-rays
- C. time and distance
- D. using plexiglass shielding instead of lead

- 5. A common gamma emitter is _____.
- A. ^{32}P
- B. ^{14}C
- C. very dangerous
- D. ^{137}Cs

- 6. X-rays are produced by _____.
- A. large machines
- B. decay or Bremsstrahlung
- C. alpha emitters
- D. C14

- 7. ___ is the number of disintegrations per a given period of time.
- A. X-rays
- B. Gamma radiation
- C. 2.2×10^{-6}
- D. Activity

- 8.Exposure is expressed in units of _____.
- A. Roentgen
- B. activity
- C. curies
- D. isobars

- 9. The half life of C14 is _____.
- A. 14.3 days
- B. 5 hrs.
- C. 5730 years
- D. 12.3 yrs.

- 10. When a material goes through 10 half lives the activity is considered_____.
- A. nanocuries
- B. 1.13×10^{-10}
- C. picocuries
- D. zero

- 11. The average annual radiation dose to an individual in the US is _____.
- A. due to medical tests and treatment
- B. 620 mrem/yr.
- C. greater than 100 but less than 1000
- D. zero

- 12. All tissues are equally sensitive to radiation.
- True
- False

- 13.UA is licensed by ____to use radiation sources.
- A. the NRC
- B. the atomic energy commission
- C. Ala Dept. of Public Health
- D. the DOE

- 14. _____ are authorized by the RCAC to supervise labs.
- A. Sublicensees
- B. Departmental chairs
- C. TA's
- D. Tenured faculty

- 15. The 3 types of sources are _____.
- A. hazardous, nominal, non haz
- B. sealed, unsealed, xray
- C. large, small, median
- D. regulated, exempt, other

- 16. The whole body dose limit is _____.
- A. 10 curies
- B. 5 rem/yr.
- C. 15 mrem
- D. 5 Roentgen

- 17. The exposure limit for a minor is _____ of an adult.
- A. one half
- B. twice
- C. 10%
- D. equal to that

- 18. Any quarterly exposures above _____ are investigated.
- A. 10 microcuries
- B. 5 Roentgens
- C. background
- D. 100 mrem

- 19.ALARA means_____.
- A. as long as reason allows
- B. as long as regs allow
- C. as lengthy as rem accumulates
- D. as low as reasonably achievable

- 20. _____ are very good ALARA techniques.
- A. Lead and bricks
- B. Time ,distance and shielding
- C. Duck and run
- D. Hand washing and vaccination

- 21. Dosimetry is changed out _____.
- A. as needed
- B. monthly
- C. quarterly
- D. annually

- 22. _____ handles all off campus shipments of radioactivity.
- A. UPS
- B. Post office
- C. Fed ex
- D. EHS

- 23. All purchases must be _____.
- A. prior approved by EHS
- B. small exempt quantities
- C. shipped by UPS
- D. made by P card

- 24. Labs must be _____ when no authorized users are present.
- A. guarded
- B. monitored
- C. locked
- D. available for use

- 25. An annual audit is conducted by_____.
- A. state inspectors
- B. NRC
- C. DOE
- D. EHS

- Return the answers along with your CWID and the room number and building where you will work with radioactive materials or machines and the sub licensee for that lab to tgoins@fa.ua.edu .You must also complete annual training which is available on the EHS web site.