Basic Facts on Radiation and Radiation Protection

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What is Radiation? 1, 2, 3, 4, 5, 6
Radiation is the process when energy is released from a source and travels to a receiving body. It may be in the form of electromagnetic waves (e.g. gamma ray, X-ray, microwave, visible light) or high speed subatomic particles (e.g. alpha-, beta-particles). Radiation can be divided into ionising and non-ionising radiation. Ionising radiation is radiation with sufficiently high energy that can ionise atoms. Most often, this occurs when an electron is stripped from an electron shell, leaving the atom with a net positive charge.

What are the Types of Ionising Radiation? 7
Alpha \( \alpha \) particles have a very short range (a few centimetres in air) but high energy transfer. Our intact skin is an effective barrier against penetration. Hazard will result only if a person has been internally contaminated such as by ingestion or inhalation. Beta \( \beta \) particles are moderately penetrating and can go as deep as a few millimetres of body tissue. Gamma \( \gamma \) radiation is electromagnetic energy. It is very penetrating and layers of lead are needed for shielding. Neutron radiation is the emission of neutrons from the nuclei of radionuclides. It can be very penetrating and requires thick layers of concrete, water or paraffin for shielding. X-ray and positrons (positively charged electrons) are ionising radiation which are very rarely considered as a concern in nuclear and radiation incidents.

How is it Measure? 7
The activity of the source of radioactivity is measure in becquerel (Bq) which means one disintegration per second. The old unit is curie Ci (1 Ci = 3.7x10^{10} Bq). The energy deposited per gram in a medium by the radiation, which is the absorbed dose, is measured in Gray (G, 1Gy = 1J/Kg). Gray can be used for any radiation, but does not represent the biological effect. The biological effect is measured in sievert (Sv), the dose equivalent, and is calculated as the absorbed dose multiplied by the quality factor Q (Si = Gy x Q). Q characterised the damaging effects of each type of radiation, which is 1 for X-ray, gamma ray and electrons. We are constantly exposed to background radiation [about 2 millisieverts (mSv) per year in Hong Kong]. For comparison, the radiation dose of a chest radiograph is about 0.06 mSv, flight at high altitude is about 0.005 mSv/Hr. 1, 2, 3, 4, 5, 6, 7

Approximate effective radiation dose of common radiological examinations in mSv : CT abdomen 15, CT thorax 7, IVU 3, CT brain 2, Spine X-ray 1.5, mammography 0.4, Chest 0.06, intraoral dental 0.005, extremity 0.001. 8

How can we Detect Radiation? 7
Ionising radiation per se is invisible, tasteless and bears no smell. We can detect the existence of ionising radiation by a Geiger-Muller (GM) counter or ionisation chamber.

What are the Biological Effects of Ionising Radiation? 8
There are two types of biological effects of ionising radiation, namely the Deterministic effects and the Stochastic effects. Deterministic effects are the predictable one when the absorbed dose is more than a threshold level such as nonmalignant skin damage, cataract, haematological effects, acute radiation syndrome (ARS) and impairment of fertility. For the Stochastic effects, no threshold exists such as cancers and genetic mutation. The probability of occurrence is proportional to the dose received. ICRP considers that the chance of contracting fatal cancers will increase by 5/100,000 for 1 mSv of radiation dose absorbed. 1, 2, 6

What are the Variables in Radiation Protection? 7
The variables in radiation protection are Time, Distance and Shielding. The less time we are exposed to radiation, the less we receive the dose. The fall in radiation dosage with distance follows the “Inverse Square Law”; i.e. the dose is only one-quarter when the distance from the source is doubled. Shielding: lead sheets or concrete walls are effective in reducing radiation exposure. Furthermore, staying indoors during the passage of a radioactive plume and avoiding consumption of contaminated food and water are important measures to reduce radiation hazards when there is environmental contamination.

References
The following websites and references provide many valuable information and recommendations:
1. Hong Kong Observatory: www.hko.gov.hk
3. International Commission on Radiological Protection: www.icrp.org
5. US Environmental Protection Agency: www.epa.gov
7. BBC: www.bbc.co.uk