

Glossary

ablation: the ejection of matter through the effect of a flow of matter, or radiation flux, on a body's surface, loss of substance resulting from chemical decomposition, change of state, or mechanical erosion.

above IC: short for "above integrated circuit;" a technology consisting in the integration of components (e.g. micromechanical or radiofrequency components) on top of an already partly completed integrated circuit, as opposed to *hybrid integration* technology, where the various components are positioned next to each other in one operation. This technology allows optimum systems integration, while using mass-production methods.

absorption: the process whereby the intensity of a radiation decreases as it passes through a material medium, to which it transfers all or part of its energy.

adsorption: the retention of **molecules** on a solid surface, as a rule through a passive, nonspecific process (for instance, by **electrostatic** effect, in a gaseous or liquid environment). **Desorption** is the opposite process.

aerosol: very fine (0.01–100 **micrometers**) solid or liquid particles, held in suspension in a gaseous medium, in the atmosphere in particular (droplets, **crystals**, dust particles...).

algorithm: a sequence of logical–mathematical operations required for the carrying out of a computation task.

alpha: see **alpha (α) particles** and **radioactivity**.

alpha (α) particles: helium nuclei, comprising two **protons** and two **neutrons**. Spontaneously emitted by the heavier natural **radioactive elements** as radiation, they are, together with protons, the fundamental constituents of primary **cosmic radiation**. They exhibit high **ionization** power, but a low penetration capacity.

amino acid: an organic **molecule** forming the basic constituent of **proteins**, featuring an amino (NH_2) group and a carboxyl (COOH) group.

angstrom (\AA): unit of length ($1 \text{\AA} = 10^{-10}$ meter).

anode: the element exhibiting higher potential, in an **electrostatic** configuration (see **cathode**).

antiparticle: to every particle of matter there corresponds an antiparticle of **antimatter** having the same mass but opposite algebraic quantum numbers, as e.g. electric charge. When the two collide, they annihilate, the energy being released in the form of **photons** or other particles. The **antineutrino**, for instance, is the antiparticle of the neutrino.

atmosphere: the gaseous envelope surrounding the Earth. It is subdivided into five layers, corresponding to various segments of the curve plotting temperature variation as a function of altitude: the **troposphere** (from the Earth's surface to an altitude of 8–15 km), **stratosphere** (from 8–15 km to 50 km altitude), **mesosphere** (50–85 km), **thermosphere** (from 85 km to 350–800 km), and **exosphere** (from 350–800 km to 50,000 km). Subdivision according to electrical properties leads to distinguishing, on the other hand, the **ionosphere**, an **ionized** layer (from 60 km to more than 800 km in altitude), and, beyond this, the **magnetosphere**, the region where the Earth's magnetic field prevails against the solar wind, shielding the Earth from ionized particles making up that wind.

atom: the basic "building block" of normal matter, comprising a **nucleus** (made up of **protons** and **neutrons**) around which **electrons** orbit.

atomic number: the number of **protons (Z)** in the **nucleus** of an **atom**, or the number of orbiting **electrons**, e.g. 13 for aluminum, 73 for tantalum.

atomic transition: the switch, for an **atom**, from one state to another (the *fundamental* state, i.e. the stable state, in which energy is at a minimum; or an *excited* state, at a higher energy level). Such transitions, in particular, are the cause of the atom's emission spectrum, and of the **laser** effect.

atto-: a prefix (symbol **a**) representing 10^{-18} (one billionth of a billionth).

bar: unit of pressure. $1 \text{ bar} = 0.987 \text{ atmosphere} = 1.02 \text{ kg/cm}^2 = 10^5 \text{ pascals (Pa)}$. Submultiples include the **millibar** ($1 \text{ mbar} = 10^{-3} \text{ bar}$). Main multiples: the **megabar** ($1 \text{ Mbar} = 10^6 \text{ bar}$), the **gigabar** ($1 \text{ Gbar} = 10^9 \text{ bar}$), and the **terabar** ($1 \text{ Tbar} = 10^{12} \text{ bar}$).

barn: unit of area, used to measure **cross-sections** ($1 \text{ barn} = 10^{-24} \text{ cm}^2$; $1 \text{ nanobarn} = 10^{-33} \text{ cm}^2$; $1 \text{ picobarn} = 10^{-36} \text{ cm}^2$).

beta: see **radioactivity**.

blackbody: an ideal body which totally **absorbs** all radiation, at any wavelength, while itself emitting radiation that is a function solely of its temperature.

Boltzmann equation: the equation used in the kinetic theory of nonequilibrium gases. The gas considered is assumed to admit a local equilibrium state, in the vicinity of every point in space: it is thus assumed that gas temperature, particle density, and local pressure are well defined. The Boltzmann equation allows the investigation, in particular, of the relaxation of that gas to a global equilibrium.

bremstrahlung: radiation emitted by a charged particle, as it is deflected by the **atoms** in a material it is passing through (German for "braking radiation").

cathode: the element exhibiting lower potential, in an **electrostatic** configuration (see **anode**).

CCD (charge-coupled device): a device which yields **electrons** when it receives **photons**, forming in particular the elementary sensor in digital cameras.

coherent/noncoherent (wave trains): waves are said to be coherent when they are in phase, noncoherent in the opposite case.

complex: a neutral or charged structure, comprising **ions** and **molecules**, more rarely **atoms**. **Complexation** is the formation of such a structure.

computation code (or software): the assembly, in a computer software, in the form of coded mathematical expressions, of the simplified representation, in numerical form (**model**), of a system, or a process, for the purposes of simulation.

conductivity: characterizes the capacity for (heat, or electric) **conduction** of a substance. Electric conductivity is measured in siemens per unit length.

convective (motions): motions generated inside a fluid mass owing to differences in density and temperature at various points in this mass, contributing to heat transport. Natural convection is the automatic transfer of heat through such circulation.

cosmic radiation: a stream of charged particles (**electrons**, **protons**, and **nuclei**) traveling through interstellar space at **relativistic** velocities. Most of these particles originate outside the solar system, while others are accelerated during solar eruptions. Charged particles reaching the Earth in their propagation interact with **atoms** in the upper **atmosphere**, only some of the products from these interactions (such as muons, **gamma radiation**, and secondary electrons) being able to reach the Earth's surface.

cosmogenic (nucleus): an **atomic nucleus** yielded by a nuclear reaction in the **atmosphere**, induced by **cosmic radiation**.

cross-section: the measure of the probability, expressed in **barns**, of interaction between two particles, in particular between a particle and a target **nucleus**.

cryogenic: literally, "cold-generating;" more broadly: "relating to low temperatures." Cryogenic liquids, for instance, have boiling points below $-150\text{ }^{\circ}\text{C}$.

cryostat: a device allowing temperature to be kept at constant low levels, as a rule through circulation of a liquefied gas.

crystal: an assembly of **atoms**, **ions**, or **molecules** arrayed in regular, periodic fashion over all three space directions.

decay: the spontaneous transformation of an unstable particle (whether elementary or composite, as e.g. a **radioactive nucleus**) into other particles. A radioactive nucleus decays into a stable or unstable nucleus, by emitting one or more particles. An unstable particle may decay into lighter, stable particles (as instanced by the beta decay of the **neutron**: $n \rightarrow p + \text{electron} + \text{antineutrino}$).

deconvolution: a method consisting in taking into account the deformation of information due to the measuring system, in order to extract the initial information.

deuterium: a "heavy" **isotope** of **hydrogen**, featuring a **nucleus** comprising one **proton** and one **neutron**. **Deuterated:** containing deuterium.

dielectric: a substance that does not conduct electric current, but is able to store **electrostatic** energy.

diffraction: a process that occurs as waves encounter an obstacle, or reach a different medium, resulting in deflections in their propagation, as instanced by the altered path of a light wave as it passes from one medium to another, of different **opacity**.

diode: an electronic component which emits a large number of **electrons** (or allows passage of a current) when subjected to a voltage rising above a threshold (below which no electron is emitted). **Laser diode:** a **coherent** light source in which beam intensity may be varied through application of a variable voltage. **Photodiode:** a **semiconductor** component having the ability to capture optical radiation, and convert it into an electrical signal. **Avalanche photodiode:** a semiconductor device making use of a process of multiplication of the number of free carriers, i.e. of current gain, under the action of an intense applied electric field: the *charge carriers* generated are sufficiently accelerated, between the collisions they undergo within the material, to yield additional secondary **electron-hole pairs**. These pairs are themselves endowed with sufficient energy to yield further pairs, and so on.

DNA chip: a device making use of microelectronics techniques, allowing the detection of a **DNA strand**, through the pairing of this strand with its complementary, known as a probe, fixed to the chip, on **hybridization** sites, in accordance with the principle underlying the DNA double helix. This technique enables, for instance, global analysis of the **genetic** expression of a cell.

doping: the introduction, into a **crystalline** or amorphous network, of an extraneous **atom**, to alter that network's properties.

Doppler effect: an apparent variation in frequency, for a wave, that is proportional to the relative velocity of the source, with respect to the observer.

dose: the amount of energy deposited by penetrating radiation in a material, per unit mass. International unit: 1 **gray** = 1 **joule**/kilogram. Customary unit: 1 **rad** = 0.01 gray.

dose rate: the **dose** of radiation deposited per unit time.

elastic scattering (or interaction): an interaction between particles taking the form of a transfer of momentum from one particle to another, while not altering the latter's nature (the classical equivalent being the collision of two billiard balls). The incident particle rebounds off the target particle with a kinetic energy lower than its initial energy. The transferred momentum imparted to the target makes it recoil. If its **recoil energy** is sufficient, the target particle thus emitted may be detected (one speaks, for instance, of a **recoil electron**, when scattering takes place on an electron target). In the case of electromagnetic waves, scattering is said to be elastic when the scattered **photon** has the same frequency as the incident photon (e.g.: *Rayleigh scattering*).

electromagnetic radiation: a form of radiation that propagates in a vacuum at the velocity of light, in the form of oscillating electric and magnetic fields, and transports energy (**photons**).

electron: a negatively-charged elementary particle. One of the constituents of the **atom**, orbiting around the **nucleus**.

electron-hole pair: a pair of *charge carriers*, not bound to an **atom**, and thus able to move through the entire **crystal** in which they were formed, one of which is negative (an **electron** in the *conduction band*), the other one positive (absence of an electron in the *valence band*).

electronvolt (eV): unit of energy, corresponding to the energy gained by an **electron** accelerated by a potential of 1 volt, i.e. $1\text{ eV} = 1.602 \cdot 10^{-19}\text{ joule}$. Main multiples: the **kiloelectronvolt (keV)**: 1,000 eV, the **megaelectronvolt (MeV)**: 1 million eV, and the **gigaelectronvolt (GeV)**: 1 billion eV.

electrostatic (force): only involving Coulomb attraction and repulsion forces, in other words based on nonmoving electric charges (zero magnetic field).

element: an **atom** defined by the number of its **protons (atomic number)**. A distinction is made between **light elements (hydrogen, helium, lithium, beryllium, boron)**, and **heavy elements** (all other elements, from carbon to **uranium**, as far as natural elements are concerned).

enzyme: a **protein** which activates a biochemical reaction by catalyzing it.

epicenter (of an earthquake): the point on the Earth's surface located precisely vertically above the seismic focus, where the earthquake's *intensity* is greatest.

epitaxy (from the Greek *taxis* [order] and *epi* [above]): a technique consisting in the deposition, by **molecular jets**, onto the surface of a **monocrystalline** substrate, positioned on a support held at high temperature, of layers consisting of a few **atomic** planes. This relies on evaporation of the various pure constituents of the material being fabricated, inside a vessel kept under high vacuum.

equation of state: a relation between temperature, density, and pressure, or between energy density and pressure.

equivalent dose: a quantity defined as the product of the absorbed **dose**, in a tissue or organ, by a weighting factor, varying according to the nature and energy of the radiation involved.

fissile: liable to undergo **fission**.



fission: the division (splitting) of a heavy **nucleus** into two fragments, with concomitant emission of **neutrons**, and **radiations** (**gamma**, **beta** radiation). The recoil of the two nucleus fragments, and part of the radiation are converted into released energy, as these interact with matter.

fluorescence: the reemission, usually very swiftly, of a **photon** of lower energy, by an **atom** or **molecule** (a **fluorophor**) which has **absorbed** a photon of given energy.

fluorophor: a **molecule** involved in **fluorescence**.

4th-generation nuclear reactor: a new generation of nuclear power systems, being investigated on an international scale, exhibiting improved qualities, in terms of economy, safety, waste minimization, and proliferation resistance, compared with extant reactors, or those currently being built. Six reactor pathways, mostly of the closed-fuel-cycle, **fast-neutron** type, were selected for further investigation, these using as **coolant** sodium, lead, supercritical water, **gas (helium)**, or **molten salts**.

free electron: an **electron**, normally bound, at a distance, to the **nucleus** of an **atom**, which has broken from its bond with that atom.

fusion (thermonuclear): a nuclear reaction whereby small **atomic nuclei** combine at high temperature to form larger nuclei having a mass lower than the sum of the masses of the initial nuclei, the difference in mass being converted into energy in accordance with the Einsteinian mass–energy equivalence law: $E = mc^2$.

galaxy (from the Greek *galaktos*, meaning “milk,” by analogy with the Milky Way): an aggregate of stars (10^8 – 10^{13}), gaseous interstellar matter, and dark matter, the nature of the latter remaining as yet unknown, its existence however being indirectly proved through the gravitational attraction it exerts.

gamma: see **radioactivity** and **gamma (γ) radiation**.

gamma (γ) radiation: the most energetic form of radiation in the electromagnetic spectrum. Gamma **photons** have energies lying in a range above 10 **keV**.

gene: a **DNA sequence** on a chromosome representing a unit of hereditary information, enabling the production of a phenotypic character (observable character of an individual), through production of one or more **proteins**.

genome: the ensemble of **genetic** material of a living organism.

gravity waves: in climatology, concentric variations in atmospheric pressure caused by the drop of an air mass (due to relief, for instance). Such waves, the equivalents of surface waves for a three-dimensional medium, may result in the formation of parallel cloud bands, corresponding to pressure minimums and maximums (wave “crests”).

gray: unit of **dose** (energy deposited): 1 gray (**Gy**) = 1 J/kg = 100 **rad**.

greenhouse gases (GHGs): gases whose physical properties are such that their presence in the Earth’s **atmosphere** contributes to a **greenhouse effect** at the Earth’s surface. Since these gases are transparent to certain wavelengths of solar radiation, the latter can penetrate down to the Earth’s surface. The fraction of radiation that is **absorbed** by the Earth supplies heat to it, which it releases back to the atmosphere, in the form of **infrared radiation**, escape of which is blocked, in part, by GHGs and clouds, thus trapping heat which warms the lower atmosphere. Water vapor, **carbon dioxide (CO₂)**, **methane (CH₄)**, nitrous oxide, and **ozone** occur naturally, however human activities have caused

their concentrations to rise, along with the arrival of industrial greenhouse gases, such as chlorofluorocarbons, which moreover impair the Earth’s ozone layer.

helium: chemical **element** (He), the lightest element after **hydrogen**. Its **nucleus** comprises two **protons** and two **neutrons**, for **helium 4**, the most common **isotope** (the nucleus of **helium 3** features one single neutron).

hormone: a substance secreted by a group of cells, or an organ, and transported *via* the bloodstream, exerting a specific action on another organ, or other cells.

hybridization: the ability of the *bases* in a **nucleic acid** strand to recognize spontaneously the complementary bases in another nucleic acid, to pair with them.

hydrogen: the simplest **atom** (H), comprising one **proton** and one **electron**.

ignition: the self-sustenance of the **plasma** temperature in a **thermonuclear fusion** machine, at a level sufficient for reactions to proceed continuously.

inelastic scattering (or interaction): an interaction between particles whereby the energy yielded by the incident particle to the target alters the latter’s nature. In the case of a target **nucleus**, this change in nature takes the form of the nucleus reaching an excited state, or one or more of its constituents being expelled, or even the nucleus breaking up. In the case of electromagnetic waves, scattering is said to be inelastic when the scattered **photon** undergoes a decrease in frequency (e.g.: *Compton scattering*).

infrared (IR) radiation: a segment of the electromagnetic spectrum covering radiation of wavelengths ranging from 760–780 **nm** to 1 mm. Physicists subdivide infrared radiation into the **near infrared** (760 nm–4 μ m), **intermediate IR** (4–14 μ m), **far IR** (14–100 μ m), and **submillimeter IR** (100 μ m–1 mm).

infrasound: acoustic waves of a frequency lower than 20 **hertz (Hz)**, making them inaudible to the human ear, which perceives, on average, frequencies ranging from 20 Hz to 20,000 Hz.

intermediate (or vector) boson: a spin particle, acting as vector for fundamental interactions at the microscopic level; e.g. the **photon** is the intermediate boson for the electromagnetic interaction.

ion: an **atom** or **molecule** that has lost, or gained, one or more **electrons**, and thus exhibits an electrical charge (**cation**: positive ion; **anion**: negative ion).

ionization: a state of matter in which **electrons** are separated from the **nuclei**. The process whereby **ions** are produced, through collisions with **atoms** or electrons (collision ionization), or interaction with **electromagnetic radiation (photoionization)**.

isotopes: forms of one and the same chemical **element**, for which the **nuclei** have the same number of **protons** (and hence of surrounding **electrons**), but different numbers of **neutrons**, and which, as a result, have different masses. **Heavy isotopes** have a high **atomic number**.

isotropic: showing identical physical properties in all directions (antonym: **anisotropic**).

joule (J): derived unit of work, of energy, and of heat in the International System of Units (SI). The joule is defined as the work done by a force of 1 newton, when the point of application is displaced 1 meter in the direction of the force; or the work done when a current of 1 ampere passes through a resistance of 1 ohm for 1 second.

kelvin (K): unit of temperature in the International System of Units (SI). The Kelvin scale features a single fixed point, this being, by convention, the thermodynamic temperature of the triple point of water (i.e. the point at which the three phases, solid, liquid, and vapor, coexist) at 273.16 K, i.e. 0.01 °C. Ice melts at 273.15 K (0 °C); water boils at 373.15 K (100 °C). Zero kelvin ("absolute zero") is the temperature corresponding to zero **molecular** agitation.

kilo-: prefix (symbol **k**) representing 1,000 (10^3); 1 **kilojoule (kJ)** = 10^3 **joules**.

labeled molecule: a **molecule** the location of which may be determined by means of a **radioisotope**, used to label it. Labeling may be effected by substituting for one of the **atoms** in the molecule one of its **radioactive isotopes**, or by tagging onto the molecule a radioactive atom. The labeled molecule thus becomes a **tracer**.

lanthanide: an **element** having an **atomic number** lying in the range from 57 (lanthanum) to 71 (lutetium).

laser: a light source yielding waves that are *monochromatic* (of a single wavelength) and **coherent** (always in phase).

lipids: organic **molecules** containing a fatty acid, or a fatty-acid derivative, not water-soluble, but soluble in nonpolar (hydrophobic) organic solvents.

lithium: a light chemical **element** (Li), coming third in the periodic table after **hydrogen** and **helium**. Its **nucleus** comprises three **protons** and four **neutrons**.

luminescence: the property, exhibited by certain substances, of yielding back, in the form of light (**photons** of energy $q = h\nu$) of nonthermal origin, part of the energy **absorbed** in the course of excitation: this thus corresponds to deactivation to a lower energy state. Light emission is linked to the slow deexcitation of the **atoms** in a **molecule**, excited by light (**photoluminescence**) or other radiation (**radioluminescence**). It may equally be induced by an electric current, a chemical reaction the energy from which is "recovered" by **electrons** in certain materials (*chemiluminescence*, or *bioluminescence*), or yet as a consequence of mechanical motions, through the breaking of asymmetrical bonds within a **crystal**, when this material is scratched, broken, or rubbed (*triboluminescence*).

luminophor: a **luminescent** substance.

magnetic moment: a quantity M , described in mathematical terms by a vector having the dimension of a current intensity (in amperes), multiplied by an area ($A \cdot m^2$), related to the torque Γ to which a magnet is subjected, when placed in a uniform magnetic field B , by the formula: $\Gamma = M \cdot B \cdot \sin \theta$, where θ is the angle separating M and B .

magnitude (of an earthquake): a measure of the amount of energy released during an earthquake, on the basis of the measurement of the amplitudes of waves recorded in a seismogram, taking into account the distance from the earthquake's **epicenter**. This is often expressed in terms of the Richter scale, which is based on a logarithmic relation. Seismic *intensity*, on the other hand, refers to the earthquake's effects, at a given location.

mega-: a prefix (symbol **M**) representing 1 million (10^6): 1 **megajoule (MJ)** = 10^6 **joules**.

metabolite: an organic substance produced in the course of **metabolic** processes (synthesis, or degradation), or involved in them. **Metabolism:** the ensemble of chemical processes taking place in living organisms, and within every cell.

metabolome: the ensemble of organic compounds present in a biological environment, insofar as they are the outcome of influences exerted by the **genome** (the structure of **proteins**), the cell (protein maturation), and the environment.

metastable: refers to an **atom** which may remain for a certain time at atomic energy levels that are close to the fundamental level, though they are isolated in spectroscopic terms (radiative transition to the fundamental level being forbidden).

micro-: a prefix (symbol μ) representing one millionth (10^{-6}). **Micrometer (μm):** unit of length ($1 \mu\text{m} = 10^{-6}$ m), commonly referred to as the **micron**.

minor actinides: heavy **nuclei** generated in relatively small amounts inside a reactor, through successive **neutron** captures, from the nuclei of irradiated nuclear fuel. These mainly include neptunium, americium, and curium.

modeling: the working out of a numerical representation (known as a **model**) of a system or a process, for the purposes of simulating it. **Empirical model:** a model that is essentially based on empirical data.

mole: unit of amount of matter (symbol **mol**), corresponding to a system comprising as many elementary entities as there are **atoms** in 0.012 kg carbon 12. The symbol **M** stands for mole/liter.

molecule: a group of **atoms**, held together by chemical bonds.

Monte-Carlo: a type of **code**, consisting in taking on board equations (transport equations for a beam of particles, for instance) by sampling in terms of a number of entities (macroparticles, in this case), which are each treated independently, by making random draws to **model** the probabilities for the effects being investigated (reactions between particles, in this example).

n, p: see **semiconductor**.

nano-: a prefix (symbol **n**) representing one billionth (10^{-9}); 1 **nanometer (nm)** = 10^{-9} meter; 1 **nanosecond (ns)** = 10^{-9} second; 1 **nanogram (ng)** = 10^{-9} gram; 1 **nanojoule (nJ)** = 10^{-9} **joule**.

neutron: an electrically neutral particle. A neutron is 1,839 times heavier than an **electron**. Neutrons and **protons** are the constituents of **atomic nuclei (nucleons)**.

neutron fluence: the integral of a **neutron** flux density, over a given irradiation time interval. This is measured in neutrons per square centimeter (n/cm^2).

neutron spectrum: the energy distribution of **neutrons**.

nucleic acid: a **polymer** formed by the concatenation of **nucleotides**. There are two types of nucleic acid: **DNA** (deoxyribonucleic acid), which serves as the carrier for the **genetic** information inside every living cell, and **RNAs** (ribonucleic acids), in particular **messenger RNA**, which is a copy of the DNA coding for a gene, specifying the **sequence** of **amino acids** for a **protein**.

nucleotide: elementary component unit of **nucleic acids**, comprising a *purine base* (adenine, guanine, for instance) or *pyrimidine base* (e.g. cytosine, thymine), a sugar, and one or more phosphate groups.

nucleus (atomic): the essential constituent of an **atom**, bearing a positive charge and comprising **protons** and **neutrons** (except in the case of **hydrogen**), around which **electrons** orbit.

nucleide: a nuclear species characterized by its *mass number* A , this being the sum of the number of **neutrons** N , and the number of **protons** Z (i.e. its **atomic number**).

opacity (spectral): the capacity of matter to **absorb** radiation.



ozone: a **molecule** comprising three **atoms** of oxygen, present in the Earth's **atmosphere**. It is generated, on the one hand, at high altitude, by the Sun's **ultraviolet radiation**, and, on the other, at ground level, by combustion of organic materials.

particle accelerator: a machine designed to generate, shape and accelerate a beam of charged particles, directed onto targets, or other beams of accelerated particles, in order, for instance, to investigate their constituents. Accelerators may use, for acceleration purposes, **electrostatic** (Van de Graaff accelerator) or electromagnetic forces (cyclotrons, linear accelerators, synchrotrons).

PCR (polymerase chain reaction): a **polymerization** technique, allowing *in vitro* amplification of a **DNA** fragment, using the **enzyme** DNA polymerase.

period: a constant time interval, separating two like events. The inverse of frequency (which is measured in **hertz [Hz]**).

photoelectric effect: the emission of **electrons** by a material, as the latter, when exposed to **electromagnetic radiation** of sufficiently high frequency (depending on the material), **absorbs photons**.

photon: the *quantum* of energy of an **electromagnetic radiation**. An elementary particle, having zero mass and no electric charge, associated to such radiation (**visible**, **infrared**, or **ultraviolet**, **gamma**, or **X**-radiation, according to photon energy). The energy of gamma photons yielded by nuclear reactions is as a rule higher (though not systematically so) than that of X-photons.

photosynthesis: a biological process through which solar energy is used by a living cell (in plants, and certain bacteria) to cover its energy requirements.

photovoltaic (effect): the effect whereby the energy of light is directly transformed into electric energy in a **semiconductor**.

pico-: a prefix (symbol **p**) representing one thousandth of a billionth (10^{-12}); 1 **picometer (pm)** = 10^{-12} meter; 1 **picosecond (ps)** = 10^{-12} second.

piezoelectric: the property, exhibited by certain materials, of changing their electric **polarization** when pressure is applied to them. The reverse effect exists, whereby an electric field, applied to a piezoelectric material, causes it to change shape.

pinhole: the opening of a *camera oscura*, or any other optical device used in lieu of a lens.

pixel: abbreviation for "pic[ture] element." Elementary area in a picture, over which the signal is deemed to remain uniform.

Planck's law: the law setting out the intensity of heat radiation emitted by a **blackbody** as a function of its temperature. This intensity, known as *monochromatic brightness*, is defined as a flux per unit area, per unit solid angle, per unit wavelength. Planck's law allows the wavelength to be determined, for which monochromatic brightness stands at an energy maximum.

plasma: a state of matter characterized by high temperature, such that **atoms** are **ionized**, for the greater part, or in their totality. Plasma properties are determined by the electromagnetic forces prevailing between its constituents (**ions** and **electrons**), resulting in various types of behavior. Seen on Earth as the fourth state of matter, this forms, around the Universe, its main state.

plutonium: element of **atomic number** 94, and symbol Pu, having **isotopes** ranging from ^{232}Pu to ^{247}Pu . Five of these isotopes are important, from ^{238}Pu to ^{242}Pu , especially ^{239}Pu , a **fissile** element, generated inside nuclear reactors from **uranium** 238.

polarized: having an electric-field vector which, as it describes an electromagnetic vibration, remains in a definite plane.

polymer: a macromolecule of high molecular weight, repeating an identical pattern, known as a **monomer**, each bound to the following one by a *covalent bond*.

positron: a positively charged particle, the **antiparticle** of the **electron**.

ppb: part per billion (US "billion:" 10^9); **ppbv:** part per billion by volume (measure of concentration).

ppm: part per million; **ppmv:** part per million by volume (measure of concentration).

ppt: part per trillion (US "trillion:" 10^{12}).

protein: the main macromolecular constituent in cells, comprising a definite **sequence** of **amino acids**, from a set of twenty, encoded by **DNA**.

proteome: the ensemble of **proteins** expressed by the **genome** of a given species (a **gene** is said to "code" for a protein).

proteomics: a term covering all investigations and methods allowing **proteome** analysis to be directly addressed. One of the aims of this discipline, based as it is on the large-scale identification, and quantification of **proteins**, is to draw up the inventory of the proteins present in a specific cell type, at a given time, in a given environment. It further investigates protein distribution in various cell compartments, or substructures.

proton: a particle – a constituent of the **atomic nucleus (nucleon)** – bearing a positive electric charge, equal to that of the **electron**, and of opposite sign. A proton is 1,836 times heavier than an electron.

pyrochemical path: the use of high temperatures to carry out chemical operations in nonaqueous environments, in particular for the partitioning of long-lived radionuclides.

rad (for "radiation absorbed dose"): unit of absorbed irradiation dose, defined as the transfer of 0.01 **joule** per kilogram. The authorized annual dose, for a worker exposed to **gamma radiation**, is 2 rads, i.e. 0.02 gray. Multiples include the **megarad (Mrad)**, equal to 10^6 rads.

radioactivity: the property, exhibited by some natural or artificial **elements**, of spontaneously emitting **alpha particles (helium nuclei)**, **beta (β) radiation** (a form of radiation consisting of charged particles: **electrons** [beta⁻ radioactivity], or **positrons** [beta⁺ radioactivity]), and/or **gamma radiation** (high-energy **photons**). More broadly, this term is used to refer to the emission of radiation concomitant with the **decay** of an unstable element, or **fission**.

radionuclide: a **radioactive isotope**, also known sometimes as a **radioisotope**, of an **element**.

recoil nucleus: see **elastic scattering (or interaction)**.

reduction: the process whereby an **atom**, or an **ion**, gains peripheral **electrons**.

relativistic: relating to processes involving velocities close to the speed of light. Matter is said to be relativistic when thermal agitation velocity is close to the speed of light.

resistivity: the specific resistance of a material to **electron** travel.

resolution: also known as *resolving power*, i.e. the ability to discriminate, of a detection device. Resolution may be **spatial** (i.e., the measure of the smallest angular or linear separation between two objects, characterizing in particular the ability of an optical system to distinguish, or reproduce, details in a scene or its image), or **temporal** (the shortest time interval separating two successive instances of a signal over time, allowing these to be perceived as separate). **Spectral** resolution specifies the ability of a detection system to discriminate between **electromagnetic radiations** of different frequencies.

scintillator: a device consisting of a material that emits light subsequent to radiation **absorption**, taking the form of a **fluorescent** screen, in many cases coupled to a digital camera, or the form of a device in which the **photons** emitted by the scintillator material are amplified by means of a photomultiplier, and subsequently counted.

semiconductor: a material featuring a electronic *band gap*, which is neither solely an insulator nor solely a conductor at nonzero temperatures. Some of its **electrons**, being very weakly bound to their **atoms**, may become conduction electrons. A semiconductor may be of the *n* type (with mainly electron *charge carriers*), or of the *p* type (mainly hole *charge carriers*), depending on the **doping** agents used.

sequence: the order in which the constituent elements are concatenated, in biological **polymers** (**DNA**, **RNA**, **proteins**). **Sequencing** is the determination of that order.

silicon: the most common **semiconductor** material, used, according to the applications considered, in a variety of **crystalline** forms: microcrystalline ($\mu\text{-Si}$), monocrystalline (*sc-Si*), multi-crystalline (*mc-Si*), or polycrystalline (*pc-Si*).

Stark effect: the splitting of spectral lines under the effect of an electric field.

stationary wave: a wave resulting from the simultaneous propagation, in the same medium, and in different directions, of several waves having the same frequency, generating a figure featuring fixed points (vibration nodes).

sugar (complex): a polysaccharide.

superconductor: a metal or alloy in which **resistivity** suddenly vanishes to a near-zero value, at a so-called critical temperature.

supernova: the final, exploding state for massive stars, or for a *white dwarf* (the final state for stars of low mass) coupled to a *red giant* (the phase of strong expansion for stars of intermediate mass).

thermalization: the gradual bringing of a radiation, or particle stream into thermal equilibrium with the medium in which it **scatters**.

thorium: chemical **element** of **atomic number** 90, and symbol Th, having **isotopes** ranging from ^{223}Th to ^{235}Th . Isotopes ^{227}Th , ^{229}Th and ^{233}Th are **fissile** by means of *thermal neutrons*. Natural isotope ^{232}Th may be included in the composition of fuel for *fast-neutron* reactors, and as a fertile material, yielding ^{233}U as primary fuel.

tokamak: Russian acronym for *toroidal'naja kamera s magnitnymi katushkami* ("toroidal chamber with magnetic coil"), or possibly associating the three Russian words *tok* ("current"), *kamera* ("chamber"), and *mak* (literally "poppy," here for *magnity*, "magnetic"), defining toroidal machines for the investigation of magne-

tic-confinement **thermonuclear fusion**, i.e. confining the **plasma** inside which fusion reactions take place by means of magnetic fields.

tomography: an imaging technique allowing, on the basis of signal recording and processing, a three-dimensional image to be obtained. Mathematically, this breaks down into direct **modeling** of the physical processes being measured, and a reverse model, or reconstruction, based on the findings from the direct model.

toxin: a toxic substance, secreted by a living organism.

tracer: an organism, or substance – natural or artificial – enabling the investigation of physical, chemical, or biological processes, in the environment in which it occurs. The tracer, in particular, may be of an **isotopic** and/or **radioactive** nature.

transcriptome: the ensemble of **messenger RNAs**, transcribed from the **genes** and precursors for **proteins**, produced in given biological conditions.

tritium: the heaviest **isotope** of **hydrogen**, and the only **radioactive** one. Its **nucleus** comprises one **proton** and two **neutrons**.

turbulence: a flow mode in fluids, in which, onto the mean motion, a random agitation motion is superposed.

ultrasound: acoustic waves of a frequency higher than 20 **kHz**, inaudible to the human ear.

ultraviolet (UV) radiation: a segment of the electromagnetic spectrum covering radiation of wavelengths, ranging from 400 **nm** to 10 **nm**, that lie between those of **visible radiation**, and of **X-radiation**. The ultraviolet is subdivided into the **near ultraviolet** (400–250 **nm**), **far UV** (250–180 **nm**), so-called "**vacuum**" **UV** (180–100 **nm**), and **extreme UV** (100–10 **nm**). A large proportion of UV radiation is **absorbed** by the Earth's **atmosphere**.

uranium: chemical **element** of **atomic number** 92, and symbol U, having three natural **isotopes**: ^{234}U , ^{235}U , and ^{238}U . ^{235}U is the only natural **fissile nuclide**, hence its use for energy generation purposes.

virus: an organism that can only reproduce inside cells (*obligate parasite*), bearing only one single, small **nucleic acid** (**DNA** or **RNA**).

visible radiation: the part of the electromagnetic spectrum that is visible to the human eye, i.e. radiation having wavelengths ranging from 380–400 **nanometers** (violet) to 760–780 **nm** (red), bounded on the one hand by **ultraviolet**, and, on the other, by **infrared**.

watt: unit of power (**W**), corresponding to production of 1 **joule** per second. Main multiples: the **kilowatt** (1 **kW** = 1,000 watts), the **megawatt** (1 **MW** = 1 million watts), the **gigawatt** (1 **GW** = 10^9 watts), the **terawatt** (1 **TW** = 10^{12} watts), and the **petawatt** (1 **PW** = 10^{15} watts).

watt-hour (Wh): unit of work and energy, the product of power multiplied by time. The main multiple is the **kilowatt-hour** (1 **kWh** = 3.6 million **joules**).

X-radiation: electromagnetic radiation having wavelengths ranging from a few fractions of a **nanometer** (0.005 **nm**) to 10 **nm**, and energies ranging from a few **kiloelectronvolts** to several hundred kiloelectronvolts. A distinction is made between **soft X-rays** (for the longer wavelengths), and **hard X-rays** (of shorter wavelengths). Since X-rays are **absorbed** by the Earth's **atmosphere**, X-ray astronomy is carried out in space.

Z: see **atomic number**.