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and thus be human life enriched."

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and archaeologist Giambattista Piranesi used etching to serve his fantasy in his series "Carceri" (*c.* 1745), a group of interior views of foreboding imaginary prisons. More horrific was the series "Los desastres de la guerra" (1810–14), by the Spanish artist Francisco de Goya. Unlike most of his other prints, Goya's "Desastres" were done mainly in etching with little aquatint.

During the late 18th and early 19th centuries, soft-ground etching, or *vernis mou,* became current. This technique involves drawing with a pencil on a sheet of paper placed on a copperplate coated with an extremely soft, sticky ground. The ground adheres to the paper wherever the pencil passes, leaving the metal exposed in broad, soft lines. The plate is exposed to acid and, when printed, yields results similar to pencil or chalk drawings. It was primarily a reproductive technique but was used by the 18th-century English artists Thomas Gainsborough, John Sell Cotman, and Thomas Girtin for original designs, mainly landscapes.

Etching continued to be used by most artists throughout the 19th century, and in the 20th century the technique was adopted with new enthusiasm by several prominent artists. Primary among them is Pablo Picasso, who first made etching a vehicle for his Cubist ideas and subsequently exploited the technique's purity of line in his "classical" period. Henri Matisse, Marc Chagall, Georges Rouault, Joan Miró, and Stanley Hayter also did much important work in this medium.

etesian wind, remarkably steady southbound drift of the lower atmosphere over the eastern Mediterranean and adjacent lands in summer. From about mid-May to mid-September, it generally dominates the Adriatic, Ionian, and Aegean seas and the adjacent countries.

The name (from Greek *etos,* "year") is suggestive of the wind's regular recurrence. The wind is of such significance to human activities that the ancient Greeks announced its expected beginning in the marketplaces. An extreme example of its constancy is at Cairo, where July winds blow from the northwest, north, or northeast 98 percent of the time.

The etesian wind, which reaches maximum intensity in the early afternoon and may cease during the night, is part of the general inflow of air toward an intense low-pressure area usually centred over northwestern India in summer. The wind is not of the class generally termed monsoon winds because it is practically rainless, is not accompanied by high relative humidity, and is not replaced in winter by a drift from the opposite direction.

Similar wind regimes and climates, called etesian climates and characterized by dry summers and rainy winters, are present in California, Chile, South Africa, and southwestern Australia.

ethanal (chemistry): *see* acetaldehyde.

ethane, a colourless, odourless, gaseous hydrocarbon (compound of hydrogen and carbon), belonging to the paraffin series; its chemical formula is C_2H_6. Ethane is structurally the simplest hydrocarbon that contains a single carbon–carbon bond. The second most important constituent of natural gas, it also occurs dissolved in petroleum oils and as a by-product of oil refinery operations and of the carbonization of coal.

The industrial importance of ethane is based upon the ease with which it may be converted to ethylene (C_2H_4) and hydrogen by pyrolysis, or cracking, when passed through hot tubes. Like propane and, to a lesser extent, butane, ethane is a major raw material for the huge ethylene petrochemical industry, which produces such important products as polyethylene plastic, ethylene glycol, and ethyl alcohol. More than 90 percent of the ethane produced in the 1960s was burned as fuel without separation from natural gas. Ethane gas can be liquefied under pressure or at reduced temperatures and thus be separated from natural gas. Unlike propane, liquid ethane is not in common use as an industrial or domestic fuel.

ethanol: *see* ethyl alcohol.

ethanolamine, the first of three organic compounds that can be derived from ammonia by successively replacing the hydrogen atoms with hydroxyethyl radicals ($-CH_2CH_2OH$), the others being diethanolamine and triethanolamine. The three are widely used in industry, principally as absorbents for acidic components (*e.g.,* carbon dioxide) of natural gas and of petroleum-refinery gas streams. As salts (soaps) with fatty acids, they are used as emulsifiers in numerous household and industrial products. Triethanolamine is a corrosion inhibitor for automobile antifreeze solutions and airplane-engine coolants. The ethanolamines are commercially prepared by the reaction of ammonia and ethylene oxide.

Ethelbald (personal name): *see under* Aethelbald.

Ethelbert (personal name): *see under* Aethelberht.

Ethelfleda (queen of Mercia): *see* Aethelflaed.

Ethelfrith (Anglo-Saxon king): *see* Aethelfrith.

Etheling (Old English title): *see* Aetheling.

Ethelred (personal name): *see under* Aethelred, except as below.

Ethelred II, also spelled AETHELRED, byname ETHELRED THE UNREADY, or AETHELRED UNRAED (b. 968?—d. April 23, 1016, London), king of the English from 978 to 1013 and from 1014 to 1016. He was an ineffectual ruler who failed to prevent the Danes from overrunning England. The epithet "unready" is derived from *unraed,* meaning "evil counsel."

Ethelred II, coin, 10th century; in the British Museum
Peter Clayton

The son of King Edgar (ruled 959–975), Ethelred ascended the throne upon the assassination of his half brother King Edward the Martyr in March 978. Widespread suspicion that Ethelred may have had a part in the murder created much of the distrust and disloyalty that undermined his authority. Hence, there was no unified defense when the Danish invasions resumed in 980.

Nearly all of the country was ravaged, and Ethelred's efforts to buy peace only made the invaders more rapacious. When they did begin to settle down in towns, Ethelred provoked further invasions by launching a massacre of Danish settlers (Nov. 13, 1002). By the end of 1013 the Danish king Sweyn I had been accepted as king in England, and Ethelred had fled to Normandy.

After Sweyn died in February 1014, Ethelred's council of advisers invited him to return to the throne on condition that he agree to satisfy their grievances. At the time of Ethelred's death in 1016, Sweyn's son Canute was ravaging England. Ethelred was succeeded by his son Edmund II Ironside (ruled 1016); one of his other sons ruled England as Edward the Confessor from 1042 to 1066.

Ethelred OF RIEVAULX, SAINT: *see* Aelred of Rievaulx, Saint.

Ethelstan: *see* Athelstan; Guthrum.

Ethelwerd (English chronicler): *see* Aethelweard.

Ethelwulf (Anglo-Saxon king): *see* Aethelwulf.

ether, also spelled AETHER, also called LUMINIFEROUS ETHER, in physics, a theoretical, universal substance believed during the 19th century to act as the medium for transmission of electromagnetic waves (*e.g.,* light and X-rays) much as sound waves are transmitted by elastic media such as air. The ether was assumed to be weightless, transparent, frictionless, undetectable chemically or physically, and literally permeating all matter and space. The theory met with increasing difficulties as the nature of light and the structure of matter became better understood; it was seriously weakened (1881) by the Michelson-Morley experiment (*q.v.*), which was designed specifically to detect the motion of the Earth through the ether and which showed that there was no such effect.

With the formulation of the special theory of relativity by Einstein in 1905 and its acceptance by scientists generally, the ether hypothesis was abandoned as being unnecessary in terms of Einstein's assumption that the speed of light, or any electromagnetic wave, is a universal constant.

ether, any of a class of organic compounds characterized by an oxygen atom attached to two carbon atoms that are part of a hydrocarbon. Ethers are similar to alcohols but are generally less dense, less soluble in water, and have lower boiling points. They are relatively inert.

A brief treatment of ethers follows. For full treatment, *see* MACROPAEDIA: Chemical Compounds.

At room temperature, ethers are pleasant smelling, colourless liquids. In nature, ethers are found as part of substances such as sugar, starch, and cellulose. Ethers may be manufactured by dehydrating alcohols, but catalytic hydration (addition of water) of olefins (forms of hydrocarbons) is the major method of production.

While often regarded as derivatives of alcohol, ethers exhibit properties that are more likely to resemble those of their parent hydrocarbons. They form salts called oxonium compounds when they are reacted with strong inorganic acids and Lewis acids (compounds capable of accepting electron pairs). When strong acids break one of the carbon–oxygen linkages, alcohols are formed. Other organic derivatives are produced if both linkages are broken. Heat decomposes ethers into olefins. In the presence of oxygen, ethers slowly oxidize to unstable peroxides; this reaction can result in an explosion.

Ethers will form azeotropes (constant-distillation mixtures) with a large number of organic compounds. As a result, they are used extensively for extraction and separation of organic chemicals. Ethers are also employed as solvents for fats, oils, waxes, perfumes, resins, dyes, gums, and hydrocarbons. Vapours of certain ethers are used as insecticides, miticides, and fumigants for soil. Ethers are also very important in medicine and pharmacology, especially for use as anesthetics. Codeine,

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Michelsen began his career as a lawyer; later he started his own shipping firm, which became one of the largest in Norway. A member of the Storting (parliament) from 1891, he adhered at first to the "Pure" Left Party but later broke with it and in 1903 was returned to the Storting as a member of the Coalition Party (conservatives and moderate liberals). In February 1905 he abandoned the coalition ministry of G.F. Hagerup in protest against Hagerup's extremely moderate policy in the growing conflict with Sweden. On March 11 Michelsen was appointed prime minister in a new coalition; thenceforth he was the unquestioned leader of the Norwegians in the conflict that led to the dissolution of the union with Sweden and the establishment of the new Kingdom of Norway under King Haakon VII. Michelsen remained in office until Oct. 28, 1907, when he retired because of illness. In 1909 he helped organize the moderately conservative Liberal Left Party, although he refused to be its leader; after 1910 he retired from political life.

Michelson, A(lbert) A(braham) (b. Dec. 19, 1852, Strelno, Prussia—d. May 9, 1931, Pasadena, Calif., U.S.), German-born U.S. physicist who established the speed of light as a fundamental constant and pursued other spectroscopic and meteorological investigations. He received the 1907 Nobel Prize for Physics.

Michelson
By courtesy of the University of Chicago

Michelson came to the United States with his parents when he was two years old. From New York, the family made its way to Virginia City, Nev., and San Francisco, where the elder Michelson prospered as a merchant.

At 17, Michelson entered the United States Naval Academy at Annapolis, Md., where he did well in science but was rather below average in seamanship. He was graduated in 1873, then served as science instructor at the academy from 1875 until 1879. In 1878 Michelson began work on what was to be the passion of his life, the accurate measurement of the speed of light. He was able to get useful values with homemade apparatus. Feeling the need to study optics before he could be qualified to make real progress, he travelled to Europe in 1880 and spent two years in Berlin, Heidelberg, and Paris, resigning from the navy in 1881. Upon his return to the United States, he determined the velocity of light to be 299,853 kilometres (186,329 miles) per second, a value that remained the best for a generation. When it was bettered, Michelson bettered it.

While in Europe, Michelson began constructing an interferometer, a device designed to split a beam of light in two, send the parts along perpendicular paths, then bring them back together. If the light waves had, in the interim, fallen out of step, interfererence fringes of alternating light and dark bands would be obtained. From the width and number of those fringes, unprecedently delicate measurements could be made, comparing the velocity of light rays travelling at right angles to each other.

It was Michelson's intention to use the interferometer to measure the Earth's velocity against the "ether" that was then thought to make up the basic substratum of the universe. If the Earth were travelling through the light-conducting ether, then the speed of the light travelling in the same direction would be expected to be equal to the velocity of light plus the velocity of the Earth, whereas the speed of light travelling at right angles to the Earth's path would be expected to travel only at the velocity of light. His earliest experiments in Berlin showed no interference fringes, however, which seemed to signify that there was no difference in the speed of the light rays, and, therefore, no Earth motion relative to the ether.

In 1883 he accepted a position as professor of physics at the Case School of Applied Science in Cleveland and there concentrated his efforts on improving the delicacy of his interferometer experiment. By 1887, with the help of his colleague, American chemist Edward Williams Morley, he was ready to announce the results of what has since come to be called the Michelson-Morley experiment. Those results were still negative; there were no interference fringes and apparently no motion of the Earth relative to the ether.

It was perhaps the most significant negative experiment in the history of science. In terms of classical Newtonian physics, the results were paradoxical. Evidently, the speed of light plus any other added velocity was still equal only to the speed of light. To explain the result of the Michelson-Morley experiment, physics had to be recast on a new and more refined foundation, something that resulted, eventually, in Albert Einstein's formulation of the theory of relativity in 1905.

In 1892 Michelson, after serving as professor of physics at Clark University at Worcester, Mass., from 1889, was appointed professor and the first head of the department of physics at the newly organized University of Chicago, a position he held until his retirement in 1929. From 1923 to 1927 he served as president of the National Academy of Sciences. In 1907 he became the first American ever to receive a Nobel Prize in the sciences, for his spectroscopic and meteorological investigations, the first of many honours he was to receive.

Michelson advocated using some particular wavelength of light as a standard of distance (a suggestion generally accepted in 1960) and, in 1893, measured the standard metre in terms of the red light emitted by heated cadmium. His interferometer made it possible for him to determine the width of heavenly objects by matching the light rays from the two sides and noting the interference fringes that resulted. In 1920, using a 6-metre (20-foot) interferometer attached to a 254-centimetre (100-inch) telescope, he succeeded in measuring the diameter of the star Betelgeuse (Alpha Orionis) as 386,160,000 km (300 times the diameter of the Sun). This was the first substantially accurate determination of the size of a star.

In 1923 Michelson returned to the problem of the accurate measurement of the velocity of light. In the California mountains he surveyed a 35-km pathway between two mountain peaks, determining the distance to an accuracy of less than 2.5 cm. He made use of a special eight-sided revolving mirror and obtained a value of 299,798 km/sec for the velocity of light. To refine matters further, he made use of a long, evacuated tube through which a light beam was reflected back and forth until it had travelled 16 km through a vacuum. Michelson died before the results of his final tests could be evaluated, but in 1933 the final figure was announced as 299,774 km/sec, a value less than 2 km/sec higher than the value accepted in the 1970s. (I.A.)

BIBLIOGRAPHY. Full-length studies of Michelson include Bernard Jaffe, *Michelson and the Speed of Light* (1960); and Dorothy Michelson Livingston, *The Master of Light* (1973), a well-written biography by Michelson's daughter that contains interesting anecdotal detail.

Michelson–Morley experiment, an attempt to detect the velocity of the Earth with respect to the hypothetical luminiferous ether, a medium in space proposed to carry light waves. First carried out in 1881 by physicists A.A. Michelson and E.W. Morley in the United States, the test was later refined by them and by many others.

The procedure depended on a Michelson interferometer, a sensitive optical device that compares the optical path lengths for light moving in two mutually perpendicular directions. It was reasoned that, if the speed of light were constant with respect to the proposed ether through which the Earth was moving, that motion could be detected by comparing the speed of light in the direction of the Earth's motion and the speed of light at right angles to the Earth's motion. No difference was found. This null result seriously discredited the ether theories and ultimately led to the proposal by Albert Einstein in 1905 that the speed of light is a universal constant.

Michener, James A(lbert) (b. Feb. 3, 1907?), U.S. novelist and short-story writer who, perhaps more than any other single author, made foreign environments accessible to Americans through fiction. Best known for his novels, he wrote epic and detailed works classified as fictional documentaries.

Michener was a foundling discovered in Doylestown, Pa. He was adopted by Mabel Michener and raised as a Quaker. In his teens he ran away from home and eventually became a teacher and editor. He served as a naval historian in the South Pacific from 1944 to 1946, and his early fiction is based on this area. He won a Pulitzer Prize in 1948 for the collection *Tales of the South Pacific* (1947), which presented the world of the South Pacific as exotic and foreign yet still part of the brotherhood of man.

Michener's novels were typically massive in scope, and he researched them extensively. A Michener novel such as *Hawaii* (1959) traditionally opens with the earliest history of an area—the geology, flora, and fauna—and ultimately encompasses the people who settle and rule there. He might spend years preparing a book, as he did in Spain for *Iberia: Spanish Travels and Reflections* (1968). Michener wrote with journalistic skill, aiming to instruct. Although he was criticized for the abundance of detail and facts in his fiction, his books were extremely popular, offering the reader a carefully and elaborately created world. In his later years, Michener turned his interest to American landscapes, in *Centennial* (1974) and *Chesapeake* (1978). *The Covenant* (1980) concerned South Africa and the background of apartheid. Another massive opus was *Space* (1982) in which he tried, with mixed results, to fictionally chronicle the U.S. space program.

Michiel, Vitale II (d. 1172, Venice), doge of Venice who ruled during an important crisis in the Venetian Republic's relations with the Byzantine Empire and whose assassination led to a significant revision of the Venetian constitution.

Elected at the beginning of the Guelf-Ghibelline (papal–imperial) struggle, Vitale II maintained strict neutrality in spite of Venice's Guelf leanings. He relaxed this policy in 1160 during the siege of Milan by the emperor Frederick I Barbarossa, when he sent supplies to the Milanese.

Vitale's actions were an indication of the growing independence of Venice, which was nominally subject to the Byzantine Empire. In 1166 the Byzantine emperor Manuel I Com-