absorbed dose: average amount of energy imparted to an element of matter exposed to ionizing radiation divided by the mass of this element. It is expressed in **grays** (Gy). 1 gray represents an absorbed energy of 1 joule per kg of matter

actinides: naturally occurring and/or artificial **radioelements** with an atomic number (i.e. the number of protons in the nucleus) between 89 (actinium) and 103 (lawrencium)

activation: process whereby, when bombarded by neutrons or other particles, certain **nuclides**, particularly within reactor structural materials, are **transmuted** and become **radioactive**

activity: number of **disintegrations** per unit time inside a **radioactive** source. Expressed in **becquerels** (Bq). One Bq is equivalent to one disintegration per second and is therefore an extremely small unit

anion: a negative ion

assembly (fuel)**:** a group of **fuel** elements assembled together and loaded into a nuclear reactor as a single unit. In a pressurized-water reactor, a fuel assembly can consist of several hundreds fuel rods

Atalante (ATelier Alpha et Laboratoires pour ANalyses, Transuraniens et Etudes de retraitement)**:** a group of laboratories equipped with series of shielded cells located at the CEA/Valrhô-Marcoule site in France. Specialized in the study of spent-**fuel reprocessing** and high-level radioactive waste conditioning

barn: see **cross-section**

barriers (of a radioactive-waste disposal facility)**:** devices set up between waste and the medium or environment in which it is stored to prevent or restrict the dissemination of **radioactive** materials. Barriers can successively be the glass matrix (e.g. in vitrified waste), the package, **engineered barriers** for filling and anchoring, designed to protect the packages and prevent or slow down the flow of **radionuclides** to the **geosphere** in the event of deterioration, and finally the actual geological disposal environment in which the waste is placed

biosphere: all the Earth's ecosystems, including all living organisms and the environments in which they live

burnup: strictly speaking, this represents the percentage of heavy atoms (uranium and plutonium) of **fuel** having undergone **fission** within a given period. Commonly used to determine the quantity of thermal energy per unit mass of fuel obtained in the reactor between fuel loading and unloading, it is expressed in megawatt·days per ton (MW·d/t)

cathode: electrode where electrochemical **reduction** reactions occur

cation: a positive ion

cercer: ceramic material embedded in a ceramic matrix

cermet: ceramic material embedded in a metal matrix

chain reaction: a series of nuclear **fissions** during which the neutrons released cause new fissions which in turn generate more neutrons leading to more fissions, and so on

complexation: formation of a structure or **complex** made up of ions and molecules and obtained using extractant systems and species to be extracted

coolant: fluid (gas or liquid) used to extract the heat produced by **fission** in a nuclear reactor

coordination number: number of bonds that an ion can form with electron-donor atoms

criticality: expression of a precise equilibrium between the neutrons produced through **fission** and those disappearing through absorption or leakage in a medium containing **fissile** nuclei

cross-section: a measure of the probability of an interaction between a particle and a target nucleus, expressed in **barn units** (1 barn = 10^{-24} cm^2). In the case of a neutron, it defines the probability of interaction between the neutron and the nuclei of the materials used to make the various parts of the core

cycle (fuel…)**:** all the different stages in the life of a **fissile fuel**, from ore extraction to fabrication (front-end), to the possible **(re)processing** of spent fuel and waste disposal (back end) after use in the reactor. There are two types of cycle: "closed" when spent fuel is processed for **recycling** purposes, and "once-through" when spent fuel is considered as waste

delayed neutrons: neutrons released by **fission** fragments, with an average delay of several seconds after fission. Owing to this time delay, it is ultimately these neutrons that are used to control the reactor, even though they account for less than 1% of emitted neutrons

depleted uranium: uranium in which the 235 **isotope** concentration (235 is its only **fissile** isotope) is lower than in naturally occurring uranium (0.72% by mass). It is generally obtained either as a coproduct of an **enrichment** operation (about 0.3% of ^{235}U), or as a by-product (1% of ^{235}U) of spent **fuel (re)processing** after irradiation in a reactor

Diamex (DIAMide EXtraction)**:** process used to separate the **lanthanides + minor actinides** group from **fission products**

disintegration: transformation of an unstable nucleus into a stable or unstable nucleus during which the number and nature of the nucleons change (nucleons = neutrons or protons, the particles making up the nucleus)

dispersion: mixture of small particles (mineral or organic) in a homogeneous medium

Doppler effect: local change in the **reactivity** of a nuclear reactor owing to a local increase in **fuel** temperature. This immediate effect is a crucial safety factor in reactors

dose equivalent: absorbed dose in a tissue or organ, multiplied by a weighting factor that takes into account the biological effect related to the type and energy level of the radiation in question. Expressed in **sieverts** (Sv)

dose equivalent rate: the rate of quantity of **absorbed dose**, with the biological effects weighted by *quality factors* varying according to the type of radiation. Expressed in **sieverts** per second (Sv/s)

dose factor: coefficient used to calculate a dose (expressed in **sieverts**) equivalent to the **activity** of 1 **becquerel** of a given **radionuclide**, entering the body *via* ingestion or inhalation

dose rate: the increase in dose (energy absorbed by matter per unit mass) divided by the time in which the increase occurs. The official unit is the **gray** per second (Gy/s)

effective dose: sum of **dose equivalents** imparted to the various tissues and organs of an individual, weighted by a factor specific to each organ or tissue. Expressed in **sieverts** (Sv)

electronvolt (eV): unit of energy used in nuclear physics. 1 eV = 1.6 x 10^{-19} joule. The **megaelectronvolt** (MeV = 10^6 eV) and **gigaelectronvolt** (GeV = 10^9 eV) are commonly used multiples of this unit

enriched uranium: uranium in which the only **fissile isotope**, the 235 isotope, has been increased from its naturally occurring low level (0.72% by mass) to a concentration of 3.5%, for example, for a **fuel** intended for use in a pressurized-water reactor

enrichment: process used to increase the concentration of a certain **isotope** in an element. In the case of uranium, various means are employed (gaseous diffusion, ultracentrifugation, selective laser excitation) to increase the concentration of the 235-isotope with respect to the 238-isotope that predominates in naturally occurring uranium

epithermal neutrons: neutrons within the 10 **eV** to 20 keV energy range, traveling faster than **thermal neutrons**

EPR (European Pressurized-water Reactor)**:** a new-generation pressurized-water reactor (PWR) being developed by Framatome–ANP (part of the Areva group) and a number of electric utilities. It features many improvements in safety, **fuel** use and cost-effectiveness

fast neutrons: neutrons released during **fission**, traveling at very high speed (20,000 km/s). Their energy is in the region of 2 million **electronvolts**

fertile: refers to a material in which the nuclei yield **fissile** nuclei when they absorb neutrons. This is the case of uranium-238 which yields plutonium-239. Materials that do not react in this way are said to be sterile

fissile (material)**:** a material able to undergo **fission** through the absorption of neutrons

fission: the splitting of a **heavy nucleus** into two parts, accompanied by the emission of neutrons, radiation and the release of a considerable amount of energy

fission products: nuclides generated either directly through nuclear **fission**, or indirectly through the **disintegration** of fission fragments

formulation: definition of the chemical composition

fuel (nuclear)**: fissile** material placed on a non-fissile support in a geometrical arrangement designed to sustain a **chain reaction** in a nuclear-reactor core; **fuel element:** the smallest part of a reactor core, containing fuel and with its own specific structure

geosphere: the part of the Earth which includes the upper layer of the lithosphere, the hydrosphere and the atmosphere and serves as a support to the **biosphere**

half-life: time required for half the atoms of a **radioactive nuclide** to disappear as a result of **disintegration**

heavy nuclei: name given to **isotopes** with at least 80 protons (i.e. an atomic number of at least 80). All **actinides** and their *daughter products* belong to this group

hydrolysis: chemical breakdown by water

hydrometallurgical (process)**:** process used in spent-**fuel (re)processing**. It involves dissolving the waste in an acid solution then putting it through a liquid–liquid extraction process

incineration (of nuclear waste)**: transmutation** of **actinides** – especially **minor actinides** – in a nuclear reactor, through **fission** and **neutron capture**. Only the second method can be used for the transmutation of **fission products**

integrated dose (or simply **dose**)**:** term used to estimate, in the case of a material, the neutron flux (or **fluence**) integrated during its irradiation. Expressed in n/cm^2

irradiation cycle (in reactor)**:** the time between two nuclear-reactor refueling operations (whether partial or complete)

isotopes: different forms of the same chemical element. Their nuclei have the same number of protons but a different number of neutrons

lanthanides: group of elements with an atomic number (i.e. the number of protons in the nucleus) between 57 (lanthanum) and 71 (lutetium)

leaching: slow removal of materials by water

ligand: in **hydrometallurgy**, a molecule or ion in an aqueous solution liable to form coordinate bonds with a metal ion

major actinides: uranium and plutonium **heavy nuclei** present or produced in nuclear **fuel**

minor actinides: heavy nuclei formed in relatively small quantities in a reactor by successive **neutron capture** from **fuel** nuclei. The main long-lived **isotopes** concerned here are neptunium (237), americium (241, 243) and curium (243, 244, 245)

model: simplified representation of a system or process. It can have a mathematical expression which, translated into a **computer software** package (often called a code), may be used for simulation purposes

moderator: material made from light nuclei that slow down neutrons through elastic scattering. The moderator must have a low **capture** factor to avoid "wasting" neutrons, yet must be dense enough to slow down the neutrons effectively

MOX (Mixed Oxides)**:** mixture of **uranium** (natural or **depleted**) oxide and plutonium oxide

multiplication factor *k*: ratio between the number of neutrons produced by **fission** to the number of neutrons disappearing, over a given period of time. In an infinite medium (i.e. with no neutron leakage), it is noted k_∞. In a finite medium (i.e. allowing for neutron leakage), it is termed as effective and noted k_{eff}

near field: part of a **radioactive**-waste disposal facility exposed to strong thermal, hydraulic, mechanical and chemical disturbances, in contrast to the **far field**, which is the part of the **geosphere** less affected by this type of disturbance

neutron capture: absorption of a free neutron (by a nucleus) that does not lead to **fission**

nuclide: matter made up of atoms with identical nuclei, therefore with the same *atomic number* (number of protons *Z*) and the same *mass number A* (equal to the sum of the number of protons and neutrons)

outlet: point at which a substance, particularly water, can flow out of a given system or environment

oxidizing agent: an agent that removes electrons from an atom or ion; **oxidation:** reaction in which an atom or ion loses electrons

passive: term used to describe systems that operate using natural forces, such as convection and gravity. In theory, such systems make facility safety less reliant on active systems such as pumps, motors, valves, etc.

potential radiotoxicity or **radiotoxic inventory: activity** of a certain quantity of **radionuclides** multiplied by **ingestion dose factors**. It is therefore the dose received by all the people who might have intaken this quantity of matter

Purex (Plutonium Uranium Refining by EXtraction)**: hydrometallurgical** process used to separate uranium and plutonium from spent **fuel**

R7T7 glass: type of glass for conditioning high-level **radioactive** waste produced by Cogema in La Hague. Its name comes from two vitrification facilities, R7 and T7, at the UP2-800 and UP3 plants respectively

radioactive decay chain (or **disintegration chain** of an element)**:** succession of different **radionuclides** created by spontaneous transformation of an unstable nucleus over time. The chain ends with a stable element (non **radioactive**)

radioactivity: property found in certain naturally occurring or artificial elements causing them to emit spontaneously **alpha** particles (helium nuclei), **beta** particles (positrons [beta + emission] or electrons [beta - emission]) and/or **gamma** radiation (high-energy photons). More generally speaking, the term refers to radiation emitted during the **disintegration** of an unstable element or **fission**

radioelement: element where all the **isotopes** are **radioactive**

radiolysis: breakdown of matter due to ionizing radiation

radionuclide: radioactive isotope of an element. Sometimes referred to as a radioisotope

recoil nucleus: a nucleus to which kinetic energy is imparted by a nuclear reaction or **radioactive** emission. In the case of alpha **disintegration**, for example, energy is released as kinetic energy divided between the alpha particle (98%) and the recoil nucleus (2%)

recycling: valorization of reusable materials at the end of a production cycle. In a nuclear reactor, using **fissile** materials (generated plutonium, residual uranium-235, etc.) from a previous cycle within a **fuel**. The term monorecycling is used when the fissile material has only been irradiated once, and **multirecycling** when it has been through succesive irradiation cycles

reducing agent: an agent that adds electrons to an atom or ion; **reduction:** reaction in which an atom or ion acquires electrons

(re)processing (spent fuel...)**:** selectively partitioning of materials contained in spent **fuel** to extract those that can be **recycled** (uranium and plutonium) or possibly **transmuted**, and conditioning the different types of final waste for storage or disposal

resonance: large **cross-section** value for a precise value of incident energy imparted to the nucleus by a neutron. Resonance comes from the structure of the energy levels of the *compound nucleus* (i.e. a nucleus modified after absorbing a neutron)

Sanex (Selective ActiNides EXtraction)**:** process used to separate **lanthanides** and **actinides**

Sésame (Selective Extraction and Separation of Americium by Means of Electrolysis)**:** process used to separate americium and curium

solvent: liquid substance capable of dissolving another substance

sorption: reversible fixation of an atom or a molecule on a solid surface

spectrum (neutron...)**:** distribution according to energy of neutrons in a reactor core

stoichiometry: the proportions in which the reagents combine in a chemical reaction. A reaction is termed **stoichiometric** when the quantities of reagents occur in the same molar proportions as the chemical equation

subcritical: a reactor core is said to be subcritical when the number of neutrons emitted by **fission** is lower than the number of neutrons disappearing as a result of absorption or leakage

subsurface: used to describe a waste storage or disposal site several tens of meters underground and protected by its natural surroundings (e.g. on a hillside). Distinguished from **near-surface** sites (e.g. protected by an above-grade tumulus) and **deep disposal** sites (usually 500 m deep) in which the geological environment acts as an effective **barrier**

thermal creep: irreversible deformation of a material subjected to combined mechanical and heat-induced stress

thermal neutrons: also known as slow (or **thermalized**) **neutrons**, these are neutrons in thermal equilibrium with the matter through which they pass at an approximate speed of 2–3 km/s. Their energy is less than 1 **electronvolt**

thermalization: the process of slowing down fast neutrons, gradually establishing thermal equilibrium between them and the reactor matter in which they are scattering

transmutation: transformation (**incineration**) through a nuclear reaction of one **isotope** into another induced by neutrons (**fission**, **capture**). This type of reaction is used to transform long-lived **radioactive** isotopes into short-lived or stable isotopes to reduce the long-term **radiotoxic inventory** of radioactive waste

transuranic elements: all elements with a higher atomic number (number of protons in the nucleus) than uranium. In reactors, **heavy nuclei** are obtained from uranium by **neutron capture** or **radioactive disintegrations** other than **fission**. They are divided into seven **isotope** families: uranium, neptunium, plutonium, americium, curium, berkelium and californium

UOX: standard **fuel** used in light-water reactors, made from **uranium** oxide **enriched** with uranium-235

valence: the number of bonds that an atom can form. An atom is said to be **monovalent** if it can form one bond, **divalent** if it can form two, and **trivalent** if it can form three, etc.