J

jacinth *See* ZIRCON.

Jacob–Monod hypothesis The theory postulated by the French biologists François Jacob (1920–) and Jacques Monod (1910–76) in 1961 to explain the control of *gene expression in bacteria (*see* OPERON). Jacob and Monod investigated the expression of the gene that codes for the enzyme β-galactosidase, which breaks down lactose; the operon that regulates lactose metabolism is called the **lac* operon.

jade A hard semiprecious stone consisting either of jadeite or nephrite. **Jadeite**, the most valued of the two, is a sodium aluminium pyroxene, $NaAlSi_2O_6$. It is prized for its intense translucent green colour but white, green and white, brown, and orange varieties also occur. The only important source of jadeite is in the Mogaung region of upper Burma. **Nephrite** is one of the amphibole group of rock-forming minerals. It occurs in a variety of colours, including green, yellow, white, and black. Important sources include Siberia, Turkistan, New Zealand, Alaska, China, and W USA.

jadeite *See* JADE.

Jahn–Teller effect If a likely structure of a nonlinear molecule or ion would have degenerate orbitals (i.e. two molecular orbitals with the same energy levels) the actual structure of the molecule or ion is distorted so as to split the energy levels ('raise' the degeneracy). The effect is observed in inorganic complexes. For example, the ion $[Cu(H_2O)_6]^{2+}$ is octahedral and the six ligands might be expected to occupy equidistant positions at the corners of a regular octahedron. In fact, the octahedron is distorted, with four ligands in a square and two opposite ligands further away. If the 'original' structure has a centre of symmetry, the distorted structure must also have a centre of symmetry. **Jahn–Tellar splitting** is the splitting of spectral lines as a result of this effect. H. A. Jahn and Edward Teller predicted this effect in 1937 using group theory.

jargoon *See* ZIRCON.

jasper An impure variety of *chalcedony. It is associated with iron ores and as a result contains iron oxide impurities that give the mineral its characteristic red or reddish-brown colour. Jasper is used as a gemstone.

JavaScript A scripting language designed to add features to web pages. JavaScript code is embedded in the HTML code and is run by the web browser. JavaScript is loosely based on the Java programming language and was produced by Netscape and Sun Microsystems. The language has been standardized by ECMA International, and its official name is **ECMAScript**.

SEE WEB LINKS

- Mozilla's documentation for JavaScript

jaw The part of the vertebrate skeleton that provides a support for the mouth and holds the teeth. It consists of two bones, the upper jaw (maxilla) and the lower jaw (mandible). Members of the Agnatha lack jaws.

Jaynes–Cummings model A model used in *quantum optics and atomic physics to describe the interactions between an atom with two energy levels and a quantized mode of an electromagnetic field. This model, which was put forward by the American physicists Edwin Jaynes (1922–98) and Fred Cummings in 1963, has proved to be very useful in establishing which aspects of quantum optics are purely quantum mechanical and which can be dealt with by using quantum mechanics for the two-level atom and classical electrodynamics for the electromagnetic field.

Jeans instability Instability in a cloud of gas in space due to fluctuations in the density of the gas, causing the matter in the cloud to clump together and lead to gravitational collapse. The conditions under which this occurs were worked out by Sir James Hopwood Jeans (1877–1946) in terms of Newtonian gravity. The analogous analysis of this problem using general relativity theory is the basis of the theory of *structure formation.

jejunum The portion of the mammalian

*small intestine that follows the *duodenum and precedes the *ileum. The surface area of the lining of the jejunum is greatly increased by numerous small outgrowths (*see* VILLUS). This facilitates the absorption of digested material, which is the prime function of the jejunum.

jellyfish *See* CNIDARIA.

Jenner, Edward (1749–1823) British physician, who is best known for introducing smallpox vaccination to Britain in 1796 (announced two years later), using a vaccine made from cowpox.

jet A variety of *coal that can be cut and polished and is used for jewellery, ornaments, etc.

jet propulsion (reaction propulsion) The propulsion of a body by means of a force produced by discharging a fluid in the form of a jet. The backward-moving jet of fluid reacts on the body in which it was produced, in accordance with Newton's third law of motion, to create a reactive force that drives the body forward. Jet propulsion occurs in nature, the squid using a form of it to propel itself through water. Although jet-propelled boats and cars have been developed, the main use of jet propulsion is in aircraft and spacecraft. Jet propulsion is the only known method of propulsion in space. In the atmosphere, jet propulsion becomes more efficient at higher altitudes, as efficiency is inversely proportional to the density of the medium through which a body is flying. The three principal means of providing jet propulsion are the turbojet, the ramjet, and the rocket. The **turbojet** is an air-breathing *heat engine based on the *gas turbine, used to power jet aircraft. The **ramjet** is also an air-breathing engine, but compression of the oxidant is achieved by the forward motion of the device through the atmosphere. This enables the compressor and turbine of the gas turbine to be dispensed with and the remaining system consists simply of an inlet diffuser, a combustion chamber in which fuel is burnt, and a jet nozzle through which the products of combustion are discharged. Used in guided missiles, the ramjet must be accelerated to its operating velocity before it can fly (*see also* PULSE JET). These two forms of jet propulsion, being air-breathing engines, can only be used in the earth's atmosphere. The *rocket, however, carries its own oxidant and can thus be used in space. *See also* ION ENGINE.

jet stream A narrow wind current that occurs in the earth's atmosphere above the lower troposphere (*see* EARTH'S ATMOSPHERE). The wind flows towards the east at speeds of between 60 km/h (summer) and 125 km/h (winter).

jeweller's rouge Red powdered haematite, iron(III) oxide, Fe_2O_3. It is a mild abrasive used in metal cleaners and polishes.

j-j coupling A type of *coupling in many-fermion systems, such as electrons in atoms and nucleons in nuclei, in which the energies associated with the spin–orbit interactions are much higher than the energies associated with electrostatic repulsion. *Multiplets of many-electron atoms having a large atomic number are characterized by j-j coupling. Multiplets in the *shell model of nuclei characterized by j-j coupling are invoked to explain the *magic numbers of nuclei. The multiplets of many atoms and nuclei are intermediate between j-j coupling and *Russell–Saunders coupling (**intermediate coupling**).

JMol A commonly used molecular viewing program similar to RasMol. It can be used as an applet in a web page.

SEE WEB LINKS

- Details and a download for JMol from SourceForge

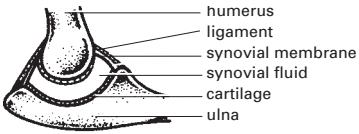
joint The point of contact between two (or more) bones, together with the tissues that surround it. Joints fall into three classes that differ in the degree of freedom of movement they allow: (1) **immovable joints**, e.g. the *sutures between the bones that form the cranium; (2) **slightly movable joints**, e.g. the *symphyses between the vertebrae of the spinal column; and (3) **freely movable** or **synovial joints**, e.g. those that occur between the limb bones. Synovial joints include the **ball-and-socket joints** (between the limbs and the hip and shoulder girdles), which allow movement in all directions; and the **hinge joints** (e.g. at the knee and elbow), which allow movement in one plane only. A synovial joint is bound by ligaments and lined with *synovial membrane.

Joliot-Curie, Irène (1897–1956) French physicist, daughter of Marie and Pierre *Curie, who was educated by her mother and her scientist associates. In 1921 she began work at the Radium Institute, becoming director in 1946. In 1926 she married **Frédéric Joliot** (1900–58). They shared the 1935 Nobel

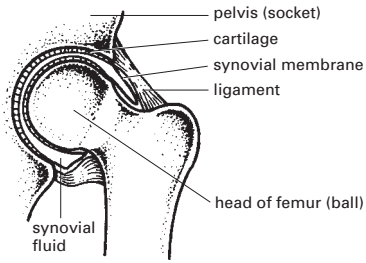
Prize for chemistry for their discovery of artificial radioactivity the previous year.

joliotium *See* TRANSACTINIDE ELEMENTS.

Joly's steam calorimeter An apparatus invented by John Joly (1857–1933) to measure the specific heat capacity of a gas at constant volume. Two equal spherical containers are suspended from the opposite ends of a balance arm. One sphere is evacuated and the other contains the sample gas. The whole apparatus is enclosed in a steam bath, the specific heat capacity of the sample gas being calculated from the difference between the masses of the water that condenses on each sphere.



a hinge joint (the elbow)



a ball-and-socket joint (the hip)

Joint. Types of freely movable joint.

Josephson effects Electrical effects observed when two superconducting materials (at low temperature) are separated by a thin layer of insulating material (typically a layer of oxide less than 10^{-8} m thick). If normal metallic conductors are separated by such a barrier it is possible for a small current to flow between the conductors by the *tunnel effect. If the materials are superconductors (*see* SUPERCONDUCTIVITY), several unusual phenomena occur:
(1) A supercurrent can flow through the barrier; i.e. it has zero resistance.
(2) If this current exceeds a critical value, this conductivity is lost; the barrier then only passes the 'normal' low tunnelling current and a voltage develops across the junction.
(3) If a magnetic field is applied below the critical current value, the current density changes regularly with distance across the junction. The net current through the barrier depends on the magnetic field applied. As the field is increased the net current increases from zero to a maximum, decreases to zero, increases again to a (lower) maximum, decreases, and so on. If the field exceeds a critical value the superconductivity in the barrier vanishes and a potential difference develops across the junction.
(4) If a potential difference is applied across the junction, a high-frequency alternating current flows through the junction. The frequency of this current depends on the size of the potential difference.

A junction of this type is called a **Josephson junction**; two or more junctions joined by superconducting paths form a **Josephson interferometer**. Such junctions can be used in measuring fundamental constants, in defining a voltage standard, and in the highly accurate measurement of magnetic fields. An important potential use is in logic components in high-speed computers. Josephson junctions can switch states very quickly (as low as 6 picoseconds). Moreover they have very low power consumption and can be packed closely without generating too much heat. It is possible that computers based on such devices could operate 50 times faster than the best existing machines. The effects are named after Brian Josephson (1940–), who predicted them theoretically in 1962.

joule Symbol J. The *SI unit of work and energy equal to the work done when the point of application of a force of one newton moves, in the direction of the force, a distance of one metre. 1 joule = 10^7 ergs = 0.2388 calorie. It is named after James Joule.

Joule, James Prescott (1818–89) British physicist. In 1840 he discovered the relationship between electric current, resistance, and the amount of heat produced. In 1849 he gave an account of the *kinetic theory of gases, and a year later announced his best-known finding, the *mechanical equivalent of heat. Later, with William Thomson (Lord *Kelvin), he discovered the *Joule–Thomson effect.

Joule heating The production of heat in a conductor as a result of the passage of an electric current through the conductor. The quantity of heat produced is given by *Joule's law (def. 1).

Joule's laws **1.** The heat (Q) produced when an electric current (I) flows through a resistance (R) for a time (t) is given by $Q = I^2Rt$. **2.** The *internal energy of a given mass of gas is independent of its volume and pressure, being a function of temperature alone. This law applies only to *ideal gases (for which it provides a definition of thermodynamic temperature) as in a real gas intermolecular forces would cause changes in the internal energy should a change of volume occur. *See also* JOULE–THOMSON EFFECT.

Joule–Thomson effect (Joule–Kelvin effect) The change in temperature that occurs when a gas expands through a porous plug into a region of lower pressure. For most real gases the temperature falls under these circumstances as the gas has to do internal work in overcoming the intermolecular forces to enable the expansion to take place. This is a deviation from *Joule's law (def. 2). There is usually also a deviation from *Boyle's law, which can cause either a rise or a fall in temperature since any increase in the product of pressure and volume is a measure of external work done. At a given pressure, there is a particular temperature, called the **inversion temperature** of the gas, at which the rise in temperature from the Boyle's law deviation is balanced by the fall from the Joule's law deviation. There is then no temperature change. Above the inversion temperature the gas is heated by expansion; below it, it is cooled. The effect was discovered by James Joule working in collaboration with William Thomson (later Lord Kelvin).

Jovian Relating to the planet Jupiter.

JUGFET *See* TRANSISTOR.

jugular vein A paired vein in the neck of mammals that returns blood from the head to the heart. It joins the subclavian vein at the base of the neck.

jumping gene *See* TRANSPOSON.

junction detector (solid-state detector) A sensitive detector of *ionizing radiation in which the output is a current pulse proportional to the energy falling in or near the depletion region of a reverse-biased *semiconductor junction. The first types were made by evaporating a thin layer of gold on to a polished wafer of *n*-type germanium; however, gold–silicon devices can be operated at room temperature and these have superseded the germanium type, which have to be operated at the temperature of liquid nitrogen to reduce noise. When the gold–silicon junction is reverse-biased a depletion region, devoid of charge carriers (electrons and holes), forms in the silicon. Incoming ionizing radiation falling in this depletion region creates pairs of electrons and holes, which both have to be collected in order to give an output pulse proportional to the energy of the detected particle.

Junction detectors are used in medicine and biology as well as in space systems.

junction transistor *See* TRANSISTOR.

Jupiter The largest planet in the *solar system and the fifth in order from the sun (778.54×10^6 km distant). Its equatorial diameter is 142 985 km and its *sidereal period is 11.86 years. Jupiter is a *gas giant. Its mass has been calculated as 1.899×10^{27} kg or 318 times that of the earth. Viewed through an optical telescope it appears as an elliptical disc crossed by a number of bands. These are zones and belts of high and low atmospheric pressure respectively in the planet's outermost cloud layers. A peculiar feature of the Jovian disc is the **Great Red Spot**, an anticyclonic vortex, roughly oval in shape and brick-red in colour, that is located in the planet's southern hemisphere. It rotates anticlockwise once every 6 earth days. With a *radio telescope thermal radiation can be detected from the Jovian stratosphere of mainly hydrogen and helium, indicating a temperature between 100 and 130 K close to the outermost layer. Jupiter puts out more heat than it receives from the sun, so it must have an internal heat source. Microwave nonthermal emission can also be detected from the Jovian *Van Allen belts. The planet has at least 63 satellites, the largest of which are known as the *Galilean satellites. A planetary ring system was discovered in 1979 by the US Voyager I probe.

SEE WEB LINKS

- Transcript of 2007 podcast discussion between Fraser Cain and Dr Pamela Gay, astronomer, writer, and teacher

Jurassic The second geological period of the Mesozoic era. It followed the Triassic, which ended about 200 million years ago, and extended until the beginning of the Cre-

taceous period, about 145 million years ago. It was named in 1829 by A. Brongniart after the Jura Mountains on the borders of France and Switzerland. Jurassic rocks include clays and limestones in which fossil flora and fauna are abundant. Plants included ferns, cycads, ginkgos, rushes, and conifers. Important invertebrates included *ammonites (on which the Jurassic is zoned), corals, brachiopods, bivalves, and echinoids. Reptiles dominated the vertebrates; the first flying reptiles – the pterosaurs – and the first primitive bird, *Archaeopteryx,* appeared.

juvenile hormone A hormone secreted by insects from a pair of endocrine glands (**corpora allata**) close to the brain. It inhibits metamorphosis and maintains the presence of larval features.