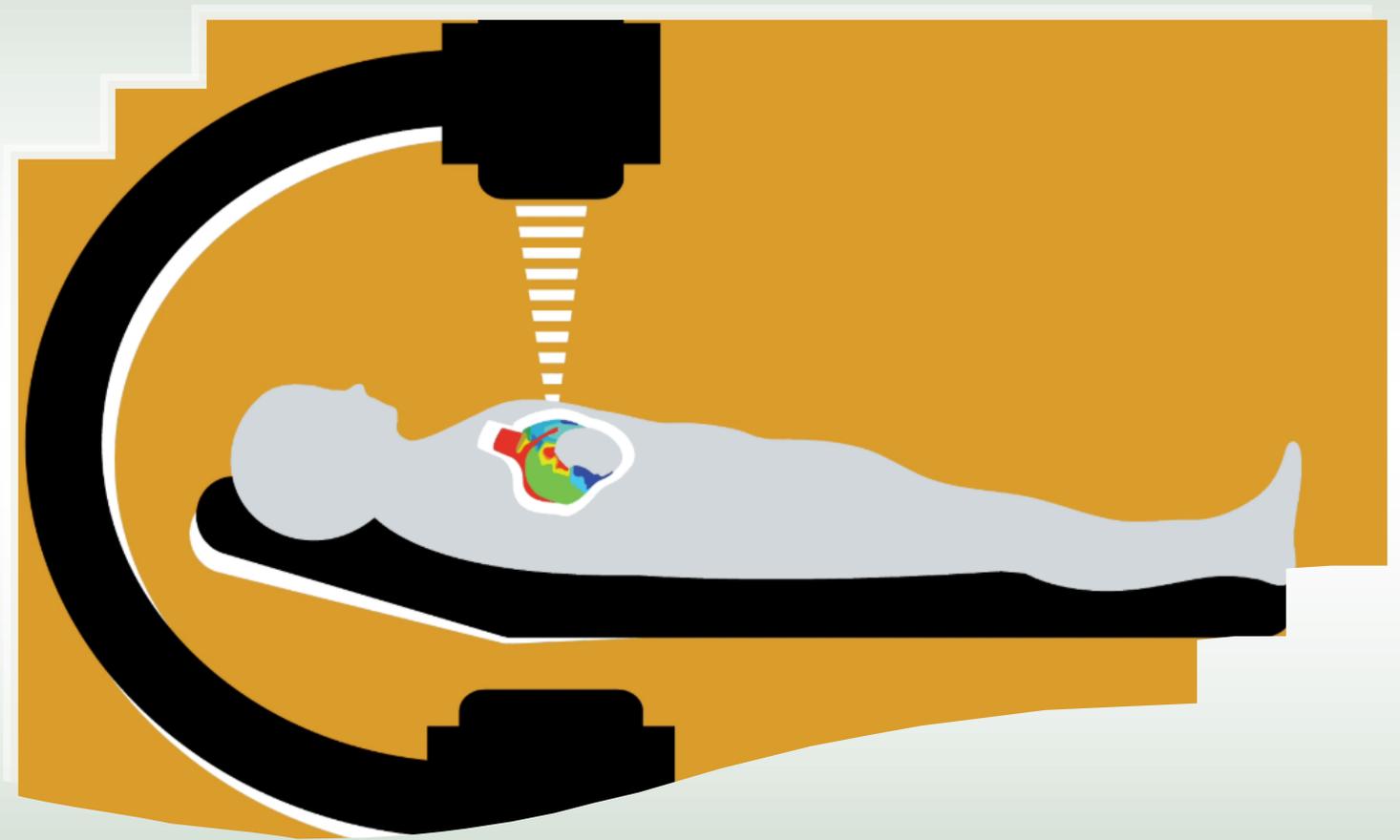


RADIATION EFFECTS



A Pinku and Dadaji
Series

Radiation is good and bad both

Pinku: Good Morning Dadaji

Dadaji: Very good morning Pinku. So why did you get up so early today on a holiday?

Pinku: Well Dadaji, I need to prepare to write an essay on radiation and its effects.

Dadaji: Hmm... seems to be a very good topic.

Pinku: Dadaji can you give more insight on this topic so that I can easily write my essay please.

Dadaji: Oh Sure! To understand radiation, you must know what radio-active elements are. To understand what radio-active elements are, you should first understand what an element is? Can you give me any example of elements you know?

Pinku: Yes I do know. Oxygen, hydrogen, calcium, nitrogen so on and so forth...

Dadaji: Do you know why they are called elements?

Pinku: Yes I do Dadaji. An element is a pure substance that cannot be broken down by chemical methods into simpler components. For example, the element gold cannot be broken down into anything other than gold. If

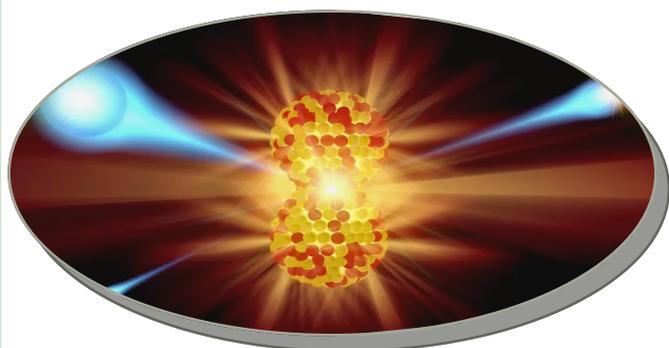
Controlled radiation has always been good to human kind

you kept hitting gold with a hammer, the pieces would get smaller, but each piece will always be gold.

Dadaji: Wow! You are brilliant Pinku. Adding to what you said, elements consist of only one type of atom. An atom is the smallest particle of an element that still has the same properties of that element. All atoms of a specific element have exactly the same chemical makeup, size, and mass.

Pinku: Now what is this atom Dadaji?

Dadaji: Atoms are the basic building blocks of ordinary matter. Atoms can join together to form molecules, which in turn form most of the objects around you. An atom itself is made up of three tiny kinds of particles called subatomic particles namely, protons, neutrons, and electrons. The protons and the neutrons make up the center of the atom called the nucleus and the electrons fly around above the nucleus in a small cloud.



Controlled Radiation is always good

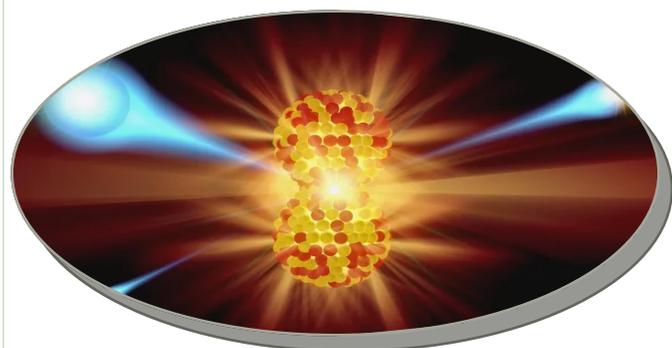
As per deeper study, even protons and the neutrons are made up of particles called quarks and gluons.

Pinku: I understood Dadaji but why are telling all these things to me?

Dadaji: Good question Pinku. You should now know what a radioactive element is. Radioactive element is an element subject to spontaneous degeneration of its nucleus accompanied by the emission of alpha particles, beta particles, or gamma rays. All elements with atomic numbers greater than 83 are radioactive. Naturally occurring radioactive elements include radium, thorium, and uranium.

Pinku: I understood what a nucleus is but, what is this term degeneration of nucleus?

Dadaji: Each atom has a set number of protons and neutrons in the nucleus, but sometimes there are more or less neutrons than usual, which make the element an isotope. Elements can be distinguished from isotopes by their mass number, or the total number of neutrons and protons in an atom. If there are more or less, the isotope will have a different mass



Be aware and
Be away from radiation

number than the original element. For example, normally carbon has 6 protons and 6 neutrons, giving it a mass number of 12. The isotope carbon-14 has two extra neutrons, making the isotope carbon-14. Isotopes are usually, unstable and release neutrons, protons, or energy as time goes on called degeneration of nucleus or radioactive decay.

Pinku: How is that related to our topic radiation?

Dadaji: Radioactive decays are of three types called alpha, beta, and gamma decays respectively. During each of these decay's radiations called alpha rays, beta rays and gamma rays gets released.

Pinku: How do these rays affect human beings
Dadaji?

Dadaji: Well! Alpha decay releases the largest particle during radioactive decay, which consists of two neutrons and two protons.

Lighter Radiation penetrate more

This type of decay ejects the subatomic particles very quickly, which can damage our cells if they get into our bodies. However, since alpha particles are very big, they don't get too far and are easily blocked by our clothing. When an element undergoes alpha decay, it releases protons, which turn it into a different element entirely. Beta decay occurs when one neutron ejects an electron and becomes a proton. Alpha decay often creates unstable isotopes that undergo beta decay. Beta particles are a bit lighter than alpha particles, so they can go farther and penetrate materials deeper. However, clothing will still stop beta particles. In gamma decay no particles are released, but the isotopes formed by alpha and beta decay still have too much energy. The energy is released as gamma rays. These rays penetrate the farthest and can even go through a foot of concrete. Gamma rays are very damaging to human beings.

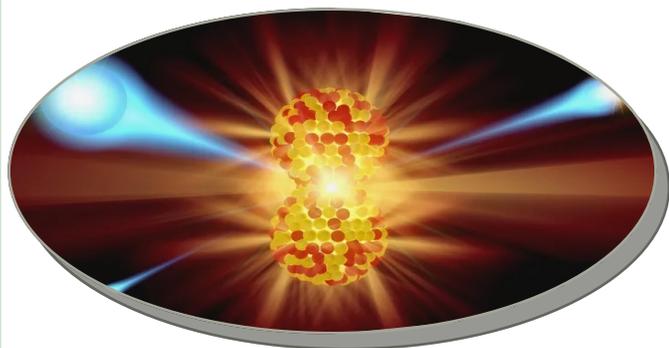
Pinku: Is gamma ray's used by human beings?

Dadaji: Yes Pinku. Gamma rays are used to treat some types of cancer, since the rays also kill cancer cells.

Burning candle emits radiation as heat and light.

Pinku: What about Beta ray's?

Dadaji: Beta rays have a number of important uses in industrial processes. Since they can pass through some materials, they are used to gauge the thickness of films of material coming off production lines such as paper and plastic film. A similar process checks the integrity of sewn seams in textiles. In another application, the thickness of various coatings, such as paints, can be deduced from the amount of beta particles scattered back from that surface. In a process known as brachytherapy, beta radioisotopes can be used to irradiate areas inside a patient to prevent the growth of certain tissues. Beta particles are also used in some forms of therapy to kill cancer cells similar to gamma rays. In addition, the emission of beta particles is used indirectly in the medical scanning technique known as positron emission tomography (PET).



Reduce pollution to avoid UV Radiation

Pinku: and Alpha rays?

Dadaji: There are several uses of Alpha radiation such as it is used in some smoke detectors. The alpha particles from americium-241 bombard air molecules, knocking electrons free. These electrons are then used to create an electrical current. Smoke particles disrupt this current, triggering an alarm. Radioisotope thermoelectric generators are used to power a wide array of satellites and spacecraft. Alpha radiation is used as an energy source to power heart pacemakers. Plutonium-238 is used as the fuel source for such batteries; with a half-life of 88 years, this source of power provides a long lifespan for pacemakers. Alpha radiation is also used to power a wide array of seismic and other oceanographic devices.

Pinku: Wow! So many uses of radiations... Now tell me which are the rays which enter earth atmosphere?

Dadaji: Some infrared, some ultraviolet, and microwaves, pass through the atmosphere and reaches the Earth's surface. Gamma rays, X-rays, most of the ultraviolet and some of the infrared are absorbed by the atmosphere

**Alpha, Beta, Gamma Decay
is due to unstable atoms**

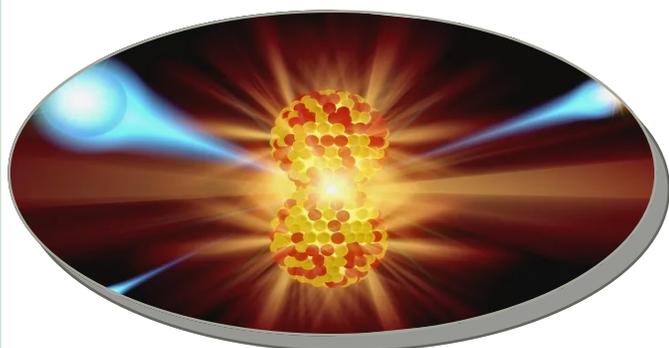
and do not reach the Earth's surface. Ozone layer is responsible for protecting the mother earth from these radiations.

Pinku: Ozone layer... hmm... I have heard about this layer. Can you elaborate Dadaji?

Dadaji: Well! The ozone layer acts as a filter for the shorter wavelength and highly hazardous ultraviolet radiation (UVR) from the sun, protecting life on Earth from its potentially harmful effects such as skin allergies and sometimes leading to cancer on too much of exposure to UVR.

Pinku: Yes! Now I remember, ozone layer is getting depleted by the pollution caused by us humans.

Dadaji: True Pinku... Today, there is widespread concern that the ozone layer is deteriorating due to the release of pollution containing the chemicals chlorine, fluorine and bromine.



Someone should build ozone layer one day

You must have heard Chloro Fluoro Carbon or CFC's, they deteriorate Ozone and allow large amounts of ultraviolet B rays to reach Earth, which can cause skin cancer and cataracts in humans and harm animals as well.

Pinku: If we are adept in so many chemical compositions, why human is unable to create ozone layer?

Dadaji: To fix the ozone hole, we need to constantly pour more ozone into the stratosphere. This is not a reasonable solution, primarily because the amount of energy needed to pump ozone into the stratosphere is overwhelming. It would require over 500 billion watts of power to constantly pour the necessary ozone into the stratosphere to make up for what CFCs destroy.

Pinku: But! Somebody should start pumping it or we will see a day of extinction. Why not a world forum be started to fill up Ozone.

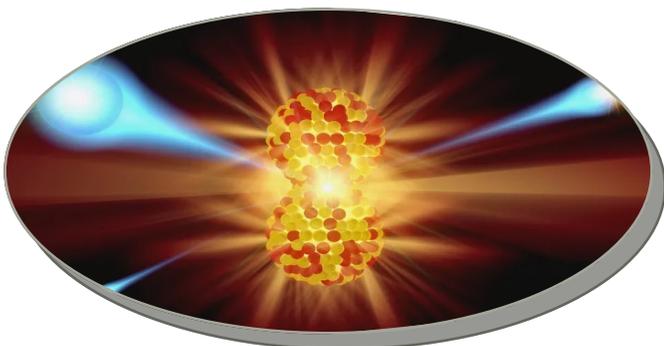
Dadaji: That's a fantastic suggestion Pinku. People who have similar thinking like you hopefully start investing in Ozone one day.

Pinku: Hopefully. Let me change the topic now Dadaji, tell me why X-rays do not affect our

Chloro Fluoro Carbon's Deplete the Ozone Layer

body when our body scans is done though these rays in hospitals?

Dadaji: I will answer that, however, you should know the story behind X-rays. X-rays were discovered in 1895 by Wilhelm Conrad Roentgen who was a Professor at Wuerzburg University in Germany. Working with a cathode-ray tube in his laboratory, Roentgen observed a fluorescent glow of crystals on a table near his tube. The tube that Roentgen was working consisted of a glass envelope (bulb) with positive and negative electrodes encapsulated in it. The air in the tube was evacuated, and when a high voltage was applied, the tube produced a fluorescent glow. Roentgen shielded the tube with heavy black paper, and discovered a green colored fluorescent light generated by a material located a few feet away from the tube.



Avoid high radiation frequency devices

He concluded that a new type of ray was being emitted from the tube. This ray was capable of passing through the heavy paper covering and exciting the phosphorescent materials in the room. He found that the new ray could pass through most substances casting shadows of solid objects. Roentgen also discovered that the ray could pass through the tissue of humans, but not bones and metal objects. One of Roentgen's first experiments late in 1895 was a film of the hand of his wife, Bertha. Now to your answer your question, X-rays are dangerous but not when controlled properly.

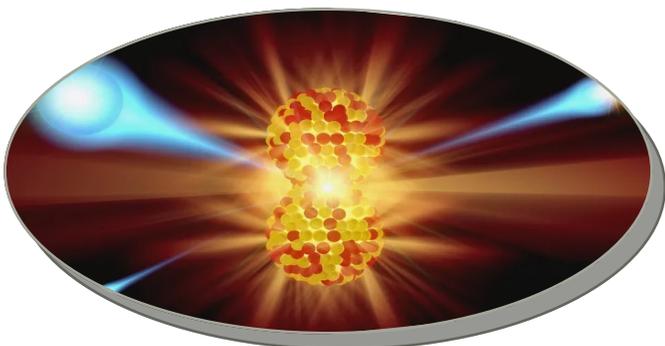
Meaning, a low dose of X-rays radiation is made enter through our body to check whether there is a fracture or not is fine. Now, how it works? This beam travels through the air, comes into contact with our body tissues; Since, soft tissue, such as skin and organs, cannot absorb the high-energy rays, the beam passes through them however, dense materials inside our bodies, like bones, absorb the radiation hence; their image is imprinted on the metal film.

Pinku: Got it. That's about X-ray. Great gyan Dadaji... Let's now talk about Wi-Fi's. What

Wi-Fi is Radio Frequency Communication Device.

about normal Wi-Fi what rays are remitted by Wi-Fi? Are they dangerous?

Dadaji: Wi-Fi is one of the radio frequency communication devices. A wireless router is used for transmission that connects to your computer (or computers)/mobile using radio waves instead of cables. Wireless routers give off electromagnetic radiation in the low-gigahertz frequency. This level is considered not potentially dangerous to people even though it is not risk free. Electro-magnetic radiations pass through walls but, it is not considered dangerous as radio radiations are non-ionizing radiations meaning, this radiation does not have enough energy to ionize atoms (Ionization is the process by which an atom or a molecule acquires a negative or positive charge by gaining or losing electrons which can cause other chemical changes hence, dangerous to humans).



Avoid Wi-Fi and avoid radiation sickness

Pinku: But isn't too much of radiation dangerous every other house now has a wi-fi?

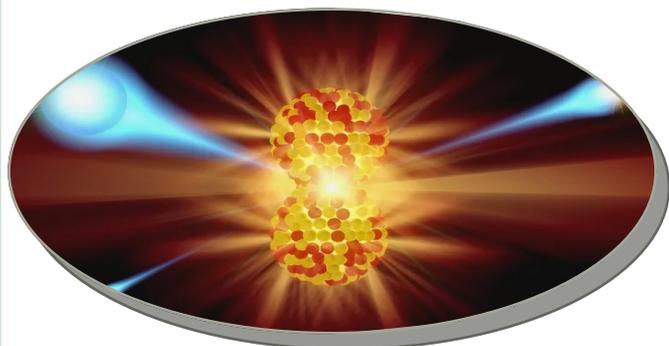
Dadaji: We exactly do not know the broad affect Pinku but, Wi-Fi's non-ionizing wavelengths that are longer than light tend not to be dangerous.

Pinku: What about rays of mobile phones Dadaji how dangerous they are?

Dadaji: It's not different Pinku. Mobile phones also use radio frequency radiations. Hence, you may prefer to use less of mobile phones. Not only, mobile phones are addictive but keeping mobile closed to your body for longer time, may have radiation effects on your body as well. If someone talks for hours through mobile phone, there are chances that these radiations may cause brain cancer.

Pinku: Well then what about people who are actually working in radiations area say workers working or staying near nuclear plants?

Dadaji: Well! At high doses, ionizing radiation can cause immediate damage to a person's body, including radiation sickness and death. Ionizing radiation is also a carcinogen, even at



Carcinogen Causes Cancer

low doses; it causes cancer primarily because it damages DNA.

Pinku: Carcinogen and what is that?

Dadaji: A carcinogen is something that can cause you to have cancer. It may be a substance in the air, a product you use, or a chemical in foods and drinks. Radiation is one of the carcinogens.

Pinku: Can you give some more examples please?

Dadaji: Oh sure! Tobacco, asbestos, crispy brown foods...

Pinku: Crispy brown foods do you mean potato chips?

Dadaji: "Yes" you heard it right... Crispy fried potatoes contain high levels of harmful chemical acrylamide and acrylamide is a human carcinogen. Acrylamide is present in high quantity in fried potatoes, including French fries and potato chips.

Try to avoid cooking food in ovens

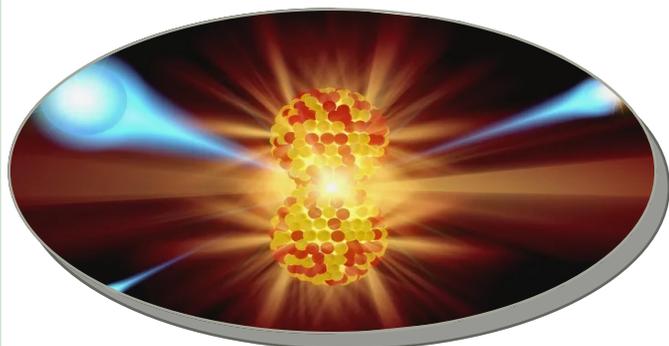
But, with the right potato variety, the risk can be minimized.

Pinku: Continuing the above topic, how then the nuclear plants take care of their employees?

Dadaji: Radiation workers in nuclear industry who receive doses of radiation are regularly measured and these records are maintained. If radiation protection standards are correctly followed by nuclear plants, the risk is minimal.

Pinku: Ah! I understood Dadaji. Ok let me get back to the more simple questions related to daily life. Please tell me cakes are prepared in microwave-ovens, meats are cooked in microwave-ovens. I understand oven is also based on radiations. Isn't it dangerous too?

Dadaji: Microwaves are high frequency radio waves (radiofrequency fields) and, like visible radiation (light), are parts of the electromagnetic spectrum. Other than ovens, microwaves are also used primarily for TV broadcasting, radar for air and sea navigational aids, and telecommunications including mobile phones. The design of microwave ovens ensures that the microwaves are contained within the oven and can



Radiation workers require at-most measures

only be present when the oven is switched on and the door is shut. However, leakage is a problem. Microwave energy can be absorbed by the body and produce heat in exposed tissues. Organs with a poor blood supply and temperature control, such as the eye have a higher risk of thermal damage. Users should check that the door closes properly and that the safety interlocks devices, fitted to the door to prevent microwaves from being generated while it is open, work correctly. The door seals should be kept clean and there should be no visible signs of damage to the seals or the outer casing of the oven. If any faults are found or parts of the oven are damaged, it should not be used until it has been repaired by an appropriately qualified service engineer.

Pinku: Dadaji can you list out what kind of rays are used in what devices?

Dadaji: Oh! Sure Pinku. Here you go...

Infra red radiation is part of our life

- ⇒ CT Scan: Computed tomography (CT) scan is an imaging procedure that uses special x-ray equipment to create detailed pictures, or scans, of areas inside the body.
- ⇒ Remote Controls: Remote Controls (such as TV remote) send signals using infrared radiation
- ⇒ MRI: Magnetic resonance imaging combines a powerful magnet with radio waves (instead of X-rays) and a computer to manipulate these magnetic elements and create highly detailed images of structures in the body.
- ⇒ Ultrasound: Ultrasound is safe and painless, and produces pictures of the inside of the body using sound waves. Ultrasound imaging, also called ultrasound scanning or sonography, involves the use of a small transducer (probe) and ultrasound gel placed directly on the skin.
- ⇒ Laser surgery: Laser surgery is commonly used on the eye. Techniques used include LASIK, which is used to correct near and far-sightedness in vision, and photorefractive keratectomy, a proce-

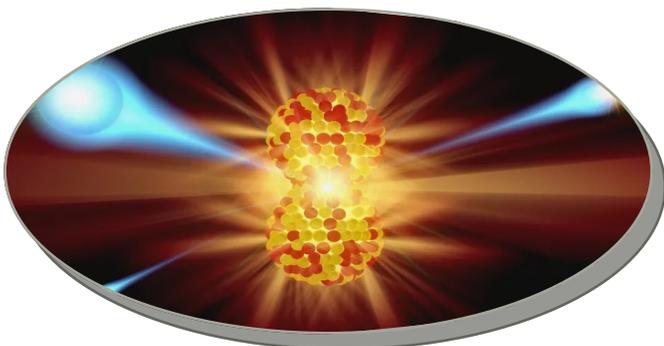
Infrared waves are longer than those of visible light

cedure which permanently reshapes the cornea using an excimer laser to remove a small amount of the human tissue.

- ⇒ Radar: Full form of Radar is "radio detection and ranging." A radio wave is a type of electromagnetic radiation.
- ⇒ Sonar: Sonar comes from the first letters of "sound navigation ranging." Sonar can detect and locate objects under the sea by echoes, much as porpoises and other marine animals navigate using their natural sonar systems.

Pinku: Ah! We did not discuss about infra-red radiations. Is it dangerous too Dadaji?

Dadaji: Well! We are immersed in infrared radiation every day. It is nothing more than heat. On the other hand, you certainly would not want to place your hand on a hot stove, in which case IR radiation would be dangerous. All objects that are not at absolute zero emit infrared radiation.



More altitude mean more radiation affect

Pinku: and what about laser light?

Dadaji: Improperly used laser devices are potentially dangerous. Effects can range from mild skin burns to irreversible injury to the skin and eye.

Pinku: Ah! See that aero plane Dadaji... As these planes are routing high in altitude, do they have radiation affects?

Dadaji: Airliners are most exposed to radiation at higher altitudes, where the atmosphere is thinner. Hence, pilots are recommended they fly at lower altitudes when possible.

Pinku: Ah! Makes sense Dadaji. When so many radioactive materials are used say in medicine, radioactive nuclear plants etc., aren't these radioactive wastes harmful to us?

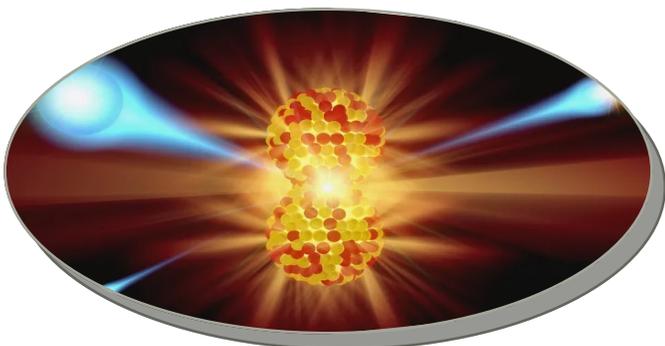
Dadaji: Wonderful question Pinku... Yes definitely and disposing them becomes extremely difficult as they are radioactive. There is a series to be followed while disposing such wastes which are collecting, sorting, treating, conditioning, storing and finally disposing safely. They cannot be just disposed; they need to be sealed in a special container which absorbs

Storage of Radioactive material requires specialization

radioactive rays. They are extremely harmful hence, require specialization. There are separate companies and specialized people who do this job.

Pinku: Interesting. If imagination is correct, nuclear plants require utmost care to be taken can you elaborate more on waste management in nuclear plants dadaji...

Dadaji: Oh sure Pinku. The nuclear wastes produced from nuclear power plants are classified into three categories (i.e. gas, liquid and solid wastes). Each nuclear power plant has its own waste processing facilities to properly treat the gas and liquid wastes generated during daily operation of the plant. The waste treatment process includes filtering, clean-up, storage, decay and dilution depending on the characteristics of the wastes and its radioactivity. When the radioactivity of the waste has diminished to a very low level, it would be released to the environment on condition that it would not exceed the permissible limit.



Disposing radioactive elements is risk

The gaseous waste is released to the environment after treatment via the stack. The liquid waste is mixed and diluted with the effluent from the plant after treatment before discharging to the sea. But, solid nuclear wastes produced by the nuclear power station will not be released to the environment.

Pinku: Hmm... then what they do with the solid waste Dadaji?

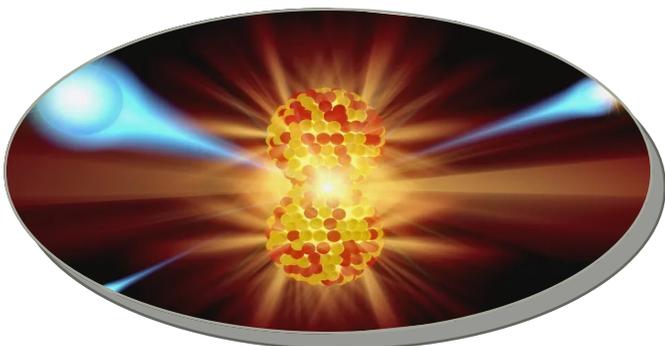
Dadaji: Well! There are three types of solid nuclear wastes classified in terms of its radioactivity (i.e. low, intermediate and high-level wastes). Low-level waste (LLW) consists of daily refuse such as paper, gloves, plastic containers, disposable overalls and overshoes with low radioactive contamination. LLW is compressed into steel drums, sealed and stored temporarily at the nuclear power station and eventually be transported to the repository for disposal. Intermediate-level waste (ILW) consists of radioactive resin and chemical sludge, spent filter cartridges etc. collected from waste treatment process and maintenance work. ILW is solidified by mixing it with sand/cement and then poured into concrete drums. The ILW would be

Waste handling is the most difficult in nuclear plants

transported to the repository for burial eventually after temporary storage at the nuclear power station. The used fuel assemblies taken out from the reactor (spent fuel) during the refueling outage are regarded as High-level waste (HLW). The HLW contains highly-radioactive fission products and radionuclides with long-lived radioactivity. The spent fuels would be stored and cooled in the "spent fuel pool" inside the Fuel Building for about 10 years to allow for the radioactive decay of its nuclides and removal of the residual heat. The spent fuels would then be arranged for either reprocessing or direct deep underground burial in repository for HLW.

Pinku: When these plants require so much of care to be taken they why the nuclear power plants are encouraged by most of the governments in the world?

Dadaji: No Pinku, your information is wrong.



Radiation is the only alternative for fuels

Globally, more nuclear power reactors have closed than opened in recent as it is more hazardous and dangerous. At the same time continuous efforts are being done to streamline the process of generating power using nuclear plants so that very less waste is generated or waste generated is re-used as efficiently. And remember Pinku, this is the only alternate source to coal which is getting depleted very fast.

Pinku: Yes true Dadaji.

Dadaji: Well! Then that's all I have for you as of now I am getting late for my walk. See you after your school.

Pinku: Thanks Dadaji that were great knowledge bytes from you.

Waste handling is the most difficult in nuclear plants

Radiation used in
limit levels are
good and beyond
limit levels are
bad

Thank
You.

