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Absorbed Dose—The energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the rad and the gray (Gy). (See also Rad, Gray, and Units, Radiological.) Absorbed dose is defined per unit mass of absorbing material.

Absorbed Fraction—A term used in internal dosimetry. It is that fraction of energy radiated by the source organ that is absorbed by the target organ. For example, for ^{131}I in the thyroid (source organ), the absorbed fraction could be the fraction of gamma radiation absorbed in the liver (one of the target organs).

Absorber—Any material that absorbs or lessens the intensity of ionizing radiation. Neutron absorbers (boron, hafnium, and cadmium) are used as material in control rods for reactors. Concrete, steel, and lead are typical absorbers for x rays and gamma rays. A thin sheet of paper or metal will absorb alpha particles and all except the most energetic beta particles.

Absorption—The process by which radiation imparts some or all of its energy to any material through which it passes.

Absorption Ratio, Differential—The ratio of concentration of a nuclide in a given organ or tissue to the concentration that would be obtained if the same administered quantity of this nuclide were uniformly distributed throughout the body.

Activation—The process of inducing radioactivity by neutron irradiation of a target material.

Activity—The number of nuclear transformations occurring in a given quantity of material per unit time. (See Curie, Becquerel, and Units, Radiological, for more information on activity.)

Activity Median Aerodynamic Diameter (AMAD)—The diameter of a unit density sphere with the same terminal settling velocity in air as that of the aerosol particle whose activity is the median for the entire aerosol.

Acute Exposure—An exposure to ionizing radiation for a duration of less than 15 days. Regarding acute radiation syndrome, high radiation levels involve an exposure period up to 2 days.

Acute Radiation Syndrome—The signs and symptoms which, taken together, characterize a person suffering from the effects of intense radiation. The effects occur within hours of exposure.

ALARA—The acronym for "As Low As is Reasonably Achievable." This term refers to the practice of making every reasonable effort to keep exposure to radiation as far below the dose limit as possible while still achieving the purpose for which radiation is licensed to be used. The benefits of reducing dose must be weighed against economic, engineering, and social costs of doing so.

Alpha Particle (symbolized by Greek letter α)—A charged particle emitted from the nucleus of certain radioactive atoms. An alpha particle has a mass of 4 atomic mass units (amu) and is equal to a helium nucleus (i.e., two protons and two neutrons, and a charge of +2).

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Annihilation Radiation—The photons produced when an electron and a positron unite and cease to exist. The annihilation of a positron-electron pair results in the production of two photons, each of 0.51 MeV in energy (see pair production).

Annual Limit on Intake (ALI)—The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. For a given radionuclide, ALI is defined as the smaller of the intakes that would result in a committed effective dose equivalent of 5 rem or a committed dose equivalent of 50 rem to any individual organ or tissue (see also Committed Effective Dose).

Antineutrino— A neutral particle of rest mass near zero that is emitted during beta transformation (nucleus with a neutron excess) which occurs via the pathway by converting a neutron into a proton: n---> p + e$^-$ + anti-nu(e), where n means neutron, p means proton, e$^-$ means electron, and anti-nu(e) means an antineutrino of the electron type.

Artificial Radioactivity—The radioactivity produced by particle bombardment or electromagnetic irradiation in an accelerator or reactor and not existing in nature.

Atomic Mass—The mass of a neutral atom of a nuclide, usually expressed in terms of "atomic mass units." The "atomic mass unit" is one-twelfth the mass of one neutral atom of carbon-12; equivalent to 1.6604×10^{-24} gm. (Symbol: u)

Atomic Mass Number—The total number of nucleons (neutron plus protons) in the nucleus of an atom.

Atomic Number—The number of protons in the nucleus of an atom. The "effective atomic number" is calculated from the composition and atomic numbers of a compound or mixture. An element of this atomic number would interact with photons in the same way as the compound or mixture. (Symbol: Z).

Atomic Weight—The weighted mean of the masses of the neutral atoms of an element expressed in atomic mass units.

Background Radiation—Radiation resulting from cosmic rays and naturally occurring radioactive material. Background radiation is always present and its level can change with altitude and the amount of radioactive material present in soil and building materials.

Becquerel (Bq)—A unit of measure for the quantity of radioactive material; one becquerel is that quantity of radioactive material in which one atom decays in one second. (See also Units, Radiological.)

Beta Particle (symbolized by Greek letter β) —A charged particle emitted from the nucleus of some radioactive atoms. A beta particle has a mass and charge equal in magnitude to that of the electron. The charge may be either +1 or -1, and may be shown with the respective symbol, β$^+$ or β$^-$.

Bioassay—A determination of the kind, quantity, concentration, or location of radioactive material in the body by either direct measurement or the analysis and evaluation of materials excreted or removed from the body.

Bone Seeker—Any compound or ion in the body that preferentially migrates into actively forming bone to become part of the hydroxyapatite mixture.

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Branching—The occurrence of two modes by which a radionuclide can undergo radioactive transformation. For example, ^{214}Bi can undergo α or β^- transformation, ^{64}Cu can undergo β^-, β^+, or electron capture transformation. 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 transformation or disintegration).

Bremsstrahlung—Electromagnetic radiation (photons) produced by the acceleration that a fast charged particle (usually an electron) undergoes from the effect of an electric or magnetic field, for instance, from the field of another charged particle (usually a nucleus). Bremsstrahlung is emitted when beta particles or electrons are stopped by a shield.

Cancer Effect Level (CEL)—The lowest dose of chemical in a study, or group of studies, that produces significant increases in the incidence of cancer (or tumors) between the exposed population and its appropriate control.

Carcinogen—A chemical capable of inducing cancer.

Carcinoma—A malignant neoplasm composed of epithelial cells, regardless of their derivation.

Cataract—A clouding of the crystalline lens of the eye that obstructs the passage of light.

Chronic Exposure—An exposure to ionizing radiation for 365 days or more, as specified in the ATSDR toxicological profiles.

Collective Dose—The sum of the individual doses received in a given period of time by a specified population from exposure to a specified source of radiation, in units such as person @rem or person @Sv.

Committed Dose Equivalent (H_{T50})—The dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

Committed Effective Dose—The International Commission on Radiological Protection (ICRP) term for committed effective dose equivalent. (See Committed Effective Dose Equivalent.)

Committed Effective Dose Equivalent (H_{E50})—The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to the organs or tissues ($H_{E50} = 3 W_T H_{T50}$). The committed effective dose equivalent is used in radiation safety because it implicitly includes the relative carcinogenic sensitivity of the various tissues.

Compton Scattering—An attenuation process observed for x or gamma radiation in which an incident photon interacts with an orbital electron of an atom to produce a recoil electron and a scattered photon of energy less than the incident photon.

Contamination, Radioactive—The deposition of radioactive material in any place where it is not desired.

Cosmic Rays—High-energy particulate and electromagnetic radiations that originate outside the earth's atmosphere.

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Count (Radiation Measurements)—The external indication of a radiation-measuring device designed to enumerate ionizing events. It may refer to a single detected event or to the total number registered in a given period of time. This term can be used with equipment and geometry efficiencies to quantify the rate of transformation of ionizing events.

Counter—A general description applied to radiation detection instruments or survey meters that detect and measure radiation. The signal that announces the detection of an ionization event is called a count. (See also Counter, Geiger-Mueller and Counter, Scintillation.)

> **Counter, Geiger-Mueller**—A sensitive, gas-filled radiation-measuring device that responds to individual ionizing particles.

> **Counter, Scintillation**—The combination of phosphor, a photomultiplier tube, and associated circuits for counting light emissions produced in the phosphors by ionizing radiation.

Cumulative Dose—The total dose resulting from continuous or intermittent exposures of radiation to the same region of the body, or to the whole body, from internally deposited radioisotopes over a period of time. (See Also Weighting Factor.)

Curie (Ci)— The quantity of radioactive material in which 37 billion radioactive atoms transform per second, which is approximately the activity of 1 gram of radium.

Decay Constant—See transformation constant.

Decay Product (Daughter Product, Progeny)—Isotopes that are formed by the radioactive transformation of some other nuclide. In the case of ^{226}Ra, for example, there are 10 successive daughter products or progeny, ending in the stable isotope ^{206}Pb.

Decay, Radioactive—Transformation of the nucleus of an unstable nuclide by spontaneous emission of charged particles and/or photons.

Deep Dose Equivalent (H_d)—The dose equivalent at a tissue depth of 1 cm inside the body surface from external whole-body radiation.

Delayed Health Effects—The health effects that manifest themselves after an extended period.

Derived Air Concentration (DAC)—The concentration of a given radionuclide in the air which, if breathed by the reference man for one working year (2,000 hours) under conditions of light work, results in an intake of one ALI.

Detector—A material or device that is sensitive to radiation and can produce a response signal suitable for measurement or analysis.

Deterministic Effects—Health effects for which there exists a definite threshold and which become more severe as the dose is increased. The dose response curve is sigmoid-shaped. Examples of deterministic effects are acute radiation syndrome and cataracts (previously referred to as non-stochastic effects)

Developmental Toxicity—The occurrence of adverse effects on a developing organism that may result from exposure to a chemical or to ionizing radiation prior to conception (either parent), during prenatal development, or postnatally to the time of sexual maturation. Adverse developmental effects may be detected at any point in the life span of the organism.

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Disintegration, Nuclear—A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus. When large numbers of nuclei are involved, the process is characterized by a physical half-life. (See also Transformation, Nuclear.)

Dose (or Radiation Dose)—A general term denoting the amount of energy from radiation that is absorbed per unit mass of absorber. A generic term meaning absorbed dose, dose equivalent, deep dose equivalent, effective dose, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, equivalent dose, or total effective dose equivalent. For special purposes it must be appropriately qualified. If unqualified, it refers to the absorbed dose.

Dose Assessment—An estimate of the radiation dose to an individual or a population group usually by means of predictive modeling techniques, often supplemented by the results of measurement.

Dose Conversion Coefficient (or dose conversion factor)—A factor (Sv/Bq or rem/Ci) that is multiplied by the intake quantity of a radionuclide (Bq or Ci) to estimate the committed dose equivalent from radiation (Sv or rem). The dose conversion factor depends on the route of entry (inhalation or ingestion), the lung clearance class (D, W, or Y) for inhalation, the fractional uptake from the small intestine to blood (f1) for ingestion, and the organ of interest. EPA provides separate dose conversion factor tables for inhalation and ingestion, and each provides factors for the gonads, breast, lung, red marrow, bone surface, thyroid, remainder, and effective whole body.

Dose Equivalent (DE)—A quantity used in radiation protection. It expresses all radiations on a common scale for calculating the dose for purposes of radiation safety. It is the product of the absorbed dose in rad or gray and a quality factor, whose value depends on the radiation. (The unit of dose equivalent is the rem. In SI units, the dose equivalent is the sievert, which equals 100 rem.)

Dose, Fractionation—The division of a therapeutic radiation dose into fractions that are administered over a period of time. Dose is delivered during discrete time periods. Between fractions, there is no dose.

Dose, Radiation—The amount of energy imparted to matter by ionizing radiation per the unit mass of matter, usually expressed as the rad, or in SI units, the gray (Gy), 100 rad = 1 Gy (See also Absorbed Dose.)

Dose Rate—The radiation dose delivered per unit time. The rate can be measured, for example, in gray per hour, sievert per hour, rem per hour, or rad per hour.

Dosimetry—Quantification of radiation doses to individuals or populations resulting from specified exposures.

Early Effects (of radiation exposure)—Effects which appear within 60 days of an acute exposure; usually associated with acute radiation syndrome when whole body is exposed.

Effective Dose—The sum of the weighted equivalent doses in all the tissues and organs of the body.

Effective Dose Equivalent (H_E)—The sum of the products of the dose equivalent to the organ or tissue (H_T) and the weighting factors (W_T) applicable to each of the body organs or tissues that are irradiated ($HE = 3 W_T H_T$). The effective dose equivalent recognizes the carcinogenic radiosensitivity of the several different tissues of the body.

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Effective Half-Life (also effective half-time)—The time required for a radioactive element in an animal body to be diminished 50% as a result of the combined action of radioactive transformation and biological elimination. It is described by the following equation:

Effective Half-Life = (Biological half-life x radioactive half-life) / (biological half-life + radioactive half-life).

Electron—A stable elementary particle having an electric charge equal to ± 1.60210 x 10^{-19} Coulombs (C), and a rest mass equal to 9.1091 x 10^{-31} kg. A positron is a positively charged "electron" (see Positron).

Electron Capture—A mode of radioactive transformation involving the capture of an orbital electron by its nucleus. Capture from a particular electron shell is designated as "K-electron capture," "L-electron capture," and so on. The atom then emits x rays.

Electron Volt—A unit of energy equivalent to the energy gained by an electron in passing through a potential difference of one volt.   It is the energy unit for an ionizing particle or photon often expressed as keV for thousand or kilo electron volts or MeV for million or mega electron volts. (symbol: eV, as in 1eV' 1.6×10^{-12} erg.)

Embryo/Fetus—The developing human (or animal) from the time of conception up to the time of birth.

Embryotoxicity and Fetal toxicity—Any toxic effect on the conceptus as a result of prenatal exposure to ionizing radiation or a chemical; the distinguishing feature between the two terms is the stage of development during which the insult occurred. The terms, as used here, include malformations and variations, altered growth, and *in utero* death.

Enriched Material—(1) Any material in which the relative amount of one or more isotopes of a constituent has been increased over its natural abundance. (2) Uranium in which the percentage of ^{235}U to total uranium of all isotopes is increased from its natural value of 0.72% to a higher value.

Equilibrium, Radioactive—In a radioactive series, the state that prevails when the ratios between the activities of two or more successive members of the series remain constant, or when the activities are equal.

Eventration—Disembowelment or protrusion of the bowels from the abdomen.

Excitation Energy—The energy required to change a system from its ground state to an excited state. Each different excited state has a different excitation energy.

Excitation—The addition of energy to a system, thereby transferring it from its ground state to an excited state. Excitation of a nucleus, an atom, or a molecule can result from absorption or scattering of photons or from inelastic collisions with particles. The excited state of an atom is an unstable state and will return to the ground state by radiation of the excess energy.

Exposure—A measure of the intensity of an x ray or gamma ray field in air, whose value depends on the ionization produced in air by x or gamma radiation. The traditional unit of exposure is the roentgen (R), and the SI unit is the coulomb per kilogram.

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External Dose—The amount of energy, expressed per unit mass of matter, imparted to an organism by ionizing radiation from a source outside the body.

External Radiation—Radiation exposure from a source outside the body.

Eye Dose Equivalent—The dose equivalent of radiation received by the lens of the eye which is at a depth of 0.3 cm below the outside surface (cornea) of the eye, delivered by an external radiation source.

Fission, Nuclear—A nuclear transformation characterized by the splitting of a nucleus into two or three other nuclei and two or three neutrons, and the release of a relatively large amount of energy.

Fundus—the bottom or base of anything. Pertaining to hollow organs, it is the portion farthest from its mouth or opening. Pertaining to the eye, the fundus is the back portion of the interior of the eyeball.

   Tapetal fundus—a highly reflective structure in the dorsal portion of the fundus of the eye.

   Nontapetal fundus—the nonreflective ventral portion of the fundus of the eye.

Gamma Ray (synbolized by Greek letter γ)—A short wavelength electromagnetic radiation of nuclear origin (range of energy from about 10 keV to about 9 MeV, which is sufficient to cause ionization).

Genetic Effect of Radiation—An inheritable change, chiefly mutations, produced by the absorption of ionizing radiation by germ cells.

Gray (Gy)—The SI unit of the absorbed dose. One Gy equals the absorption of 1 joule of energy (about 1/4 of a calorie) per kilogram of absorber. One gray equals 100 rad. (See also Units.)

Half-Life, Biological (or biological half-time)—The time required for the body to eliminate one-half of any absorbed substance by regular physiological processes of elimination. It is the same for both stable and radioactive isotopes of a particular element.

Half-Life, Effective—The time required for a radioactive element in an animal body to be diminished 50% as a result of the combined action of radioactive transformation and biological elimination.

Half-Life, Physical (see Half-Life Radioactive)

 Half-Life, Radioactive—The time required for a radioactive substance to lose 50% of its activity by transformation. Each radionuclide has a unique half-life.

Half-Time (see Half-Life, Biological)

High-LET—The characteristic ionization patterns by alpha particles, protons, or fast neutrons having a high relative specific ionization per unit path length.

Immunologic Toxicity—The occurrence of adverse effects on the immune system that may result from exposure to agents such as radiation or chemicals.

In Vitro—The condition of being isolated from a living organism and artificially maintained, as in a test tube.

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In Vivo—Any condition occurring within a living organism.

Induced Radioactivity—The radioactivity produced in a substance after bombardment with neutrons or other particles. The resulting activity is "natural radioactivity" if formed by nuclear reactions occurring in nature, and "artificial radioactivity" if the reactions are caused by humans.

Intensity—The amount of energy per unit time passing through a unit area perpendicular to the line of propagation at the point in question.

Intermediate Exposure—An exposure to radiation for a duration of 15–364 days.

Internal Conversion—One of the possible mechanisms of transformation from the metastable state (isomeric transition) in which the transition energy is transferred to an orbital electron, causing its ejection from the atom. The ratio of the number of internal conversion electrons to the number of gamma quanta emitted in the de-excitation of the nucleus is called the "conversion ratio."

Internal Radiation— Radiation from radionuclides inside the body.

Ion—An atomic particle, atom or chemical radical bearing a net electrical charge, either negative or positive.

Ion Pair—Two particles of opposite charge, usually referring to the electron and positive atomic or molecular residue resulting after the interaction of ionizing radiation with the orbital electrons of atoms.

Ionization— The process by which ionizing radiation (photons or particles) remove electrons from an atom. The process in chemical reactions by which a neutral atom or molecule acquires a positive or negative charge.

Ionizing Energy—The average energy lost by ionizing radiation in producing an ion pair. For air, the ionizing energy is about 34eV per ion pair by beta particles.

Ionizing Density—The number of ion pairs per unit volume.

Ionization Path (Track)—The trail of ion pairs produced by ionizing radiation in its passage through matter.

Ionization Potential —The energy, in electron-volts (eV), necessary to separate one electron from an atom, resulting in the formation of an ion pair.

Ionizing Radiation—Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

Isotopes—Any nuclide of the same element having the same number of protons in their nuclei, and hence the same atomic number, but differing in the number of neutrons and therefore in the mass number. Almost identical chemical properties exist between isotopes of a particular element, but physical properties such as diffusion through a membrane may differ. This term should not be used as a synonym for nuclide.

Joule—The unit for work and energy, equal to one newton expended along a distance of one meter (1 J =1 N x l m). There are 4.2 joules per calorie. In terms of radiological units, 1 J = 1 Gy-kg.

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Kerma (k)—The initial kinetic energy of the primary ionizing particles produced by the interaction of the incident radiation per unit mass of interacting medium, expressed as J/kg or grays (rads).

Labeled Compound—A compound consisting, in part, of labeled molecules. These are molecules including radionuclides in their structure. By observations of radioactivity or isotopic composition, this compound or its fragments may be followed through physical, chemical, or biological processes.

Late Effects (of radiation exposure)—Any effects that appear 60 days or more following an acute exposure.

Lethal Dose$_{50}$ (LD$_{50}$)—The dose of radiation or a chemical that has been found to cause death in 50% of a defined population.

Lethal Dose$_{50/30}$ (LD$_{50/30}$)—The dose of radiation or a chemical which kills 50% of the population within 30 days.

Linear Energy Transfer (LET)—The average amount of energy transferred locally to the medium per unit of particle or electromagnetic radiation track length.

Linear Hypothesis or Linear No Threshold (LNT) Hypothesis—The assumption that a dose-response curve derived from data in the high dose and high dose-rate ranges may be extrapolated linearly through the low dose and low dose-rate ranges to zero, implying that, theoretically, any amount of radiation will cause some damage.

Low-LET—The characteristic ionization patterns of electrons, x rays, and gamma rays having a low relative specific ionization per unit path length compared to high LET radiation.

Lowest-Observed-Adverse-Effect Level (LOAEL)—The lowest dose of chemical in a study, or group of studies, that produces statistically or biologically significant increases in the frequency or severity of adverse effects between the exposed population and its appropriate control.

Malformations—Any permanent structural changes that may adversely affect survival, development, or function as a result of *in utero* exposure.

Mass Absorption Coefficient—The linear absorption coefficient per centimeter divided by the density of the absorber in grams per cubic centimeter. This is the fraction of incident radiation that is absorbed per unit mass of the absorber.

Mass Number—The number of nucleons (protons and neutrons) in the nucleus of an atom. (Symbol: A)

Median Lethal Dose (MLD)—The dose of radiation required to kill 50% of the individuals in a large group of animals or organisms within a specific period, usually 30 days. Also called LD$_{30}$.

Megacurie—One million curies. (Symbol: MCi)

Microcurie—One-millionth of a curie. Amount of material in which 3.7×10^4 radioactive atoms transform per second. (Symbol: μCi)

Millicurie—One-thousandth of a curie. Amount of material in which 3.7×10^7 radioactive atoms transform per second. (Symbol: mCi)

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Minimal Risk Level (MRL)—An estimate of daily human exposure to a dose of radiation or a chemical that is likely to be without an appreciable risk of adverse noncancerous effects over a specified duration of exposure.

Monoenergetic Radiation—Radiation of a given type (alpha, neutron, gamma, etc.) in which all particles or photons originate with the same energy.

Mutagen—A substance that causes mutations.

Mutation—A mutation is a change in the genetic material in a body cell. Mutations in germ cells can lead to birth defects and miscarriages; mutations in somatic cells may lead to cancer.

Nanocurie—One-billionth of a curie. Amount of material in which 37 radioactive atoms transform per second. (Symbol: nCi)

Natural Radioactivity—The property of radioactivity exhibited by more than 50 naturally occurring radionuclides.

Neurotoxicity—The occurrence of adverse effects on the nervous system following exposure to radiation or a chemical.

Neutrino—A neutral particle of very nearly zero rest mass emitted during the beta-decay process. It plays no role in radiation bio-effects.

Non-deterministic Effects (stochastic effects) —Health effects which appear to be related to random events. Dose-response is assumed to be linear without threshold in radiation protection.

No-Observed-Adverse-Effect Level (NOAEL)—The dose of radiation or a chemical that produces no statistically or biologically significant increases in frequency or severity of adverse effects seen between the exposed population and its appropriate control. Effects may be produced at this dose, but they are not considered to be adverse.

Nucleon—Generic name for a constituent particle of the nucleus. Applied to a proton or neutron.

Nuclide—A species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons (Z), number of neutrons (N), and energy content; or, alternatively, by the atomic number (Z), mass number A' (N+Z), and atomic mass.

Pair Production—An absorption process for x ray and gamma radiation in which the incident photon is annihilated in the vicinity of the nucleus of the absorbing atom, and its energy is converted into an electron and positron pair.   This reaction only occurs for incident photon energies exceeding 1.02 MeV, which is the energy equivalence of the masses of the positron and electron.

Parent Radionuclide—A radionuclide which, upon transformation, yields a specified nuclide, either directly or as a later member of a radioactive series. The radionuclide from which a new nuclide was made as a result of radioactive transformation.

Photoelectric An interaction between an x ray or gamma ray (photon) and an atom in which an orbital electron is knocked out. The photon disappears because it gives up all of its energy in the collision.

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Photon—A quantity of electomagnetic radiation whose energy content depends on the frequency or wavelength of the radiation. The equation is: E=hv. Photon energy for ionizing radiation purposes is usually measured in eV, keV and MeV. 1 eV = 1.6 x 10^{-19}J.

Picocurie—One-trillionth of a curie ($3.7x10^{-2}$ transformations per second or 2.22 transformations per minute). (Symbol: pCi)

Positron—A particle equal in mass to the electron ($9.1091x10^{-31}$ kg) and having an equal but positive charge ($+1.60210x10^{-19}$ Coulombs). (See also Electron).

Primary Ionization—(1) In collision theory, the ionization produced by the primary particles (photoelectron, Compton electron, or positron-electron pair) as contrasted with the total ionization, which includes the secondary ionization produced by delta rays; (2) In counter tubes, the total ionization produced by incident radiation without gas amplification.

Progeny—The transformation products resulting after a series of radioactive decays. Progeny can also be radioactive, and the chain continues until a stable nuclide is formed.

Proton—An elementary nuclear particle with a positive electric charge equal numerically to the charge of the electron and a rest mass of 1.007277 atomic mass units.

Public Dose—The dose received by a member of the public from exposure to radiation caused by a licensee or to any other source of radiation under the control of a licensee, excluding background and occupational doses.

Quality—A term describing the distribution of the energy deposited by a particle along its tract; radiations that produce different densities of ionization per unit track length are said to have different qualities.

Quality Factor (Q)—The linear-energy-transfer-dependent factor by which absorbed doses are multiplied to obtain (for radiation protection purposes) a quantity that expresses the biological effectiveness of the absorbed dose on a common scale for all ionizing radiation.

Rad—The unit of absorbed dose equal to 0.01 J/kg in any medium. (See also Absorbed Dose.)

Radiant Energy—The energy of electromagnetic radiation, such as radio waves, visible light, x and gamma rays.

Radiation—(1) The emission and propagation of energy through space or through a material medium in the form of waves: for instance, the emission and propagation of electromagnetic waves, or of sound and elastic waves. (2) The energy propagated through space or through a material medium such as waves; for example, energy in the form of electromagnetic waves or of elastic waves. The term radiation or radiant energy, when unqualified, usually refers to electromagnetic radiation. Such radiation commonly is classified, according to frequency, as with Hertzian, infrared, visible (light), ultraviolet, x ray and gamma ray (see also Photon). (3) By extension, corpuscular emission, such as alpha and beta radiation, or rays of mixed or unknown type, such as cosmic radiation.

Radioactivity—The property of certain nuclides to spontaneously transform into another element by emitting alpha or beta particles, or undergoing electron capture.

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Radioisotope—Radioactive atomic species of an element with the same atomic number and identical chemical properties.

Radionuclide—A radioactive species of an atom characterized by the constitution of its nucleus.

Radiosensitivity—The relative susceptibility of cells, tissues, organs, organisms, or any living substance to the injurious action of radiation. Radiosensitivity and its antonym, radioresistance, are currently used in a comparative sense, rather than in an absolute one. Radiosensitivity depends upon the biological response being measured.

Reaction (Nuclear)—An induced nuclear transformation (i.e., a process occurring when a nucleus comes in contact with a photon, an elementary particle, or another nucleus). In many cases, the reaction can be represented by the symbolic equation: X+a6Y+b or, in abbreviated form, X(a,b) Y, where X is the target nucleus, a is the incident particle or photon, b is an emitted particle or photon, and Y is the product nucleus.

Reference Man —A theoretical human male on which dosimetry calculations related to ionizing radiation exposure are based. Reference man is 70 kg and consists of detailed organ mass data for all major human body organs. Models, which can be other than 70 kg, are also available for different ages and for females (pregnant and non-pregnant).

Relative Biological Effectiveness (RBE)—The RBE is a factor used to compare the biological effective-ness of absorbed radiation doses due to different types of ionizing radiation. More specifically, it is the experimentally determined ratio of an absorbed dose of a radiation in question to the absorbed dose of a reference radiation required to produce an identical biological effect in a particular experimental organism or tissue (see also Quality Factor). RBE depends on several experimental factors including dose, dose rate, and biological end point. RBE is not used in radiation protection practice. Quality factor is used in radiation protection but is derived from LET. RBE is an index of comparison of radiations of different quality.

Rem—A unit of dose equivalent. The dose equivalent in rem is numerically equal to the absorbed dose in rad multiplied by the quality factor. It is used only in the context of radiation safety, administrative, and engineering design purposes.

Reproductive Toxicity—The occurrence of adverse effects on the reproductive system that may result from exposure to radiation or a chemical. The toxicity may be directed to the reproductive organs and/or the related endocrine system. The manifestation of such toxicity may be noted as alterations in sexual behavior, fertility, pregnancy outcomes, or modifications in other functions that are dependent on the integrity of this system.

Roentgen (R)—A unit of exposure to photon radiation whose energy #3 MeV. One roentgen generates 2.58×10^{-4} Coulomb of charge of either sign per kilogram of air at standard temperature and pressure (0 EC, 1 atm). The roentgen is defined for x and gamma rays only.

Scattered Radiation—Radiation that, during its passage through a substance, has been deviated in direction. It usually will have been modified by a decrease in energy.

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Scientific Units

Prefix (Symbol)	Power of 10	Decimal Equivalent
atto (a)	10^{-18}	0.000000000000000001
femto (f)	10^{-15}	0.000000000000001
pico (p)	10^{-12}	0.000000000001
nano (n)	10^{-9}	0.000000001
micro (μ)	10^{-6}	0.000001
milli (m)	10^{-3}	0.001
centi (c)	10^{-2}	0.01
deci (d)	10^{-1}	0.1
kilo (k)	10^{3}	1,000.0
mega (M)	10^{6}	1,000,000.0
giga (G)	10^{9}	1,000,000,000.0
tera (T)	10^{12}	1,000,000,000,000.0
peta (P)	10^{15}	1,000,000,000,000,000.0
exa (E)	10^{18}	1,000,000,000,000,000,000.0

Secondary Radiation—Radiation that results from the interaction of other radiation in matter. It may be either electromagnetic or particulate.

Secular Equilibrium—If a parent element has a much longer half-life than its progeny (so that there is no appreciable change in its amount in the time interval required for later products to attain equilibrium), then after equilibrium is reached, equal numbers of atoms of all members of the series that are in equilibrium transform in unit time. This means that each has the same activity measured in curies or becquerels. This condition is never exactly attained, but is essentially established after 6 or 7 daughter half-lives. For example, the half-life of radium is about 1,600 years; of radon, approximately 3.82 days; and for each of the subsequent members, a few minutes. After about a month, the equilibrium amount of radon is present; then (and for a long time) all members of the series transform at the same number of atoms per unit time. Thus contained radon gas is in secular equilibrium with its parent ^{226}Ra after about 27 days.

Self-Absorption—The absorption of radiation (emitted by radioactive atoms) by the material in which the atoms are located (in particular, the absorption of radiation within a sample being assayed).

Shallow Dose Equivalent (H_S)—The dose equivalent at a tissue depth of 0.007 cm averaged over an area of 1 cm^2 from external exposure of the skin or an extremity.

SI Units—The International System of Units as defined by the General Conference of Weights and Measures in 1960. These units are generally based on the meter/kilogram/second units, with special quantities for radiation including the becquerel, gray, and sievert.

Sickness, Radiation —(1) A syndrome characterized by nausea, vomiting, diarrhea, and psychic depression following exposure to appreciable doses of ionizing radiation within a short period of hours to weeks. Its mechanism is known, and remedies include fluid replacement, antibiotics, electrolyte replacement, and in some cases, marrow stem cell support. It usually appears a few hours after irradiation and may subside within a day. In nuclear medicine applications, it may be sufficiently severe to necessitate

interrupting the treatment series or to incapacitate the patient. (2) The syndrome associated with intense acute exposure to ionizing radiations. The rapidity with which symptoms develop is a rough measure of the dose level. The syndrome also includes certain signs such as changes in peripheral blood cell counts.

Sievert—The SI unit of radiation dose equivalent. It is equal to dose in grays times a quality factor; 1 sievert equals 100 rem.

Somatic Effects—Effects of radiation limited to the exposed individual, as distinguished from genetic effects, which may subsequently affect unexposed future generations.

Specific Activity—The total activity of a given nuclide per volume or mass. It is a concentration defined as the ratio of the amount of radioactivity divided by the mass or volume of radioactive substance, e.g. the specific activity of ^{238}U metal is 0.33 µCi/g.

Stable Isotope—A nonradioactive isotope of an element.

Standard Mortality Ratio (SMR)—The ratio of the disease or accident mortality rate in a certain population compared with that in a standard population. The SMR is usually expressed in percent. Thus, an SMR is the mortality rate for the standard population.

Stopping Power—The average rate of energy loss of a charged particle per unit thickness or per unit mass of a material traversed as a result of Coulomb interactions with electrons and with atomic nuclei.

Stochastic effects—See Non-Deterministic Effects.

Surface-seeking Radionuclide—A bone-seeking radioactive material that is deposited and remains on the surface for a long period of time. This contrasts with a volume seeker, which deposits more uniformly throughout the bone volume.

Target Theory (Hit Theory)—A theory explaining some biological effects of radiation on the basis that ionization, occurring in a discrete volume (the target) within the cell, directly causes a lesion that subsequently results in a physiological response to the damage at that location. One, two, or more "hits" (ionizing events within the target) may be necessary to elicit the response. When the target is "hit," it is inactivated. A specific biological response (e.g., cell death) may require the inactivation of more than one target. A critical characteristic of target theory in the context of the linear no-threshold theory, is that targets are not repairable once they are hit or inactivated.

Teratogen—Radiation or a chemical that can lead to birth defects.

Tissue Dose—The absorbed dose received by tissue in the region of interest, expressed in Gray or rad. (See also Dose and Rad.)

Total Effective Dose Equivalent (TEDE)—The sum of the effective deep dose equivalent from external exposures and the committed effective dose equivalent from internal exposures.

Total Ionization—The total electric charge of one sign on the ions produced by radiation in a material. It is frequently used as a measure of radiation energy absorbed per unit mass of gas.

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Total Organ Dose Equivalent (TODE)—The sum of the dose equivalent to an organ or tissue from external radiation and the committed dose equivalent to that organ or tissue from radioactive materials deposited within the body.

Transformation Constant—The fraction of the number of atoms of a radioactive nuclide that transforms in unit time. λ is the symbol for the transformation constant in the equation N' $N_0 e^{-\lambda t}$, where N_0 is the initial number of atoms present, and N is the number of atoms present after some time, t.

Transformation, Nuclear—The process by which a nuclide is transformed into a different nuclide by absorbing or emitting a particle.

Transient Equilibrium—If the half-life of the parent is short enough, so that the quantity present decreases appreciably during the period under consideration, but is still longer than that of successive members of the series, a stage of equilibrium will be reached after which all members of the series decrease in activity exponentially with the period of the parent. An example of this is radon (half-life of approximately 3.82 days), and successive members of the series to ^{210}Pb.

Transition, Isomeric—The process by which an excited nuclide decays to the ground state to produce an isomeric nuclide (i.e., one of the same mass number and atomic number) by emitting a gamma ray.

Tritium—The hydrogen isotope with one proton and two neutrons in the nucleus (Symbol: ^{3}H or T). Tritium is radioactive, with a half-life of 12.3 years; it emits very low energy beta particles.

Unattached Fraction—That fraction of the radon daughters, usually ^{218}Po (Radium A), that has not yet electrostatically attached to an airborne dust particle. As a free atom, it has a high probability of being retained within the lung and depositing alpha energy when it decays.

Units, Radiological

Units	Equivalents
becquerel*	1 Bq = 1 transformation or disintegration per second = 2.7×10^{-11} Ci
curie	1 Ci = 3.7×10^{10} transformations or disintegrations per second = 3.7×10^{10} Bq
gray*	1 Gy = 1 J/kg = 100 rad
rad	1 rad = 100 erg/g = 0.01 Gy
sievert*	1 Sv = 100 rem
rem	1 rem = 0.01 sievert
Roentgen	1 R = 2.58×10^{-4} coulomb of charge of either sign produced in 1 kilogram of air at STP

*International Units are designated as SI.

Weighting Factor (W_T)—A dosimetric factor used in the practice of health physics (radiation safety) to account for the relative carcinogenic susceptibility of the various tissues.

Whole Body—For the purposes of radiation exposure, the part of the body composed of the head, trunk, arms above the elbow, legs above the knee, and gonads.

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Working Level (WL)—A unit for measuring the atmospheric concentration of radon progeny. It corresponds to the equilibrium concentration of radon progeny due to 100 pCi radon per liter of air, or any combination of short-lived radon daughters in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

Working Level Month (WLM)—Inhalation of air with a concentration of 1 WL of radon daughters for 170 working hours results is an exposure of 1 WLM.

X rays—Penetrating electromagnetic radiations whose wave lengths are shorter than those of ultraviolet light.   X rays can be classified as characteristic x rays or bremsstrahlung. Characteristic x rays are produced deliberately in x ray machines or directly when ionizing radiation passes through matter. These x rays occur when electrons are ejected from an atom and electrons in higher energy orbitals cascade down to fill in those vacancies, releasing the energy difference between those orbitals as electromagnetic radiation (x rays). Bremsstrahlung is x rays that are radiated from a beta particle as it accelerates (changes direction) in the strong electrostatic field of an atomic nucleus, as occurs when electrons are stopped in a high atomic number element, such as lead.