

GLOSSARY OF RADIATION TERMS

ABSOLUTE RISK: The rate of disease among a population.

ABSORBED DOSE, D : The fundamental dose quantity given by the mean energy imparted to matter of mass by ionizing radiation. The SI unit for absorbed dose is joule per kilogram (J kg^{-1}) and its special name is gray (Gy). $1 \text{ Gy} = 1 \text{ J/kg} = 100 \text{ rads}$.

ABSORBED DOSE, MEAN IN A TISSUE OR ORGAN, D_T : The absorbed dose D_T , averaged over the tissue or organ T, which is given by

$$D_T = \frac{\epsilon_T}{m_T}$$

where ϵ_T is the mean total energy imparted in a tissue or organ T, and m_T is the mass of that tissue or organ.

ABSORPTION: Transfer or deposition of some or all of the energy of radiation traversing matter.

ABSORPTION COEFFICIENT: Since the absorption of gamma or X-rays is exponential in nature, these radiations have no clear cut range. The fractional decrease in the intensity of such a beam per unit thickness of the absorber is

expressed by the linear absorption coefficient.

ACCELERATOR (PARTICLE): A device that accelerates charged sub-atomic particles to very great energies. These particles may be used for basic physics research, radioisotope production or for direct medical irradiation of patients.

ACTIVATION: Absorption, usually of neutrons or charged particles (the minimum energy to induce this effect is 10 MeV) by nuclei thereby making them radioactive.

ACTIVE (RED) BONE MARROW: The organ system bone marrow contains the cell systems for the formation of blood cells starting from the pluripotent haematopoietic stem cells to the mature blood cells.

ACTIVITY, A : Is the number of nuclear transformations occurring in a given quantity of material per unit time. The SI unit for the transformation rate is the Becquerel (Bq), which is defined as one disintegration per second. $1 \text{ Bq} = 2.7 \times 10^{-11} \text{ Ci}$. $1 \text{ Ci} = 3.7 \times 10^{10} \text{ Bq}$.

ACUTE RADIATION SYNDROME (ARS): A serious illness caused by receiving a dose greater than 75 rads of penetrating radiation to the body in a short time (usually minutes). The earliest symptoms are nausea, fatigue, vomiting, and diarrhea.

Hair loss, bleeding, swelling of the mouth and throat, and general loss of energy may follow. If the exposure has been approximately 1,000 rads or more, death may occur within 2 – 4 weeks.

ADAPTIVE RESPONSE: A post-irradiation cellular response which, typically, serves to increase the resistance of the cell to a subsequent radiation exposure.

ALPHA PARTICLE: A positively charged highly energetic nuclear fragment, comprised of two neutrons and two protons (helium nucleus).

AMBIENT DOSE EQUIVALENT, $H^*(10)$: The dose equivalent at a point in a radiation field that would be produced by the corresponding expanded and aligned field in the ICRU sphere at a depth of 10 mm on the radius vector opposing the direction of the aligned field. The unit of ambient dose equivalent is joule per kilogram ($J\ kg^{-1}$) and its special name is sievert (Sv).

ANION: A negatively charged ion.

ANNIHILATION RADIATION: Positrons interact with negative electrons resulting in the disappearance of both particles and the release of two annihilation 511 keV photons.

ANNUAL LIMIT ON INTAKE (ALI): The activity of a radionuclide which, upon ingestion, results in an exposure equal to the annual maximum permissible dose.

APOPTOSIS: An active biochemical process of programmed cell death following radiation or other insults.

ATOM: A particle of matter indivisible by chemical means. It is the fundamental building block of elements.

ATOMIC ENERGY BASIC LAW: The Japanese Law established in 1955, which declares the use of atomic energy only for peaceful aim through democratic administration, autonomous accomplishment and results disclosure in the public.

ATOMIC NUMBER: The number assigned to each element on the basis of the number of protons found in the element's nucleus.

ATOMIC WEIGHT (ATOMIC MASS): Approximately the sum of the number of protons and neutrons found in the nucleus of an atom.

ATTENUATION: The reduction of the intensity of a beam of gamma or x-rays as it passes through some material. Beam energy can be lost by deposition (absorption) and/or by deflection (deflection)

attenuation). The three primary mechanisms by which energy is transferred from the beam to the material through which it passes are the photoelectric effect, the Compton effect and pair production.

ATTRIBUTABLE RISK: The estimated rate of a disease (such as lung cancer) that could, in theory, be prevented if all exposures to a particular causative agent (such as radon) were eliminated.

AVERTED DOSE: The dose prevented or avoided by the application of a protective measure or set of protective measures, i.e., the difference between the projected dose if the protective measure(s) had not been applied and the expected residual dose.

BACKGROUND RADIATION: The radiation to which a member of the population is exposed from natural sources, such as terrestrial radiation due to naturally occurring radionuclides in the soil, cosmic radiation originating in outer space, and naturally occurring radionuclides in the human body.

BEAM: A flow of electromagnetic or particulate radiation that is generally unidirectional or is divergent from a radioactive source but is confined to a small angle.

BECQUEREL (Bq): The SI unit of activity

defined as one nuclear disintegration per second (dps). $1 \text{ Bq} = 2.7 \times 10^{-11} \text{ Ci}$. $1 \text{ Ci} = 3.7 \times 10^{10} \text{ Bq}$.

BETA PARTICLE: Negatively charged particle emitted from the nucleus of an atom. It is just an energetic electron.

BIAS: Factors that influence the outcome of data collection, such as causing certain measurements to have a greater chance of being included than others.

BINDING ENERGY: The minimum energy required to separate a nucleus into its component neutrons and protons.

BIOASSAY: Any procedure used to determine the nature, activity, location, or retention of radionuclides in the body by in vivo measurement or by in vitro analysis of material excreted or otherwise removed from the body.

BOHR RADIUS: The size of a ground state hydrogen atom as calculated by Niels Bohr using a mix of classical physics and quantum mechanics.

BRACHYTHERAPY: Radiation treatment of a patient using sealed or unsealed sources of radiation placed within the patient's body.

BRANCHING: The occurrence of two or

more modes by which a radionuclide can undergo radioactive decay to the ultimate stable state. An individual atom of a nuclide exhibiting branching disintegrates by one mode only. The fraction disintegrating by a particular mode is the branching fraction for that mode. The branching ratio is the ratio of two specified branching fractions (also called multiple disintegration).

BREMSSTRAHLUNG: Secondary electromagnetic radiations produced by the rapid deceleration of charged particles in strong electromagnetic fields. The likelihood of emission is proportional to the mass of the nucleus of the absorber.

BYSTANDER EFFECT: A response in unirradiated cells that is triggered by signals received from irradiated neighbouring cells.

CARRIER: A quantity of non-radioactive or non-labeled material of the same chemical composition as its corresponding radioactive or labeled counterpart.

CARRIER-FREE: A preparation of radioisotope to which no carrier has been added and for which precautions have been taken to minimize contamination with other isotopes. Material of high specific activity is often loosely referred to as "carrier-free" but is more correctly defined as "high isotopic abundance".

CASE-CONTROL STUDY: An epidemiologic study in which people with disease and a similarly composed control group are compared in terms of exposures to a putative causative agent.

CHARACTERISTIC X-RAY: A collision of the fast-moving electrons with the atom first causes a tightly bound inner-shell electron to be ejected from the atom; a loosely bound outer-shell electron then falls into the inner shell to fill the vacancy. In the process, a single photon (characteristic X-ray) is emitted by the atom with an energy equal to the difference between the inner-shell and outer-shell vacancy states.

COHORT STUDY: An epidemiologic study in which groups of people (the cohort) are identified with respect to the presence or absence of exposure to a disease-causing agent, and in which the outcomes of disease rates are compared; also called a follow-up study.

COLLECTIVE DOSE: The estimated dose for an area or region multiplied by the estimated population in that area or region.

COMMITTED DOSE EQUIVALENT: The total dose equivalent averaged throughout a tissue 50 years after body uptake of the radionuclide.

COMPTON EFFECT: Interactive effect of X-ray and gamma radiation with matter. The Compton effect is the elastic scattering of a quantum with a free or quasi-free electron from the electron sheath of an atom. Part of the energy and the pulse of the quantum is transferred to the electron, the rest remains with the scattered quantum.

CONFIDENCE LIMITS: An interval giving the lowest and highest estimate of a parameter that is statistically compatible with the data. For a 95% confidence interval, there is a 95% chance that the interval contains the parameter.

CONTAMINATION, RADIOACTIVE: Unwanted deposition of radioactive material in or on any medium or surface. The Law concerning Prevention of Radiation hazards due to Radioisotopes, etc permits no contamination greater than 40Bq/cm² in the radiation controlled area.

CONTROLLED AREA: A defined area in which specific protection measures and safety provisions are required for controlling normal exposures or preventing the spread of contamination during normal working conditions, and preventing or limiting the extent of potential exposures.

CONVERSION ELECTRON: An electron ejected from the atom by direct transfer of

excess energy of unstable nucleus to one of its own orbiting electrons.

COSMIC RADIATION: Radiation produced in outer space when heavy particles from other galaxies (nuclei of all known natural elements) bombard the earth.

COULOMB (C): The quantity of electricity transported in one second by a current of one ampere.

COUNTER: A general designation applied to radiation detection instruments or survey meters that detect and measure radiation. The signal that indicates an ionization event has been detected is called a count.

COUNTER, SCINTILLATION: Scintillation detection is based on the interaction of radiation with substances known as fluors (solid or liquid) or scintillators. Excitation of the electrons in the fluor leads to subsequent emission of light (scintillation) which is detected by a photomultiplier tube and converted into an electronic pulse. The pulse magnitude is proportional to the energy lost by the incident radiation in the excitation of the fluor.

COSMIC RADIATION: Penetrating ionizing radiation, both particulate and electromagnetic, that originates in outer space. Secondary cosmic rays, formed by interactions in the earth's atmosphere.

CRITICALITY: A fission process where the neutron production rate equals the neutron loss rate to absorption or leakage. A nuclear reactor is "critical" when it is operating.

CRITICAL MASS: The minimum amount of fissile material that can achieve a self-sustaining nuclear chain reaction.

CRITICAL ORGAN: The part of the body that is most susceptible to radiation damage resulting from the specific exposure conditions under consideration, taking into account the dose the various parts of the body receive under the exposure conditions.

CUMULATIVE DOSE: The total dose resulting from repeated or continuous exposures of the same portion of the body, or of the whole body, to ionizing radiation.

CURIE (Ci): The outmoded unit used to quantify activity of radioactive material. Defined as 3.7×10^{10} disintegrations per second.

CUTANEOUS RADIATION SYNDROME (CRS): The complex syndrome resulting from radiation exposure of more than 200 rads to the skin. The immediate effects can be reddening and swelling of the exposed area (like a severe burn), blisters, ulcers on

the skin, hair loss, and severe pain. Very large doses can result in permanent hair loss, scarring, altered skin color, deterioration of the affected body part, and death of the affected tissue (requiring surgery).

CYCLOTRON: Particle accelerator where charged particles repeatedly pass an electrical acceleration field while they move helically from their source in the centre of the machine to the outside. The particles are held in the helical level by a strong magnet. A cyclotron is not suitable to accelerate electrons. Due to the relativistic mass increase with growing speed the maximum energy achievable with a cyclotron is limited to about 400 MeV for protons.

DECAY, RADIOACTIVE: Disintegration of the nucleus of an unstable nuclide by spontaneous emission of charged particles and/or photons.

DECAY CHAIN (DECAY SERIES): The series of decays that certain radioisotopes go through before reaching a stable form. For example, the decay chain that begins with uranium-238 (U-238) ends in lead-206 (Pb-206), after forming isotopes, such as uranium-234 (U-234), thorium-230 (Th-230), radium-226 (Ra-226), and radon-222 (Rn-222).

DECAY CONSTANT: The fraction of atoms undergoing nuclear disintegration per unit time.

DECAY PRODUCTS (DAUGHTER PRODUCTS): The isotopes or elements formed and the particles and high-energy electromagnetic radiation emitted by the nuclei of radionuclides during radioactive decay. Also known as "decay chain products" or "progeny" (the isotopes and elements). A decay product may be either radioactive or stable.

DECLARED PREGNANT WOMAN: A woman who is a radiation worker and has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

DECONTAMINATION: The removal of radioactive contaminants by cleaning and washing with chemicals.

DEPOSITION DENSITY: The activity of a radionuclide per unit area of ground. Reported as becquerels per square meter or curies per square meter.

DETECTOR: A material or device that is sensitive to radiation and can produce a response signal suitable for measurement or analysis. A radiation detection instrument.

DETERMINISTIC EFFECT: Injury in populations of cells, characterized by a threshold dose and an increase in the severity of the reaction as the dose is increased further. Also termed tissue reaction. In some cases, deterministic effects are modifiable by post-irradiation procedures including biological response modifiers.

DETRIMENT: The total harm to health experienced by an exposed group and its descendants as a result of the group's exposure to a radiation source. Detriment is a multidimensional concept. Its principal components are the stochastic quantities: probability of attributable fatal cancer, weighted probability of attributable non-fatal cancer, weighted probability of severe heritable effects, and length of life lost if the harm occurs.

DETRIMENT-ADJUSTED RISK: The probability of the occurrence of a stochastic effect, modified to allow for the different components of the detriment in order to express the severity of the consequence(s).

DEUTERIUM: A non-radioactive isotope of the hydrogen atom that contains a neutron in its nucleus in addition to the one proton normally seen in hydrogen. A deuterium atom is twice as heavy as normal hydrogen.

DIRTY BOMB: A device designed to spread radioactive material by conventional explosives when the bomb explodes. A dirty bomb kills or injures people through the initial blast of the conventional explosive and spreads radioactive contamination over possibly a large area—hence the term “dirty.” Such bombs could be miniature devices or large truck bombs. A dirty bomb is much simpler to make than a true nuclear weapon.

DNA DAMAGE SIGNALLING: Interacting biochemical processes that recognize and respond to DNA damage in cells, e.g., by causing the arrest of the reproductive cell cycle and/or apoptosis. Molecules such as ATM, CHK1, p53, and p21 are known to be involved in the processes.

DOSE: Short name for absorbed dose (1 Gy = 1 J/kg) and also for equivalent dose, effective dose, and weighted dose (1 Sv = 1 J/kg). Definitions of low, medium, and high doses vary widely in the literature. For the purposes of this report, dose levels have been defined as follows: Low dose: 0–100 mGy (mSv), Medium dose: In excess of 100 mGy up to a maximum of 1 Gy, High dose: In excess of 1 Gy up to the very high total doses used in radiation therapy (on the order of 20–60 Gy).

DOSE-RATE EFFECTIVENESS FACTOR

(DREF): The factor by which the effect caused by a specific type of radiation changes at low doses or low dose rates (protracted or fractionated delivery of dose) as compared to high doses delivered at high (or acute) dose rates.

DOSE AND DOSE-RATE EFFECTIVENESS FACTOR (DDREF): A judged factor that generalizes the usually lower biological effectiveness (per unit of dose) of radiation exposures at low doses and low dose rates as compared with exposures at high doses and high dose rates.

DOSE COEFFICIENT: Used as a synonym for dose per unit intake of a radioactive substance, but sometimes also used to describe other coefficients linking quantities or concentrations of activity to doses or dose rates, such as the external dose rate at a specified distance above a surface with a deposit of a specified activity per unit area of a specified radionuclide.

DOSE CONSTRAINT: A prospective and source-related restriction on the individual dose from a source, which provides a basic level of protection for the most highly exposed individuals from a source, and serves as an upper bound on the dose in optimization of protection for that source. For occupational exposures, the dose constraint is a value of individual dose used

to limit the range of options considered in the process of optimization. For public exposure, the dose constraint is an upper bound on the annual doses that members of the public should receive from the planned operation of any controlled source.

DOSE EQUIVALENT, H : The product of D and Q at a point in tissue, where D is the absorbed dose and Q is the quality factor for the specific radiation at this point, thus: $H = DQ$. The unit of dose equivalent is joule per kilogram (J kg^{-1}), and its special name is sievert (Sv).

DOSE EQUIVALENT, DIRECTIONAL, $H'(d, \Omega)$: The dose equivalent at a point in a radiation field that would be produced by the corresponding expanded field in the ICRU sphere at a depth, d , on a radius in a specified direction, Ω . The unit of directional dose equivalent is joule per kilogram (J kg^{-1}) and its special name is sievert (Sv).

DOSE EQUIVALENT, PERSONAL, $H_p(d)$: An operational quantity. The dose equivalent in soft tissue (commonly interpreted as the 'ICRU sphere') at an appropriate depth, d , below a specified point on the human body. The unit of personal dose equivalent is joule per kilogram (J kg^{-1}) and its special name is sievert (Sv). The specified point is usually given by the position where the individual's

dosimeter is worn.

DOSE LIMIT: The value of the effective dose or the equivalent dose to individuals from planned exposure situations that shall not be exceeded.

DOSE RATE: Dose per unit time (Gy/min or Sv/min, for example).

DOSE RECONSTRUCTION: A scientific study that estimates doses to people from releases of radioactivity or other pollutants. The dose is reconstructed by determining the amount of material released, the way people came in contact with it, and the amount they absorbed.

DOSE MODIFYING FACTOR (DMF): The ratio of doses with and without modifying agents, causing the same level of biological effect.

DOSIMETER, PERSONAL: A small pocket-sized dosimeter used for monitoring radiation exposure of personnel.

DOSIMETRY: Assessment (by measurement or calculation) of radiation dose.

DOUBLING DOSE (DD): The dose of radiation (Gy) that is required to produce as many heritable mutations as those arising spontaneously in a generation.

DS02: Dosimetry System 2002, a system for estimating gamma and neutron exposure under a large variety of situations and which allows the calculation of absorbed dose to specific organs for members of the Life Span Study. DS02 improved on the DS86 dose system.

DTPA: Diethylenetriamine pentaacetate; chelators. Chelators are organic compounds capable of integrating metal ions in the organic molecule in such a way that the metal ion loses its chemical properties essential for its biological behaviour and can therefore be excreted more rapidly from the body. Thus, effective decorporation agents in the form of Ca-DTPA and Zn-DTPA - in particular for plutonium - are available.

EFFECTIVE DOSE, E : The tissue-weighted sum of the equivalent doses in all specified tissues and organs of the body, given by the expression:

$$E = \sum_T w_T \sum_R w_R D_{T,R} \quad \text{OR} \quad E = \sum_T w_T H_T$$

where H_T or $w_R D_{T,R}$ is the equivalent dose in a tissue or organ, T, and w_T is the tissue weighting factor. The unit for the effective dose is the same as for absorbed dose, J kg^{-1} , and its special name is sievert (Sv). 1Sv=100rem.

EFFECTIVE DOSE, COLLECTIVE:

Number of persons times average effective dose. Unit is person-Sv (special name used with collective dose).

EFFECTIVE DOSE, COMMITTED, $E(\tau)$:

The sum of the products of the committed organ or tissue equivalent doses and the appropriate tissue weighting factors (w_T), where τ is the integration time in years following the intake. The commitment period is taken to be 50 years for adults, and to age 70 years for children.

ELECTROMAGNETIC RADIATION:

A spectrum of discrete energy emissions such as radio waves, microwaves, ultraviolet light, visual light, X-rays, gamma rays, etc, having no charge or mass, often called photons or quanta.

ELECTRON:

An elementary particle with a unit electrical charge and a mass 1/1837 that of the proton. Electrons surround the atom's positively charged nucleus and determine the atom's chemical properties.

ELECTRON CAPTURE:

A type of radioactivity in which an atomic electron is absorbed by the nucleus, and is often followed by gamma-ray emission.

ELECTRON VOLT (eV):

A special unit of energy: 1 eV = 1.6×10^{-19} J = 1.6×10^{-12} erg; 1 eV is equivalent to the energy gained by an electron in passing through a

potential difference of 1 V; 1 keV=1000 eV;
1 MeV = 1,000,000 eV.

EMERGENCY: A non-routine situation or event that necessitates prompt action primarily to mitigate a hazard or adverse consequences for human health and safety, quality of life, property or the environment. This includes situations for which prompt action is warranted to mitigate the effects of a perceived hazard. Actions in case of emergency should be clarified and informed to radiation workers.

ENERGY, AVERAGE PER ION PAIR: The average energy expended by a charged particle in a gas per ion pair produced. For most radiological calculations, this value has been normalized to 33.73 eV.

ENERGY, BINDING: The energy represented by the difference in mass between the sum of the component parts and the actual mass of the nucleus.

ENERGY, EXCITATION: The energy required to change a system from its lowest energy state (ground state) to an excited state.

ENERGY FLUENCE: The sum of the energies, exclusive of rest energies, of all particles passing through a unit cross-sectional area.

ENERGY FLUX DENSITY (ENERGY FLUENCE RATE): The sum of the energies, exclusive of rest energies, of all particles passing through a unit cross-sectional area per unit time.

ENERGY LEVELS: Discrete set of quantized energies states within a given atomic nucleus (or atom itself).

EPIDEMIOLOGY: The study of the determinants of the frequency of disease in humans. The two main types of epidemiologic studies of chronic disease are cohort (or follow-up) studies and case-control studies.

EQUIVALENT DOSE, H_T : The dose in a tissue or organ T given by:

$$H_T = \sum_R w_R D_{T,R}$$

where $D_{T,R}$ is the mean absorbed dose from radiation R in a tissue or organ T, and w_R is the radiation weighting factor. Since w_R is dimensionless, the unit for the equivalent dose is the same as for absorbed dose, $J\ kg^{-1}$, and its special name is sievert (Sv).

EQUIVALENT DOSE, COMMITTED, $H_I(\tau)$: The time integral of the equivalent dose rate in a particular tissue or organ that will be received by an individual following intake of radioactive material into the body by a Reference Person, where τ is the

integration time in years.

ERRORS, RANDOM: Errors that vary in a non-reproducible way around a limiting mean. These errors can be treated statistically by use of the laws of probability.

ERRORS, SYSTEMIC: Errors that are reproducible and tend to bias a result in one direction. Their causes can be assigned, at least in principle, and they can have constant and variable components. Generally, these errors cannot be treated statistically.

ERYTHEMA: An abnormal redness of the skin due to distention of the capillaries with blood. It can be caused by many different agents of which heat, drugs, ultraviolet rays, and ionizing radiation (dose of 10 Sv) are the most common.

EXCESS ABSOLUTE RISK (EAR): The rate of disease incidence or mortality in an exposed population minus the corresponding disease rate in an unexposed population. The excess absolute risk is often expressed as the additive excess rate per Gy or per Sv.

EXCESS RELATIVE RISK (ERR): The rate of disease in an exposed population divided by the rate of disease in an unexposed population, minus 1.0. This is often expressed as the excess relative risk

per Gy or per Sv.

EXCITED STATE: The state of an atom or nucleus when it possesses more than its normal energy. The excess energy is usually released eventually as a gamma ray.

EXCLUSION: The deliberate exclusion of a particular category of exposure from the scope of an instrument of regulatory control.

EXEMPTION: The determination by a regulatory body that a source or practice activity involving radiation need not be subject to some or all aspects of regulatory control.

EXPOSED INDIVIDUALS: The ICRP distinguishes between three categories of exposed individuals: workers (informed individuals), the public (general individuals), and patients, including their comforters and carers.

EXPOSURE (C/kg): A measure of the ionization produced in air by X or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of the air in the volume element. The SI unit of Coulombs per kilogram replaces the

outmoded Roentgen unit.

EXPOSURE, ACUTE: An exposure to radiation that occurred in a matter of minutes rather than in longer, continuing exposure over a period of time.

EXPOSURE, CATEGORIES OF: The ICRP distinguishes between three categories of radiation exposure: occupational, public, and medical exposures of patients.

EXPOSURE, CHRONIC: Exposure to a substance over a long period of time, possibly resulting in adverse health effects.

EXPOSURE, EXTERNAL: Exposure to radiation outside of the body.

EXPOSURE, FRACTIONATED: Exposure to radiation that occurs in several small acute exposures, rather than continuously as in a chronic exposure.

EXPOSURE, INTERNAL: Exposure to radioactive material taken into the body.

EXPOSURE, MEDICAL: Exposure incurred by patients as part of their own medical or dental diagnosis or treatment; by persons, other than those occupationally exposed, knowingly, while voluntarily helping in the support and comfort of patients; and by volunteers in a program of biomedical research involving their

exposure.

EXPOSURE, OCCUPATIONAL: Exposure incurred by workers in the course of their work, with the exception of 1) excluded exposures and exposures from exempt activities involving radiation or exempt sources; 2) any medical exposure; and 3) the normal local natural background radiation.

EXPOSURE, POTENTIAL: Exposure that is not expected to be delivered with certainty but that may result from an accident at a source or an event or sequence of events of a probabilistic nature, including equipment failures and operating errors.

EXPOSURE, PRENATAL: Radiation exposure to an embryo or fetus while it is still in its mother's womb. At certain stages of the pregnancy, the fetus is particularly sensitive to radiation and the health consequences could be severe above 5 rads, especially to brain function.

EXPOSURE, PUBLIC: Exposure incurred by members of the public from radiation sources, excluding any occupational or medical exposure and the normal local natural background radiation.

EXPOSURE, WHOLE BODY: An exposure of the body to radiation, in which the entire

body, rather than an isolated part, is irradiated by an external source.

EXPOSURE PATHWAY: A route by which a radionuclide or other toxic material can enter the body. The main exposure routes are inhalation, ingestion, absorption through the skin, and entry through a cut or wound in the skin.

EXPOSURE SITUATIONS, EXISTING: A situation that already exists when a decision on control has to be taken, including natural background radiation and residues from past practices that were operated outside the ICRP recommendations.

EXPOSURE SITUATIONS, PLANNED: Everyday situations involving the planned operation of sources including decommissioning, disposal of radioactive waste and rehabilitation of the previously occupied land. Practices in operation are planned exposure situations.

FILM BADGE: Photographic film used for measurement of ionizing radiation exposure for personnel monitoring purposes. The film badge may contain two or three films of differing sensitivities, and it may contain a filter that shields part of the film from certain types of radiation.

FISSION: The splitting of a heavy nucleus

into two roughly equal parts (which are nuclei of lighter elements), accompanied by the release of a relatively large amount of energy in the form of kinetic energy of the two parts and in the form of emission of neutrons and gamma rays.

FISSION MATERIAL: Any material in which neutrons can cause a fission reaction. The three primary fissile materials are uranium-233, uranium-235, and plutonium-239.

FISSION PRODUCTS: Nuclei formed by the fission of heavy elements. They are of medium atomic weight and almost all are radioactive.

FLUENCE, PARTICLE, Φ : The quotient of dN by da , where dN is the number of particles incident upon a small sphere of cross-sectional area da .

FUSION: A reaction in which at least one heavier, more stable nucleus is produced from two lighter, less stable nuclei. Reactions of this type are responsible for the release of energy in stars.

GAMMA RADIATION: Short-wavelength electromagnetic radiation of nuclear origin, similar to X-rays but usually of higher energy (100 keV to several MeV).

GAS-FILLED DETECTOR: The most

common type of radiation detector. This instrument works on the principle that as radiation passes through air or a specific gas, ionization of the molecules in the air occur. When a high voltage is placed between two areas of the gas filled space, the positive ions will be attracted to the negative side of the detector (the cathode) and the free electrons will travel to the positive side (the anode). These charges are collected by the anode and cathode which then form a very small current in the wires going to the detector. By placing a very sensitive current measuring device between the wires from the cathode and anode, the small current measured and displayed as a signal. The more radiation which enters the chamber, the more current displayed by the instrument. Many types of gas-filled detectors exist, but the two most common are the ion chamber used for measuring large amounts of radiation and the Geiger-Muller or GM detector used to measure very small amounts of radiation.

GAS FLOW COUNTER: A proportional counter with its flowing filling gas continuously replaced by new gas. Thus, the ingress of air is avoided or ingressed air expelled.

GEIGER MUELLER (GM) COUNTER: The major component of laboratory survey meters, which function as incident radiation detectors. A Geiger-Mueller tube is

composed of a gas filled hollow tube containing two coaxial electrodes that discharge and recharge following ionizing events.

GENERATOR: Device from which a progeny nuclide is eluted from an ion exchange column containing a parent radionuclide, which is long-lived compared to the progeny.

GENETIC EFFECT OF RADIATION: The radiation induced change in the DNA of germ cells resulting in the passing of the altered genetic information to future generations.

GEOMETRY FACTOR: The fraction of the total solid angle about a radiation source that is subtended by the face of the sensitive volume of a detector.

GERM CELLS: Reproductive cells such as the sperm and egg and their progenitor cells.

GLASS BADGE: Phosphate glass dosimeter. Measuring device to determine the dose. The radio-photoluminescence effect which is the property of certain substances to emit fluorescent light of greater wave length upon irradiation with ultraviolet light when previously exposed to ionizing radiation, is used to determine the dose. Silver-activated metaphosphate

glasses - glasses made of alkaline and alkaline earth phosphates with some percent of silver metaphosphate - show this photoluminescence effect for example. The intensity of the fluorescent light is proportional over wide areas of the irradiated dose.

GONAD DOSE: Radiation dose at the gonads (testicles and ovaries).

GRAY (Gy): The SI unit of absorbed dose that is equal to one joule per kilogram. Replaces the RAD (1Gy=100Rad).

GROWTH FACTORS: Molecules that act to control cell reproduction and proliferation/differentiation of a population of cells.

HALF-LIFE, BIOLOGICAL (BHL): The time required for the body to eliminate one half of an administered dosage of any substance by regular process of elimination.

HALF-LIFE, EFFECTIVE (EHL): Time required for a radioactive element in a living organism to be diminished 50% as a result of the combined action of physical half-life (PHL) and biological elimination (BHL).

HALF-LIFE, PHYSICAL (PHL): Time required for a radioactive substance to lose 50% of its activity by decay. Each

radionuclide has its own unique half-life.

HALF VALUE LAYER (HVL): The thickness of a specified substance which, when introduced into the path of a given beam of X or gamma radiation, reduces the intensity of the beam by one half.

HEAVY WATER: Deuterium oxide, D₂O; water containing two deuterium atoms instead of the two light hydrogen atoms. Natural water contains one deuterium atom per 6,500 molecules H₂O. D₂O has a low neutron absorption cross-section. It is therefore applicable as a moderator in natural-uranium-fuelled reactors.

HEPA FILTER: High-efficiency particulate air filter to separate dry aerosols; in Germany suspended matter filter of special class S, frequently called „absolute membrane filter“.

HIGH-LET RADIATION: Neutrons or heavy, charged particles, such as protons or alpha particles, that produce ionizing events densely spaced on a molecular scale (e.g., $L > 10 \text{ keV}/\mu\text{m}$)

HORMESIS: Some physical or chemical agents have one effect at high doses and the reverse effect at low doses. This phenomenon is known as hormesis. It probably results from the activation of defense mechanisms. Hormesis is

observed with several drug molecules that are toxic at high doses, but which can have a beneficial protective effect at low doses.

HOT: A term used in nuclear technology for "highly active".

HOT CELL: Highly shielded tight casing in which highly radioactive substances can be remotely handled by manipulators observing the processes through lead-glass windows so that there is no hazard to personnel.

ICRP (INTERNATIONAL COMMISSION OF RADIOLOGICAL PROTECTION): An independent international organization that provides recommendations and guidance on protection against ionizing radiation.

ICRU (INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS): An independent international organization that provides recommendations and guidance on radiation quantities, units, and measurements.

INCIDENCE: The rate of occurrence of a disease within a specified period of time, often expressed as a number of cases per 100,000 individuals per year. Also, incidence rate.

INDUCED GENOMIC INSTABILITY: The

induction of an altered cellular state characterized by a persistent increase over many generations in the spontaneous rate of mutation or other genome-related changes.

INDUCED RADIOACTIVITY: Radioactivity that is created by bombarding a substance with neutrons in a reactor or with charged particles produced by particle accelerators.

INES (INTERNATIONAL NUCLEAR EVENT SCALE): A scale with seven levels proposed by the IAEA to evaluate the events occurring in nuclear installations according to international uniform criteria, in particular with regard to the aspect of hazards to the population. The upper levels (4 to 7) include accidents, the lower levels (1 to 3) anomalies and incidents. Notifiable events of no safety-related or radiological significance according to the international scale are designated as „below the scale“ or "Level 0".

INGESTION: 1) The act of swallowing; 2) In the case of radionuclides or chemicals, swallowing radionuclides or chemicals by eating or drinking.

INHALATION: 1) The act of breathing in; 2) In the case of radionuclides or chemicals, breathing in radionuclides or chemicals.

INTAKE: Activity that enters the body

through the respiratory tract or the gastrointestinal tract or the skin. A single intake by inhalation or ingestion, taken to occur instantaneously is called “Acute intake”, whereas an intake over a specified period of time is called “Chronic intake”.

INTERNAL CONVERSION: Direct transfer of excess energy to one of its own orbiting electrons, thereby ejecting the electron from the atom (conversion electron). It always accompanies the predominant process of gamma emission to some extent.

IN UETRO: In the womb (i.e., before birth).

ION: An atomic particle that is electrically charged, either negative or positive.

IONIZATION: The process of adding one or more electrons to, or removing one or more electrons from, atoms or molecules, thereby creating ions. High temperatures, electrical discharges, or nuclear radiation can cause ionization.

IONIZATION CHAMBER: Radiation detector used for determining the intensity of a beam of radiation or for counting individual charged particles. The device may consist of a gas-filled, cylindrical container in which an electric field is maintained by impressing a voltage that keeps the wall negative relative to a wire

extending along the axis. When a photon or a charged particle enters the chamber, it converts some of the gas molecules to positive ions and electrons; under the influence of the electric field, these particles migrate to the wall and the wire, respectively, and cause an observable pulse of current to flow through the circuit joining these elements.

IONIZATION ENERGY: The energy required to remove one electron from an atom giving rise to an ion pair. In air, the average ionization energy is 33.73 eV.

IONIZING RADIATION: Radiation sufficiently energetic to dislodge electrons from an atom, thereby producing an ion pair. Ionizing radiation includes X- and gamma radiation, electrons (beta radiation), alpha particles (helium nuclei), and heavier charged atomic nuclei. Neutrons ionize indirectly by first colliding with components of atomic nuclei.

IRRADIATION: Subjection to radiation.

ISOMER: One of several nuclides with the same number of neutrons and protons capable of existing for a measurable time in different nuclear energy states.

ISOMETRIC TRANSITION: A mode of radioactive decay where a nucleus goes from a higher to a lower energy state. The

mass number and the atomic number are unchanged.

ISOTOPE: A given element have the same atomic number (same number of protons in their nuclei) but different atomic weights (different number of neutrons in their nuclei). Uranium-238 and uranium-235 are isotopes of uranium.

JUSTIFICATION: The process of determining whether either (1) a planned activity involving radiation is, overall, beneficial, i.e. whether the benefits to individuals and to society from introducing or continuing the activity outweigh the harm (including radiation detriment) resulting from the activity; or (2) a proposed remedial action in an emergency or existing exposure situation is likely, overall, to be beneficial, i.e., whether the benefits to individuals and to society (including the reduction in radiation detriment) from introducing or continuing the remedial action outweigh its cost and any harm or damage it causes.

JOULE (J): The work done when the point of application of a force of one newton is displaced a distance of one meter in the direction of the force.

K-CAPTURE: The capture by an atom's nucleus of an orbital electron from the first K-shell surrounding the nucleus.

KERMA (KINETIC ENERGY RELEASED IN MATERIAL, K):

The quotient of the sum of the kinetic energies, dE_{tr} , of all charged particles liberated by uncharged particles in a mass dm of material, and the mass dm of that material.

$$K = \frac{dE_{tr}}{dm}$$

Kerma is defined as a non-stochastic quantity and dE_{tr} is the expectation value of the sum of the kinetic energies. The unit for kerma is joule per kilogram ($J\ kg^{-1}$) and its special name is gray (Gy).

LABELLED COMPOUND: A compound consisting, in part, of molecules made up of one or more atoms distinguished by non-natural isotopic composition (either radioactive or stable isotopes).

LATENT PERIOD: The period or state of seeming inactivity between the time of exposure of tissue to an injurious agent such as radiation, and the presentation of the associated pathology.

LD50: Dose that is lethal for half of the exposed individuals.

LIFE SPAN STUDY (LSS): The long-term cohort study of health effects in the Japanese atomic bomb survivors in Hiroshima and Nagasaki.

LINEAR ACCELERATOR: A long straight tube in which particles (mostly electrons or protons) are accelerated by electrostatic fields or electromagnetic waves and thus achieve very high energies.

LINEAR DOSE RESPONSE: A statistical model that expresses the risk of an effect (e.g., disease or abnormality) as being proportional to dose.

LINEAR ENERGY TRANSFER (LET): The rate at which an incident particle transfers energy as it travels through matter. The unit is keV per micron of path traveled, and is often given in J m^{-1} .

LINEAR-QUADRATIC DOSE RESPONSE (LQ MODEL): A statistical model that expresses the risk of an effect (e.g., disease, death, or abnormality) as the sum of two components, one proportional to dose (linear term) and the other one proportional to the square of dose (quadratic term).

LIQUID SCINTILLATION COUNTER (LSC): Scintillation counter in which the scintillator is an organic liquid (e.g. diphenyl oxazole, dissolved in toluene). Preferred detection and measuring device for the low-energetic beta radiation of tritium and carbon-14.

LNT MODEL: Linear no-threshold

dose-response for which any dose greater than zero has a positive probability of producing an effect (e.g., mutation or cancer). The probability is calculated either from the slope of a linear (L) model or from the limiting slope, as the dose approaches zero, of a linear-quadratic (LQ) model.

LOCAL RADIATION INJURY: Acute radiation exposure (more than 1,000 rads) to a small, localized part of the body. Most local radiation injuries do not cause death. However, if the exposure is from penetrating radiation (neutrons, X-rays, or gamma rays), internal organs may be damaged and some symptoms of acute radiation syndrome (ARS), including death, may occur. Local radiation injury invariably involves skin damage, and a skin graft or other surgery may be required.

LOW CONCERNING PREVENION OF RADIATION HAZARDS DUE TO RADIOISOTOPES, ETC.: The Japanese Low established in 1957, which regulates the use, sale, lease, disposal and other handling of radioisotopes, the use of radiation generating equipment, and the disposal and other handling of the articles contaminated by radioisotopes to prevent radiation hazards.

LOW ENERGY GAMMA SCINTILLATOR (LEGS): A detection system that utilizes an alkali halide crystal photomultiplier

arrangement to detect low energy gamma and x-ray radiation.

LOW FOR THE REGULATION OF NUCLEAR SOURCE MATERIAL, NUCLEAR FUEL AND REACTORS: The Japanese Low established in 1957, which enforces the necessary regulations on manufacture, processing, storage, reprocessing and disposal activities of nuclear source materials, fuel materials and nuclear reactors.

LOW-LET RADIATION: X-rays and gamma rays or light, charged particles, such as electrons, that produce sparse ionizing events far apart on a molecular scale (e.g., $L < 10 \text{ keV}/\mu\text{m}$).

MAXIMUM PERMISSIBLE CONCENTRATION: Limits set on water and air concentrations of radionuclides, which yield maximum permissible body burden values and their corresponding organ dosages.

META ANALYSIS: An analysis of epidemiologic data from several studies based on data included in publications.

MONTE CARLO CALCULATION: The method for evaluation of a probability distribution by means of random sampling.

MORTALITY (RATE): The frequency at which people die from a disease (e.g., a specific cancer), often expressed as the number of deaths per 100,000 population per year.

MULTI-CHANNEL ANALYZER: Pulse amplitude analyser sorting the pulses of energy-proportional detectors according to the amplitude and thus the radiation energy and recording them in the corresponding channel. Multi-channel analysers have more than 8,000 channels

NCRP (NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS): U.S. Council commissioned to formulate and disseminate information, guidance, and recommendations on radiation protection and measurements.

NEOPLASTIC: Pertaining to the pathologic process resulting in the formation and growth of an abnormal mass of tissue.

NEUTRINO: An electrically neutral particle with negligible mass. It is produced in many nuclear reactions such as in beta decay.

NEUTRON: One of the basic particles which make up an atom. A neutron and a proton have about the same weight, but the neutron has no electrical charge.

NEUTRON, FAST: Neutron with a kinetic energy of more than 0.1 MeV.

NEUTRON, INTERMEDIATE: Neutron with an energy beyond that of a slow neutron, however lower than that of a fast neutron; generally within the range of 10 and 100,000 eV.

NEUTRON, THERMAL: Neutrons in thermal equilibrium with the ambient medium. Thermal neutrons most probably have a neutron velocity of 2200 m/s at 293.6 K corresponding to an energy of 0.0253 eV. Fast neutrons as generated during nuclear fission are decelerated by collisions with the atoms of the moderator material (usually water, heavy water or graphite) to thermal energy, they are 'thermalized'.

NOMINAL RISK COEFFICIENT: Sex averaged and age at exposure averaged lifetime risk estimates for a representative population.

NON-CANCER DISEASES, RADIATION INDUCED: Somatic diseases other than cancer, e.g., cardiovascular disease and cataracts.

NON-DESTRUCTIVE TESTING: Testing for hidden defects in material using methods which do not damage or destroy the test pieces. Frequently X-rays, gamma

radiation or ultrasound are used.

NON-IONIZING RADIATION: Radiation that has lower energy levels and longer wavelengths than ionizing radiation. It is not strong enough to affect the structure of atoms it contacts but is strong enough to heat tissue and can cause harmful biological effects. Examples include radio waves, microwaves, visible light, and infrared from a heat lamp.

NORM (NATURALLY OCCURRING RADIOACTIVE MATERIAL): Radioactive material containing no significant amounts of radionuclides other than naturally occurring radionuclides. Material in which the activity concentrations of the naturally occurring radionuclides have been changed by some process are included in NORM.

NPT (NON-PROLIFERATION TREATY): The aim of the international Treaty on the Non-proliferation of Nuclear Weapons and the resulting nuclear material monitoring is the timely detection of nuclear material diversion for the manufacture of nuclear weapons or deterrence of such deviation through the risk of detection. Corresponding monitoring in Germany is performed by Euratom and the International Atomic Energy Agency.

NUCLEAR ENERGY: The heat energy

produced by the process of nuclear fission within a nuclear reactor or by radioactive decay.

NUCLEAR FALLOUT: Minute particles of radioactive debris that descend slowly from the atmosphere after a nuclear explosion.

NUCLEAR FUEL CYCLE: The steps involved in supplying fuel for nuclear power plants. It can include mining, milling, isotopic enrichment, fabrication of fuel elements, use in reactors, chemical reprocessing to recover the fissile material remaining in the spent fuel, reenrichment of the fuel material refabrication into new fuel elements, and waste disposal.

NUCLEAR MEDICINE: Application of open or enclosed radioactive substances in medicine for diagnostic or therapeutic purposes. In nuclear medicine functional diagnostics and localization diagnostics is distinguished.

NUCLEAR POWER PLANT: An electrical generating facility using a nuclear reactor as its power (heat) source.

NUCLEAR REACTOR: A device in which a fission chain reaction can be initiated, maintained, and controlled. Its essential components are fissionable fuel, moderator, shielding, control rods, and coolant.

NUCLEON: A constituent of the nucleus; that is, a proton or a neutron.

NUCLEUS: The core of the atom, where most of its mass and all of its positive charge is concentrated. Except for hydrogen, it consists of protons and neutrons.

NUCLEUS, STABLE: Non-radioactive nucleus. The nucleus of an atom in which the forces among its particles are balanced.

NUCLEUS, UNSTABLE: Nucleus that contains an uneven number of protons and neutrons and seeks to reach equilibrium between them through radioactive decay

NUCLIDE: A species of atom in which the nuclear constitution is specified by the number of protons (Z), number of neutrons (N), and the energy content; or alternately by the atomic number (Z), mass number $A = (N + Z)$, and atomic mass.

ODDS RATIO: The odds of being exposed among diseased persons divided by the odds of being exposed among non-diseased persons.

OPERATIONAL QUANTITIES: Quantities used in practical applications for monitoring and investigating situations involving external exposure. They are defined for measurements and assessment of doses in

the body. In internal dosimetry, no operational dose quantities have been defined which directly provide an assessment of equivalent or effective dose. Different methods are applied to assess the equivalent or effective dose due to radionuclides in the human body. They are mostly based on various activity measurements and the application of biokinetic models (computational models).

OPTIMISATION (OF PROTECTION): The process of determining what level of protection and safety makes exposures, and the probability and magnitude of potential exposures, as low as reasonably achievable (ALARA), economic and societal factors being taken into account.

PAIR PRODUCTION: Interaction of energy-rich electromagnetic radiation with matter. If the energy of a radiation is greater than 1.02 MeV and thus greater than double the rest mass of an electron ($m_e c^2 = 0.511$ MeV), it is possible to generate an electron-positron pair.

PARENT: A radionuclide that upon radioactive decay or disintegration yields a specific nuclide (the decay product or daughter).

PERIODIC TABLE: An arrangement of chemical elements in order of increasing atomic number. Elements of similar

properties are placed one under the other yielding groups or families of elements. Within each group, there is a variation of chemical and physical properties but, in general, there is a similarity of chemical behavior within each group.

PERSONNEL MONITORING: The use of portable survey meters to determine the presence or amount of radioactive contamination on an individual, or the use of a dosimeter to determine an individual's radiation dose.

PHOTO-CATHODE: Cathode where electrons are released by the photoelectric effect.

PHOTOELECTRIC EFFECT: Interaction of electromagnetic radiation with matter. The photon transfers its energy to the shell electron of the atom. The electron receives kinetic energy which is equal to the energy of the photon reduced by the binding energy of the electron.

PHOTOMULTIPLIER: Electron multiplier tube that utilizes the multiplication of electrons by secondary emission to measure low light intensities. The tube utilizes a photosensitive cathode, that is, a cathode that emits electrons when light strikes it, followed by a series of additional electrodes, or dynodes, each at a

successively higher positive potential so that it will attract electrons given off by the previous dynode.

PHOTON: A quantized amount of electromagnetic energy, which at times displays particle characteristics. An electromagnetic quantum whose energy (E_{ph}) equals the product of the Planck constant (h) and its frequency (ν). With the convenient units eV and s, and with the wave length λ in μ m: $E_{ph} = 4.136 \times 10^{-15} \nu = 1.24/\lambda$.

PLUME: The material spreading from a particular source and traveling through environmental media, such as air or ground water. For example, a plume could describe the dispersal of particles, gases, vapors, and aerosols in the atmosphere, or the movement of contamination through an aquifer (For example, dilution, mixing, or adsorption onto soil).

POCKET DOSIMETER: A small ionization detection instrument worn by an individual that directly measures the ionizing radiation exposure.

POOLED ANALYSIS: An analysis of epidemiologic data from several studies based on original data from the studies.

POSITRON: A particle equal in mass to an electron and having an equal but positive

charge.

PREVALENCE: The number of cases of a disease in existence at a given time per unit of population, usually 100,000 persons.

PROJECTED DOSE: The dose that would be expected to be incurred if no protective measure(s) – were to be taken.

PROPORTIONAL COUNTER: A radiation instrument in which an electronic detection system receives pulses that are proportional to the number of ions formed in a gas-filled tube by ionizing radiation.

PROTECTION, PRINCIPLES OF: A set of principles that apply equally to all controllable exposure situations: the principle of justification, the principle of optimisation of protection, and the principle of application of limits on maximum doses in planned situations.

PROTON: One of the basic particles which makes up an atom. The proton is found in the nucleus and has a positive electrical charge equivalent to the negative charge of an electron and a mass similar to that of a neutron: a hydrogen nucleus.

QUADRATIC-DOSE MODEL: A model that assumes that the excess risk is proportional to the square of the dose.

QUALITY FACTOR: The principal dose modifying factor which is based on the collision stopping power of an incident particle and was employed to derive the dose equivalent from the absorbed dose. Quality factor is now superseded by the radiation weighting factor in the definition of equivalent dose, but it is still used in calculating the operational dose equivalent quantities used in the monitoring.

RAD: A special unit of absorbed dose, now replaced by the SI unit gray. $1 \text{ rad} = 0.01 \text{ Gy} = 100 \text{ erg/g}$.

RADIATION: Energy emitted in the form of waves or particles by radioactive atoms as a result of radioactive decay or produced by artificial means, such as X-ray generators.

RADIATION DETRIMENT: A concept used to quantify the harmful health effects of radiation exposure in different parts of the body. It is defined by the ICRP as a function of several factors, including incidence of radiation-related cancer or heritable effects, lethality of these conditions, quality of life, and years of life lost owing to these conditions.

RADIATION PROTECTION RULES: Specific rules for the implementation of radiation control and the prevention of radiation hazards at each radiation facility.

The basis for radiation protection at each radiation facility, in which the basic concepts of radiation protection, the safety-control structure, and specific practices that radiation workers must adhere to, are all spelled out.

RADIATION PROTECTION

SUPERVISOR: Personnel responsible for supervising efforts, who are legally appointed at any establishment where radiation or radioisotopes are handled in the course of using, selling, leasing, or disposing of them.

RADIATION SICKNESS: The complex of symptoms characterizing the disease known as radiation injury, resulting from excessive exposure (greater than 200 rads or 2 gray) of the whole body (or large part) to ionizing radiation. The earliest of these symptoms are nausea, fatigue, vomiting, and diarrhea, which may be followed by loss of hair (epilation), hemorrhage, inflammation of the mouth and throat, and general loss of energy. In severe cases, where the radiation exposure has been approximately 1,000 rad (10 gray) or more, death may occur within two to four weeks.

RADIATION SOURCE: Usually a sealed source of radiation used in teletherapy and industrial radiography, as a power source for batteries (as in use in space craft), or in various types of industrial gauges.

Machines, such as accelerators and radioisotope generators, and natural radionuclides may be considered sources.

RADIATION WEIGHTING FACTOR, w_R : A dimensionless factor by which the organ or tissue absorbed dose is multiplied to reflect the higher biological effectiveness of high-LET radiations compared with low-LET radiations. It is used to derive the equivalent dose from the absorbed dose averaged over a tissue or organ.

RADIATION WARNING SYMBOL: An officially prescribed symbol (a magenta trefoil) on a yellow background that must be displayed where certain quantities of radioactive materials are present or where certain doses of radiation could be received.

RADIOACTIVE MATERIAL: Material designated in national law or by a regulatory body as being subject to regulatory control because of its radioactivity, often taking account of both activity and activity concentration.

RADIOACTIVE SERIES: A succession of nuclides, each of which transforms by radioactive disintegration into another nuclide until a stable nuclide results. The first member is called the parent, the intermediate members are called decay (or daughter) products, and the final stable

member is called the end product.

RADIOACTIVE WASTE: Materials which are radioactive and for which there is no further use.

RADIOACTIVE WASTE, HIGH LEVEL: The radioactive material resulting from spent nuclear fuel reprocessing. This can include liquid waste directly produced in reprocessing or any solid material derived from the liquid wastes having a sufficient concentration of fission products. Other radioactive materials can be designated as high-level waste, if they require permanent isolation.

RADIOACTIVE WASTE, LOW LEVEL: Radioactively contaminated industrial or research waste such as paper, rags, plastic bags, medical waste, and water-treatment residues. It is waste that does not meet the criteria for any of three other categories of radioactive waste: spent nuclear fuel and high-level radioactive waste; transuranic radioactive waste; or uranium mill tailings. Its categorization does not depend on the level of radioactivity it contains.

RADIOACTIVITY: The property of certain unstable nuclides to spontaneously undergo nuclear transformations that result in the emission of ionizing radiations. See also "ACTIVITY".

RADIOGRAPHY: 1) Medical: The use of radiant energy (such as x-rays and gamma rays) to image body systems. 2) Industrial: The use of radioactive sources to photograph internal structures, such as turbine blades in jet engines. A sealed radiation source, usually iridium-192 (Ir-192) or cobalt-60 (Co-60), beams gamma rays at the object to be checked. Gamma rays passing through flaws in the metal or incomplete welds strike special photographic film (radiographic film) on the opposite side.

RADIOISOTOPE: A radioactive atomic species of an element with the same atomic number and usually identical chemical properties. A synonym for radionuclide.

RADIOLOGY: The branch of medicine dealing with the diagnostic and therapeutic applications of radiant energy, including X-rays and radioisotopes.

RADIOLOGICAL ATTACK: The use of radioactive or nuclear materials for malicious purposes, such as blackmail, murder, sabotage, or terrorism.

RADIONUCLIDE: A radioactive species of an atom characterized by the constitution of its nucleus. A radioactive nuclide.

RADIORESISTANCE: Relative resistance

of cells, tissues, organs and organisms to damage induced by radiation.

RADIOSENSITIVITY: Relative susceptibility of cells, tissue, organs and organisms to damage induced by radiation.

REFERENCE LEVEL: In emergency or existing controllable exposure situations, this represents the level of dose or risk, above which it is judged to be inappropriate to plan to allow exposures to occur, and below which optimization of protection should be implemented. The chosen value for a reference level will depend upon the prevailing circumstances of the exposure under consideration.

REFERENCE MAN: A person assumed to have the anatomical and physiological characteristics of an average individual. These assumed characteristics are used in calculations assessing internal dose (also may be called "Standard Man").

RELATIVE BIOLOGICAL EFFECT (RBE): A term relating the ability of radiations with different LET ranges to produce a specific biologic response; the comparison of a dose of test radiation to a dose of 250keV x-ray that produces the same biologic response.

RELATIVE RISK (RR): The rate of disease in an exposed population divided by the

rate of disease in an unexposed population.

REM (RAD EQUIVALENT MAN): A special unit of dose equivalent, now replaced by the SI unit sievert. 1 rem = 0.01 Sv.

RISK: A chance of injury, loss, or detriment; a measure of the deleterious effects that may be expected as the result of an action or inaction.

RISK ASSESSMENT: The process by which the risks associated with an action or inaction are identified and quantified.

RISK COEFFICIENT: The increase in the annual incidence or mortality rate per unit dose: (1) absolute risk coefficient is the increase of the incidence or mortality rate per unit dose; (2) relative risk coefficient is the fractional increase above the baseline incidence or mortality rate per unit dose.

RISK CONSTRAINT: A prospective and source-related restriction on the individual risk (in the sense of probability of detriment due to a potential exposure) from a source, which provides a basic level of protection for the individuals most at risk from a source and serves as an upper bound on the individual risk in optimization of protection for that source. This risk is a function of the probability of an unintended event causing a dose, and the probability of

detriment due to that dose. Risk constraints correspond to dose constraints but refer to potential exposures.

RISK ESTIMATE: The increment of the incidence or mortality rate projected to occur in a specified exposed population per unit dose for a specified exposure regime and expression period.

ROENTGEN (R): The outmoded unit of exposure that has been replaced by the SI unit Coulombs per kilogram. One roentgen equals 2.58×10^{-4} Coulombs per kilogram of air.

ROENTGEN EQUIVALENT MAN (REM): The outmoded dose equivalent unit that is numerically equal to the absorbed dose in rads multiplied by the quality factor, the distribution factor and any other necessary modifying factor. It has been replaced by the SIEVERT(Sv). 100 rem = 1Sv

SAFETY: The achievement of proper operating conditions, prevention of accidents, or mitigation of accident consequences.

SCATTERING: Change of direction of subatomic particles or photons as a result of atomic collisions.

SCATTERED RADIATION: Radiation that, during its passage through a substance,

has been changed in direction. It may also have been modified by a decrease in energy. It is one form of secondary radiation.

SCINTILLATION COUNTER: An instrument that detects and measures gamma radiation by counting the light flashes (scintillations) induced by the radiation.

SCINTILLATOR: Substance in which flashes of light are generated by impinging ionizing radiation (fluorescence). NaI(Tl)-monocrystals are particularly suitable for the detection of gamma radiation and anthracene or diphenyl oxazole dissolved in toluene is suitable for beta radiation. ZnS(Ag) is a favourable scintillator for detection of alpha radiation.

SEALED SOURCE (SEALED RADIOISOTOPES): Any special radioactive material or byproduct encased in a capsule designed to prevent leakage or escape of the material.

SECULAR EQUILIBRIUM: A state of parent-daughter equilibrium which is achieved when the half-life of the parent is much longer than the half-life of the daughter. In this case, if the two are not separated, the daughter will eventually be decaying at the same rate at which it is being produced. At this point, both parent

and daughter will decay at the same rate until the parent is essentially exhausted.

SECURITY: The prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer, or other malicious acts involving nuclear material, other radioactive substances, or their associated installations.

SEMI-CONDUCTOR DETECTOR: Detection device for ionized radiation. Advantage is taken of the effect of free charge carrier generation when semi-conductor material (germanium, silicon) is irradiated. Semi-conductor counters are particularly suitable for gamma radiation spectroscopy due to their high energy resolution ability.

SHIELD: Material used to prevent or reduce the passage of ionizing radiation.

SI (SYSTEME INTERNATIONAL): International System of scientific nomenclature.

SIEVERT (Sv): The special name for the SI unit of equivalent dose, effective dose, and operational dose quantities.

SKIN DOSE: The dose equivalent at a depth of 0.07 mm in the body at the application point of the personal dosimeter.

SOMATIC EFFECT (SOMATIC INJURY):

Radiation induced damage to cells other than germ cells.

SOURCE TISSUE: Tissue (which may be a body organ) containing a significant amount of a radionuclide following intake of that radionuclide.

SPECIFIC ACTIVITY: Total activity of a given nuclide per gram of a compound, element, or radioactive nuclide.

SPECIFIC ENERGY (z): The energy per unit mass actually deposited in a microscopic volume in a single energy deposition event or at a given absorbed dose. This is a stochastic quantity as opposed to its average, the absorbed dose, D. The mean energy imparted by ionizing radiation to a medium per unit mass.

STATISTICAL POWER: The probability that an epidemiological study will detect a given level of elevated risk with a specified degree of confidence.

STEM CELL: Non-differentiated, pluripotent cell, capable of unlimited cell division.

STOCHASTIC EFFECTS: Induced pathological changes for which the probability of an effect occurring, rather than the severity, is regarded as a function

of dose without threshold (i.e. cancer).

SURVEY METER: A hand held radiation detection instrument. See also Geiger-Mueller Tube.

SYNCHROTRON: Accelerator in which particles travel on an orbit with a fixed radius. The acceleration is effected by electric fields and guidance on the orbit by magnetic fields. The larger the diameter of a synchrotron, the higher the particle energies which can be obtained.

TARGET CELLS: Cells in a tissue that have been determined to be the key cells in which changes occur in order to produce an end point such as cancer.

TERATOGENIC EFFECT: Birth defects that are not passed on to future generations, caused by exposure to a toxin as a fetus.

TERRESTRIAL RADIATION: Radiation emitted by naturally occurring radioactive materials, such as uranium (U), thorium (Th), and radon (Rn) in the earth.

THERMOLUMINESCENT DOSIMETER (TLD): A small badge worn by workers, which is used to passively monitor personal radiation doses. Lithium fluoride crystals are the functional units in the badge. In which a small fraction of the energy

absorbed from ionizing radiation is stored in a metastable energy state. This energy is later recovered as visible photons, when the material is heated.

THRESHOLD DOSE (FOR TISSUE REACTIONS): Dose estimated to result in only 1% incidence of tissue reactions.

TISSUE EQUIVALENT: Term from radiation protection measuring technology; tissue equivalent denotes a substance, with absorbing and scattering properties for a given radiation that sufficiently match those of a certain biological tissue.

TISSUE WEIGHTING FACTOR, w_T : The factor by which the equivalent dose in a tissue or organ T is weighted to represent the relative contribution of that tissue or organ to the total health detriment resulting from uniform irradiation of the body (ICRP 1991b). It is weighted such that:

$$\sum_T w_T = 1$$

TRACER, ISOTOPIC: An isotope or mixture of isotopes of an element or elements that which may be incorporated into a sample to permit observation of the course of that element, alone or in combination, through a chemical, biological or physical process. The observation may be made by measurement of radioactivity or of isotopic abundance.

TRACK STRUCTURE: Spatial patterns of energy deposition in matter along the track from the passage of ionizing radiation.

TRANSURANIC: Pertaining to elements with atomic numbers higher than uranium (92). For example, plutonium (Pu) and americium (Am) are transuranics.

UNCERTAINTY: The range of values within which the true value is estimated to lie. It is a best estimate of possible inaccuracy due to both random and systemic errors.

UNSCEAR (UNITED NATIONS SCIENTIFIC COMMITTEE ON THE EFFECTS OF ATOMIC RADIATION): A UN committee that publishes periodic reports on sources and effects of ionizing radiation.

URANIUM, DEPLETED: Uranium containing less than 0.7% uranium-235, the amount found in natural uranium.

URANIUM, ENRICHED: Uranium in which the proportion of the isotope uranium-235 has been increased by removing uranium-238 mechanically.

URANIUM, NATURAL: Uranium as found in nature. It contains about 0.7 percent uranium-235, 99.3 percent uranium-238,

and a trace of uranium-234.

VAN DE GRAAFF GENERATOR: A Machine to generate very high direct voltages used to accelerate charged particles to high energies (up to 12 MeV). By means of a non-conductive endless strip, electrical charges are transported to an insulated hollow sphere which is thereby charged to very high voltages.

VOXEL PHANTOM: Computational anthropomorphic phantom based on medical tomographic images where the anatomy is described by small three-dimensional volume elements (voxels) specifying the density and the atomic composition of the various organs and tissues of the human body.

WEIGHTED DOSE (d): The dose to A-bomb survivors, roughly adjusted to account for the increased effectiveness of the small neutron absorbed dose contribution. The weighted dose equals the gamma-ray absorbed dose to a specified organ plus the neutron absorbed dose multiplied by a weighting factor that has usually been set equal to 10 in analyses by the Radiation Effects Research Foundation (RERF).

WHOLE BODY COUNTER: A device used to identify and measure the radioactive material in the body of human beings and

animals. It typically uses heavy shielding to keep out background radiation from the ultra-sensitive radiation detectors and electronic counting equipment.

X-RAY: Electromagnetic radiation originating from the orbital electrons of an atom, usually produced by bombarding a metallic target with fast electrons in a high vacuum.

WIPE SAMPLE: A sample made for the purpose of determining the presence of removable radioactive contamination on a surface. It is done by wiping, with slight pressure, a piece of soft filter paper over a representative type of surface area. It is also known as a "swipe or smear" sample.

WIPE TEST: In addition to direct measurement, the wipe test is used to determine radioactive contamination on the surface of a solid body. In this easily performed test, part of the contamination adhering to the surface is wiped off e.g. with a paper fleece and can be measured.

Z: Atomic number of a given nuclide.

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2009

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