Radiation

**this sheet contains the two lectures by Dr madi together and doesn't follow the same order as in the records to simplify the info.
** check the tables as they contain important info the dr mentioned.

Why are certain materials considered as radioactive ?
The binding energy is a huge energy that keeps the contents of the atom together. Any nucleus that contain energy larger than this binding energy will be considered unstable, so it will radiate this extra energy as radiation to get rid of it.

From where are we exposed to radiation(sources of radiation) :-

1) Natural (background radiation) depending on your place.
2) Man made.

Natural :-

a) Cosmic radiation : coming from the sun (solar) and it will interact with the atmosphere, it's better called cosmic not solar because what actually reaches us is the outcome from the interaction of the solar radiation and radiation from other places with the atmosphere.
b) Internal radiation : everyone has certain amounts; coming from our bodies or food and water and they will accumulate inside. Some scientists say that this internal radiation is normal others say that it's not and that it may accumulate in the tissues and causes damage, for example, some say that the ovum in the ovaries of women that never come to develop is caused by these radiations.

Example on those radiations is potassium "40" , we have two isotopes: potassium "39" which is normal and potassium "40" which is radioactive. Also we have carbon "14" and hydrogen too might be radioactive. You might also swallow a radioactive material like radium.

Those materials don't distribute equally all around the body, for example potassium accumulates in the muscles, but hydrogen and carbon distribute equally around the body.

c) Terrestrial (solid materials) : like stones and soil, and based on that some places in the world has more radiation than others.

The previous three types of radiations are called "background radiation", they depend on the place, as far as you go away from the equator the radiation gets more, so at the equator the radiation is at its least. It depends on the cosmic waves, which hit the atmosphere and reflex and break apart to go to the poles. So radiation is higher at the poles.

Also when you go higher you become closer to the source – the cosmic radiations, so the radiation level increases. That's why part of the occupational hazards on pilots or climbers is exposure to this cosmic radiation.

Now the cosmic radiation becomes more as you go higher but the terrestrial radiation actually becomes less as you go higher For the first 1000 meters and what you lose from radiation of

terrestrial is more than what you gain from cosmic, after 1000 meters what you gain becomes more than what you lose so you become In a worst situation and the balance is lost. So scientists are worried about people living in higher places – higher than 3000 meters -, they get radiation three times more than people living at the level of the sea. So for each one thousand meters the radiation doubles.

Does Jordan contain radioactive (uranium) materials ?
yes in large amounts, south of the airport - Amman, so some people are demanding to build a nuclear reactor since we don't have oil or other energy sources and we have uranium, but there's still a debate.

Man made :-

a) Nuclear reactors – peaceful uses
b) Nuclear weapons or trials.
c) Occupational exposure.
d) Industrial exposure.

Nuclear reactors :-
Are used world-wide. Used for producing energy and electricity. Near to Jordan there is daimona reactor. We may have leakage or accidents in those reactors which causes radiation.
Example : Chernobyl's incident in 1986 in Ukraine, Formal Soviet Union. Also Fukushima's incident which was recent, due to a tsunami that hit Japan four years ago in 2011 and affected the nuclear reactor there.
Should we be concerned about a leakage that happened in Japan here in Jordan!? Yes, because we are affected through food items that are contaminated with the radiation. Fukushima is an island and when the disaster happened radiation leaked to the ocean and contaminated the tuna which is manufactured there and imported here to Jordan.
Also concerning Chernobyl, again we're affected by the food. Here the food is the meat or milk of the sheep since Jordan imports it from countries near Ukraine like Romania or Bulgaria..etc. the sheep eats the grass which was contaminated by radiation. Also some of our students were living there at the time of the disaster so they were affected.

Nuclear weapons :-
We mean by this : the trials we use the weapons in. The trials may take place in desert, underwater etc. Countries must try the weapons before using it in wars so this will result in a large amount of radiation which will spread in the environment.

Occupational exposure :-
It is related to the jobs that may include exposure to radiation. Means the radiation that came from the work place which refers to the workers (Radiologist, Nuclear engineer, doctors and physicians working with radiation, the nurse who accompanied the patient for x-ray.

Industrial exposure :-
Means radiation from any manufactured material such as TV or computer which refers to the consumers.
TV : sometimes it radiates some soft X-ray radiation.
So as they are manufacturing this tv, this is occupational exposure. But when I'm using this tv, this is industrial exposure.

Photography also causes industrial exposure.

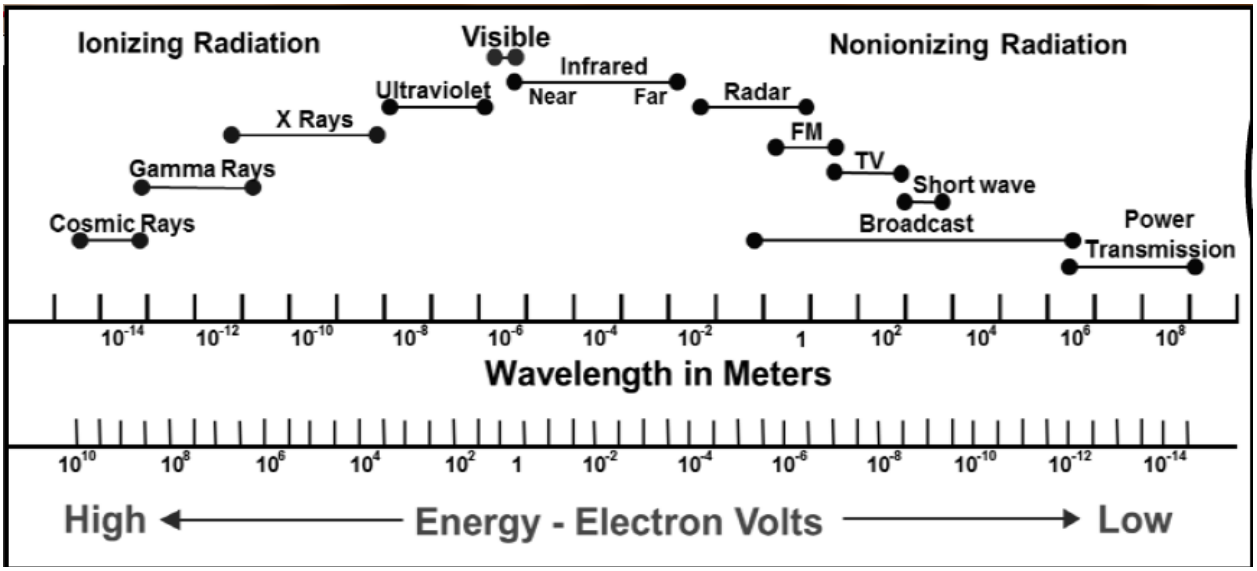
Now we are going to talk about some trials which include exposing food to radiation.

1) Trial 1 : Bring a potato from Jordan farms and leave it in the kitchen for 4 to 5 days then you will see budding. Now bring imported potato and leave it beside the first one, come back after 4 to 5 days you will see nothing but why? Because it might be exposed to radiation, which will increase its ability for storage, and decreases budding. This also is done with onions w garlic to preserve the food as long as possible.
The question now : using this imported potato is considered as occupational or industrial exposure or both? Firstly, it can't be both or industrial because if it was it will be prohibited globally using these potatoes as they affect the lives of the consumer. Secondly, it is only occupational because it will affect only people who exposes the potatoes for radiation.

2) Trial 2 : Food canning (e.g. vegetables). What is the procedure of canning?
Clean food will get rid of all contaminants, then cook it to kill as much as we can organisms, then put it under vacuum in a container to kill what remains of organisms, finally put it in a reservoir.
New procedure or method was discovered for canning it includes only washing out the food and then expose it to radiation.
The question now : consuming this food which is obtained by the new method is considered as occupational or industrial exposure or both? It may be considered both but mainly occupational according to the doctor.

How can I classify radiation? According to :-

a) Spectrum (wave length / frequency) :
   - The relation between frequency of the wave and the energy of radiation is a direct relationship, the more the frequency the more the radiation energy, while the more the length of the wave the less the energy radiation..
   - There's a common mistake that the microwaves are tiny waves due to the name, but in fact it's one of the longest waves after the radio waves



b) From what this radiation is made of (Waves or particular matter)

X-Ray	Waves
α-Radiation	Particular matter
β-Radiation	Particular matter
γ-Radiation	Waves
Infrared	Waves
U.V	Waves

c) Ionizing V.S Non-ionizing.

Ionizing means : that this radiation has the ability to ionize the media it passes through, not that it has a charge. Ionizing material can cause charge and doesn't have to carry charges.

Why it causes charge? When it passes through a media it gives an electron from air particles some power so it can get out from the atom causing it to carry a positive charge.

Example : X-Ray are Ionizing Waves while β-Radiation are Ionizing Particles.

Ionizing	Non-ionizing
α-Radiation	Infrared
β-Radiation	U.V
γ-Radiation	Micro waves
X-ray	Radio waves
Cosmic rays	TV power

There's a common mistake by people that they think that ionizing radiation is dangerous while non-ionizing is not dangerous, for example, U.V is non-ionizing and still it can cause cancer.

Note that the majority of the U.V waves are non-ionizing but some might be ionizing! There's a debate on this.

Positron(β-Radiation) is a neutron plus the positive ion β+

Story about occupational exposure :-

Group of women were asked to label the indicators of the wristwatch by radium because it is radiant, so the wristwatch can illuminate in night. Women asked their employer about the material so he/she told them not to worry, if they swallow this material they will have a rosy cheeks. So women painted their faces and tooth and turned off the light. After some time they had cancer in their cheeks.

Notes :- Marie curie and her husband discovered the properties of uranium and radiation, and this early discovery is the reason why we don't have much industrial exposure, since people know the devastating effect of it.
It is related to how much we can be exposed to radiation before it becomes harmful.
There are some people that think that if they are exposed to a small amount from any radioactive material it will not be harmful (it will be useful like for joint pain for example). The evidence for the previous point is: there are some people who go to the caves which contain water (that contain some radioactive materials such as radium) because they think it is useful. Caves that are found in Brazil, Yugoslavia and India. And this is the secret which a Yugoslavian scientist was talking about (Small amount from toxic does may be treatable).
There is some scientists said that radiation is the major reason behind the evolution of organisms and becoming more sophisticated. A radiation hit a gene making mutation which will lead to new function. This will happen over billions of years.
Others said that our bodies are so sophisticated so the chances for any mutation will have a negative effect more than a positive effect. But we can't deny that some biological mechanisms such as photosynthesis depend meanly on radiation.

Effects of radiation on our health:
Whenever someone asks you about the health impacts of some material on us, you should know the amount that you'll be exposed to and the duration, if it's continuous exposure like workers or an exposure for once.

Taking Chernobyl for example, when the radiation hit people nearby died instantly because of the huge dose of radiation. While if the amount is less it might cause cancers or other health problems. So it depends on the amount.

The type of the radiation also matters! Whether you were hit by ionizing or non ionizing radiation, α or β or γ. Anyway if the dose is huge it'll make no difference, it will kill you! But if the doses are small you have to differentiate between them.

One of the things we need to be concerned about is **penetration** as follows:

- α radiation:

1. Two neutrons and two protons ,Charge of +2 , Emitted from nucleus of radioactive atoms
2. Transfer energy in very short distances (10 cm in air) but that doesn't mean it's not damaging.
3. Shielded by paper or layer of skin.
4. Primary hazard from internal exposure (explained later)

So it doesn't penetrate as other waves, because it's a particular matter and it's heavy, it can be stopped by a piece of paper, but when it reaches your body it causes a lot of damage

- β radiation:

1. Small electrically charged particles similar to electrons ,Charge of -1 , Ejected from nuclei of radioactive atoms.
2. Emitted with various kinetic energies depending on the source
3. Shielded by wood
4. Body penetration (0.2 – 1.3 cm), it cause skin burns (β burns) or be an internal hazard if ingested.
5. it has more strength of penetration than α .

- γ radiation:
  1. emitted with kinetic energy related to radioactive sources
  2. can penetrate deep through your body
  3. can be stopped by wood or strong concrete. That's why in hospitals in x-ray departments they use lid in the walls, because it can stop the radiation at a thinner thickness compared to concrete.
  4. Extensive shields are needed and it can cause serious external radiating hazard. It doesn't have to get into your body to affect you.

  Note that engineers can calculate the thickness of any material to stop the radiation from leakage in the walls of buildings.

  We use concrete to stop radiation in nuclear shelters walls which might be expensive, the nearest nuclear shelter to us is in Tel Aviv, Israel.

- X ray:
  1. Highly penetrable (similar to γ radiation).
  2. inside an x ray tube and it's produced from orbiting or free electrons that hit a target material.
  3. the difference between x and gamma is the source, gamma comes from radioactive atoms and x ray comes from electrons.
  4. It's an external radiation hazard.

    - If I'm comparing the damage done by α radiation to the one done by β radiation (which is more penetrable). Presuming that I'm giving somebody the same amount of energy of α and β, the α is going to give all its massive energy in a short distance, while β is going to distribute its energy on a longer distance so the amount reaching each part is less.
    - Primary hazard of α radiation from internal exposure: because it's not penetrable outside but if you swallowed something contaminated by it, it's already inside and it doesn't need penetration. It accumulates in bones, kidney, liver, lungs causing local damage, and it becomes part of your internal radiation – IF you stayed alive.

Units of radiation:

1. Curie (according to madam Curie who discovered uranium): to measure activity of a source and say this source is more radioactive than other, radioactivity means number of dintegrations per unit time. How many atoms have disintegrated during certain period in time.
2. Roentgen (joul/kg): Measurement of ionization due to the passage of radiation, can be expressed in jouls – because ionization means having ions which means electrical current or energy.
3. Rad (Grey): a short for Radiation Absorbed Dose, it'll measure the amount of energy absorbed by the media in which the radiation passed.
4. Rem (Sievert): is radiation equivalent man, the unit that measures the amount of damage caused by radiation passing through the media>> the only one measuring health impacts.
   **** the first units are the old units, the one between brackets are new units.**

- How much radiation can we allow workers to be exposed to?

100m milli Sievert over 5 years with maximum of 50 per year.

- How can I measure the amount of radiation the workers have been exposed to?

Usually we use a ring or a bracelet that contains a film it's made by a piece of metal that the worker wears during his working hours and by the end of the year we take it from him and measure the radiation since those films are sensitive to radiation. Some tests nowadays are more accurate you might take a blood sample and look for the components in it like a decrease in white blood cells count.

- If we discovered that one of those workers is exceeding the limit what shall we do?

take him away from the work for a while until his radiation levels are back to normal.

- As a general public how much are we allowed to be exposed to?!

3 milli Sievert per year.

- The difference between the public and workers is huge! Why?!

This is due to something called "healthy worker effect", it means that you expect workers to be in ages between 20-60 and in this age group they're supposed to be healthier than general population, in general population we have infants and pregnant ladies and old people and sick people who can't tolerate high levels of radiation.

X- ray:

The color of the films used on x-ray patient is white/grey, when you put it behind the patient or on his chest then radiation will cross the body and reach the film. When u have a dense part of the body like bones it will stop the radiation from passing so the color of the film under that dense part will

stay white in color, but if the body part is soft like the lung tissue x ray will hit the film and won't stop on the tissue so it'll be black.

So if you see the patient's lung white then the tissue is not soft anymore there might be a cancer or fluid or pneumonia, Or if the bone is fractured then there's a little bit of black in it.

Now if I'm taking an x-ray for a teeth, the teeth are white and the tissues around it is black, if there's a cavity or abscess in the soft tissues then the color will be even darker than the color of the tissues, because the tissues can stop the x rays a little bit and appear lighter than empty spots or abscess.

The x ray plus the symptoms and biopsy and further investigation the doctors can diagnose the disease whether it's a cancer or fracture or abscess.

Tissues response to radiation:

when radiation hits the body, our tissues won't be affected the same, different tissues are affected in different ways, that's why we said that we use blood tests to monitor how much radiation the workers have been exposed to – since WBCs are highly affected by radiation.

Very High	White blood cells (bone marrow) Intestinal epithelium Reproductive cells
High	Optic lens epithelium Esophageal epithelium Mucous membranes
Medium	Brain – Glial cells Lung, kidney, liver, thyroid, pancreatic epithelium
Low	Mature red blood cells Muscle cells Mature bone and cartilage

There's a debate about brain's sensitivity, because some people like to think that the brain is the lowest tissue affected by radiation (there are glial cells) so we can say that the nervous system in general is the least affected. BUT if it was affected then the outcome is death, since the tissues can't be renewed.

Note that when you're hit by radiation your WBC count is going to be lowered so you'll be more susceptible to infections and might die because of that.