Merit Students Encyclopedia

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MERIT STUDENTS ENCYCLOPEDIA

WILLIAM D. HALSEY EDITORIAL DIRECTOR LOUIS SHORES SENIOR LIBRARY ADVISOR

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ALPHABETICAL ARRANGEMENT OF ENTRIES

The entries in the *Merit Students Encyclopedia* are arranged in a simple alphabetical order. The method of arrangement combines elements of the system used in most dictionaries with that used in telephone directories. Each entry begins with a heading in dark type. Some of these headings contain a comma; others do not. The basic principles of arrangement are listed below, including rules for placement of identical headings.

The alphabetical sequence is letter by letter.

air
air conditioning
aircraft
aircraft carrier
aircraft landing system
airedale terrier
airfoil

When headings contain words out of their usual order, a comma is used to indicate the change of order, as in

> Alaska, University of Alba, Duke of Alger, Horatio

Such entry headings are arranged in alphabetical sequence only up to the comma.

Bryansk Bryant, William Cullen Bryant College

When words preceding a comma are the same in two or more consecutive entries, the order is determined by the arrangement of the letters following the comma.

> Brooks, Phillips Brooks, Van Wyck

When two or more entries have the same heading, the entries are placed in the following order: persons, places, things.

Hannibal	Hercules	Phoenix
(person)	(person)	(place)
Hannibal	Hercules	phoenix
(place)	(constellation)	(bird)

Rulers with identical names are listed alphabetically by the name of the territory ruled. Rulers with the same name and same realm are listed according to dates of reign.

Frederick IX (of Denmark)
Frederick I (of Holy Roman Empire)
Frederick II (of Holy Roman Empire)
Frederick II (of Prussia)

Popes are listed by dates of reign, and they precede rulers of the same name.

Paul VI (Pope)
Paul I (Emperor of Russia)

Other persons with identical names are listed according to date of birth.

Butler, Samuel (born 1612) Butler, Samuel (born 1835)

Places with identical names are listed according to the importance of the political unit, in descending order.

New Brunswick (Canadian province)
New Brunswick (U.S. city)

When places of the same political unit have identical names, they are arranged alphabetically by location. Cities in the United States and Canada are always located in reference to states or provinces. Cities elsewhere are usually located in reference to countries.

Abilene (Kansas) Abydos (Egypt)
Abilene (Texas) Abydos (Turkey)

Things with identical names are arranged alphabetically according to the subject in which they are classified.

aberration, in astronomy aberration, in optics

hairlike roots at intervals. Large tree ferns have thick stems that grow upright. These stems terminate in a thick growth of leaves that is called a crown.

Leaves. In most ferns the leaves are the only part of the plant that can be seen above the ground. The leaves, commonly called fronds, vary considerably in size and shape. Some ferns have large leaves, which measure more than 18 feet long and 3 feet wide. Other ferns have short grasslike leaves that are coiled like corkscrews, and still others have long forked leaves that are armed with sharp spikes.

In most ferns each leaf consists of a stalk and a blade. The blade is usually composed of several leaflets, which arise from the central stalk. Sometimes the leaflets are composed of even smaller leaflets. When newly formed, the leaves are coiled up at the tip and are commonly called fiddleheads. As the leaves mature, they gradually unroll.

Like the leaves of other plants, the leaves of ferns manufacture food. Usually they also bear reproductive bodies. Some ferns are evergreen, while in others the leaves die each year.

Reproduction and Life Cycle

There are two generations, or phases, in the life cycle of a fern. In one generation, called the sporophyte, the fern reproduces asexually by the production of spores. The spores develop into the other generation, called the gametophyte. The gametophyte reproduces sexually by forming male and female sex cells, which unite and give rise to a sporophyte generation. This kind of life cycle is called alternation of generations.

Sporophyte. The familiar fern plant with a stem, roots, and large feathery leaves is the sporophyte, the generation that reproduces asexually. The spores are formed in sporangia, or spore cases, which look like small black or brown growths on the underside of the leaf. When the sporangia open, the spores fall to the ground. Each spore may then give rise to a small mosslike plant, called the prothallus.

Gametophyte. A prothallus is a thin flat heart-shaped plant, which is usually less than half an inch in diameter. It has no stem, roots, or leaves, but it sends tiny hairlike cells into the ground for anchorage and ab-

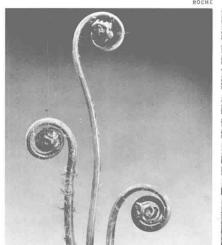


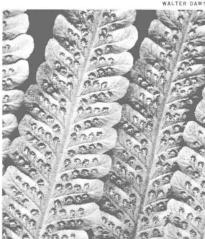
Tree ferns grow in tropical rain forests. Various kinds are used for construction materials. The cores of others provide food.

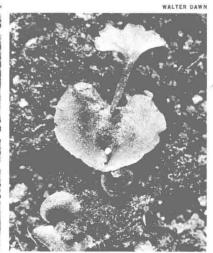
sorption of water. Usually the prothallus has both male and female sex organs, which are located on the underside of the plant. The sex organs form the gametes, or sex cells.

Since sperm cells need water for locomotion, fertilization usually takes place after a rainfall or heavy dew, when there is a film of water on the ground. After being released from the male sex organ, the sperm swim through the water and enter the female sex organ, which contains an egg cell. The contents

Fiddleheads (left) are newly formed fern leaves. As they mature, they unroll and spread out. Mature leaves (center) have spore cases on their undersides. When the cases open, the spores fall to the ground and each spore gives rise to a heart-shaped prothallus (right).







of one sperm fuse with the contents of an egg cell and form a zygote, a single cell that grows on the prothallus. By repeated cell division the zygote eventually develops into a sporophyte, and the prothallus shrivels and dies. The sporophyte continues to grow, and in a few years it is ready to produce spores, continuing the life cycle.

Vegetative Propagation. In addition to reproducing by means of spores and gametes, ferns can reproduce by vegetative propagation. The sporophyte rhizome grows horizontally underground, giving rise to new plants at the nodes. In other cases the leaves of the fern bend to the ground, where the tips take root, forming new plants.

Ferns make up a division of the plant kingdom known as Filicophyta. The division is sometimes called Pterophyta.

*Reed C. Rollins

Fernando Po. See under EQUATORIAL GUINEA.

Ferndale (fern'dāl), a city in southeastern Michigan; in Oakland County; 13 miles (21 km) west of Lake St. Clair; just north of Detroit. Pop. (1970) 30,850.

Ferndale is a residential and industrial city within the Detroit metropolitan area. Products manufactured in Ferndale include synthetic resins, iron and steel goods, automobile polish, paint, and shellac. Ferndale was incorporated as a village in 1919 and as a city in 1927. It has the mayor and council form of municipal government.

*Lewis G. Vander Velde

Ferrer, José (fərer', hō sā'), American actor and director. Born Santurce, Puerto Rico, Jan. 8, 1912.

Ferrer's versatility as an actor was demonstrated in such diverse roles as the villainous Iago in Othello, the romantic adventurer of Cyrano de Bergerac, and the tormented hero of The Shrike. He won an Academy Award in 1950 for his motion picture portrayal of Cyrano. His other films include Moulin Rouge (1952), The Caine Mutiny (1954), Ship of Fools (1965), and Enter Laughing (1966). Ferrer also directed many of the plays in which he performed. He also directed productions of The Fourposter, My Three Angels, and The Andersonville Trial.

*Richard Griffith

ferret (fer'it), any of various polecats, or weasel-like mammals, native to Europe, Asia, and North America. Specifically the name refers to a domesticated variety of ferret (Mustela putorius furo), which was developed from the European polecat and which has been used for centuries to flush rats and rabbits from burrows so that hunters or dogs can kill them. Even without training, ferrets are good hunters and attack viciously. They are very quick and usually kill their prey by biting at the base of the skull.

The domesticated ferret reaches a length of about 22 inches (55 cm) including its 6-inch (15-cm)-long tail. It has a slender body, a relatively long muscular neck, and short legs. Although the animals sometimes have dark hair and eyes like polecats, most are yellowish white with pink eyes and a pink nose.

A rare wild ferret, the black-footed ferret (*M. ni-gripes*), is native to the Great Plains and the Rocky Mountains. It grows to a length of about 2 feet (60 cm), and it has yellow-brown hair and black feet.

Ferrets are classified in the order Carnivora, family Mustelidae, genus Mustela. *George G. Goodwin

Ferris State College, Big Rapids, Mich., an accredited, coeducational, state college offering undergraduate courses of study in the arts and sciences, business, education, and pharmacy. The college also offers a wide variety of trade, technical, and vocational programs. It was founded in 1884 as Big Rapids Industrial School, and it adopted its present name in 1963. See also Schools, Colleges, and Universities.

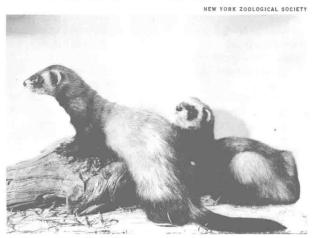
*Victor F. Spathelf



NEW YORK CITY DEPARTMENT OF MARINE AND AVIATION Ferries that carry vehicles have open ends for quick loading.

ferry (fer'i), also called ferryboat, a boat used to transport people, vehicles, and goods across narrow bodies of water. Ferries are used where other means of crossing, such as bridges or tunnels, are not available. The place at which the crossing is made is also known as a ferry. Ferryboats that transport passengers and passenger vehicles are usually operated on a time schedule over a designated route between ferrying points and at a toll, or legally established cost.

Domesticated ferrets are often trained to hunt.



4 Fertile Crescent

Most ferryboats have propellers at both ends, and they are constructed in such a way that entering and leaving can take place at either end. The design makes it possible for the boat to enter a dock in either direction and eliminates the need for it to turn around.

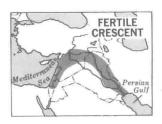
Noted passenger ferries are operated in Scandinavia, on the River Mersey in England, and in the harbor of New York City. Some ferries are designed to transport trains. A notable passenger-train ferry runs across the English Channel between Dover, England, and Dunkirk, France. It established through service between London and Paris in 1936.

The first regular ferry route in the United States was established in Boston in 1630. The first steamboat ferry was built in 1811 by the American inventor John Stevens.

William K. Fallon

Fertile Crescent (fer'təl kres'ənt), a historic region of southwestern Asia, extending in an arc from the eastern coast of the Mediterranean Sea across Syria and Iraq to the northern coast of the Persian Gulf.

Most of the region has a semiarid climate and is sparsely covered by grasses. In the spring, after the light rains of winter, the grasslands appear more fertile than the lands nearby. Throughout the centuries the Fertile Crescent has been fought over by



the nomadic people of the grasslands and the people of the neighboring highlands. The crescent has also served as a highway between the Persian Gulf and the lands of the eastern Mediterranean.

The Fertile Crescent was the site of one of the world's earliest civilizations, the Sumerian civilization, which existed in the valley of the Tigris and Euphrates rivers. The ancient Hebrew and Phoenician civilizations also flourished in the crescent, near the coast of the Mediterranean Sea. In modern times several unsuccessful proposals have been made for a Fertile Crescent Union, which would include Lebanon, Syria, Iraq, and Jordan.

The Fertile Crescent was named and defined by the American historian James Henry Breasted (1865–1935).

*Rhoads Murphey

fertilization (fer'tə lə zā'shən), the process in which a sperm, or male sex cell, fuses with an egg, or female sex cell. The fusion results in a zygote, a single cell that divides repeatedly and eventually develops into a new organism. Fertilization occurs in all animals and plants that reproduce sexually.

In mammals, birds, reptiles, and insects, fertilization occurs inside the body of the female. In many lower armals, however, fertilization takes place externally. Most fish and amphibians, for example, release sperm and egg cells into the water, where the unlike sex cells unite in pairs. The possibility of a sperm's contacting an egg is largely due to chance. However, male animals release millions of sperm at the same time, and the possibility of fertilization is thus greatly increased.

Once a sperm reaches an egg, a chemical reaction seems to occur between the surface of the egg and the surface of the sperm. It appears to bind the two cells together while the sperm penetrates into the egg cell. In most animals the penetration of a single sperm causes changes in the egg cell that probably prevent other sperm from entering. After complex changes in the egg, in the sperm, or in both sex cells, the nucleus of the sperm fuses with the nucleus of the egg. When the two nuclei have fused, the egg is fertilized and is known as a zygote. Since the zygote has been formed by the union of a cell from the mother and a cell from the father, it will develop into an individual with the characteristics of both parents.

When plants reproduce sexually, a new generation is produced only after the egg cells have been fertilized by the sperin cells. In flowering plants, for example, fertilization occurs within the ovary of the flower, where one or more egg cells unite with the sperm, which are produced in pollen. Each fertilized egg, or zygote, develops into the embryo of a seed and later grows into a new plant.

Lorus and Margery Milne

fertilizer, a substance added to the soil for its nutrient content to promote the growth and yield of plants. To thrive, all plants need certain nutritional elements. A fertilizer is a natural or manufactured substance that contains one or more of these elements.

While plants are growing, they remove large quantities of nutritional elements from the soil. For example, a ton of wheat removes and uses about 50 pounds (23 kg) of nitrogen during a season's growth. Unless such nutrients are replaced by means of legumes, manure, or fertilizer, crops planted in following years suffer from nutrient deficiencies and give low yields. Soil may also lose nutritional elements through leaching and erosion. Leaching is the washing away of elements by water that seeps through the soil. Erosion is the surface runoff of soil in water.

The elements essential to plant growth are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, boron, copper, molybdenum, zinc, and chlorine. A few kinds of plants also need small amounts of vanadium, cobalt, and sodium. Three of the essential elements, carbon, hydrogen, and oxygen, are readily obtained by plants from air and water. All the other elements must be obtained from the soil or from fertilizers. The fertilizers may be applied to the soil, where they dissolve in water and are absorbed by the plant. Occasionally they are sprayed directly on the plant.

The nutrient elements that are most frequently deficient are nitrogen, phosphorus, and potassium. Since these three elements, along with calcium, magnesium, and sulfur, are needed in fairly large amounts, they are called macronutrients. The other elements, which are required by plants in relatively small amounts, are called micronutrients, or trace elements.

To determine which elements are lacking and in what quantities they are needed, farmers send samples of soil to state and private soil testing laboratories. After testing the soil samples, experts recommend the kinds and amounts of fertilizer needed. An important consideration is the kind of crop to be grown, because different crops require different fertilizers. Based on soil test results, farmers can match soil nutrient levels and the specific rates of fertilizer applications to the needs of individual crops. The most favorable fertilizer rates range from as little as 200 pounds (90 kg) to as much as one ton per acre.

ELEMENTS NEEDED BY PLANTS

ELEMENT	USE	SIGNS OF DEFICIENCY
Nitrogen	A primary constituent of protein	Plant growth is retarded, fruit is small, and leaves may turn yellow.
Phosphorus	A component of proteins. Also necessary for many biochemical processes.	Root growth is stunted, and plants grow slowly.
Potassium	Important in many biochemical activities. Also believed essential for photosynthesis.	Plant growth is retarded, stems become weak, and leaves are often discolored.
Iron	Necessary for photosynthesis.	Plants become pale greenish yellow, and growth is stunted.
Manganese	Necessary for photosynthesis.	Gray to yellow specks and streaks on leaves.
Magnesium	A constituent of chlorophyll.	Leaves become pale greenish yellow and have dark-green veins.
Sulfur	Important in respiration. Also a component of many plant proteins.	Plant growth is retarded. Stems are long and slender.
Calcium	A constituent of plant cell walls.	Roots are stunted, and stems are weak.
Copper	A constituent of certain enzymes.	Onions do not develop golden brown color.
Zinc	A component of several enzymes and growth hormones.	Corn seedlings turn white.
Molybdenum	Important in many biochemical activities.	Cauliflower leaves are mostly stems, and heads do not develop.
Boron	Probably necessary for synthesis of proteins.	Tuber and root crops develop large brown to black spots.
Chlorine	Use not determined.	

Kinds of Fertilizers

Fertilizers are from either natural or commercial sources. Natural fertilizers are plant or animal products, such as compost or manure. Commercial fertilizers are prepared, or man-made, compounds.

Natural Fertilizers. The most abundant natural fertilizer is manure. It consists of the waste products of cattle, sheep, horses, and other animals, and it is a natural by-product on many farms. Manure contains relatively large amounts of nitrogen and potassium, but its phosphorus content is low. For this reason, manure is usually applied in combination with other fertilizers that are rich in phosphorus content.

Another widely used natural fertilizer is green manure, which consists of living green plants that are plowed into the soil. As the plants decay, they add to the soil the nutritional elements they contain.

Compost, another natural fertilizer, consists of plant material that has rotted in a compost heap. Sometimes layers of plant material are alternated with layers of soil or sod, and sometimes small amounts of fertilizer are added to speed up the rate of rotting. Like manure, compost is a rich source of nitrogen.

Other natural fertilizers include dried fish scraps and dried blood from slaughterhouses. In recent times, increasing attention is turning to using municipal wastes for their nutrient content. Such recycling of nutrients may become more widespread as the beneficial uses of wastes receive preference over wasteful disposal methods.

Certain bacteria, called nitrogen fixing-bacteria, live in nodules on the roots of legumes, or pod-bearing plants. These bacteria convert the nitrogen of air trapped in the soil into a form that can be used by plants. Many farmers add nitrogen to the soil by planting a crop of legumes every two or three years in a field where corn, wheat, or other crops are usually grown. This method of alternately planting a crop of

legumes with other kinds of plants is called crop rotation. To improve "nitrogen fixation" by legumes, farmers often inoculate the seeds of legumes with nitrogenfixing bacteria before planting.

Commercial Fertilizers. Commercially prepared fertilizers are made in the form of solids and fluids, which may be clear liquids, suspensions, or compressed gas. They are usually applied by special equipment that is attached to tractors or trucks. Fertilizer distributors are also attached to grain drills, which are used to plant wheat and other small grains. The drill sows a small amount of fertilizer along the row as the seeds are planted. Gaseous fertilizers are applied by machines that place them 4 to 6 inches (10 to 15 cm) deep in the soil.

Nitrogen Compounds. The starting point in nitrogen fertilizers is the making of ammonia. The ammonia may be applied as such or used in making such products as ammonium nitrate, urea, and ammonium phosphate. For each of these products, making ammonia must come first. In the United States, about 95 percent of this ammonia comes from natural gas.

Nitrogen products can be applied as a compressed gas (ammonia), liquid, or solid. About half of the total nutrient quantity of fertilizers in the United States consists of nitrogen in various forms.

Phosphorus Compounds. The chief phosphate fertilizer is superphosphate. It is made by treating phosphate rock with sulfuric acid, which yields normal superphosphate, or with phosphoric acid, which yields concentrated superphosphate.

Ammonium phosphates are becoming increasingly important as a source of fertilizer phosphate. They are made from phosphoric acid and ammonia.

A major phosphate fertilizer in Europe, but only of minor importance in the United States, is basic slag. This by-product of the steel industry is made by treating phosphorus, a component of all steel ore, with lime. Potassium Compounds. Potassium chloride, called muriate of potash, is the principal potash fertilizer. It is obtained by underground mining of potash-bearing minerals. The world's largest known deposit of this mineral is in Saskatchewan, Canada. The Soviet Union and Europe also have large deposits.

Another form of potash fertilizer is potassium sulfate. This form is obtained from underground mines and also from lake brines, such as found at Searles Lake, California, and Salt Lake, Utah.

Mixed Fertilizers. Although many commercially prepared fertilizers consist of only one essential element, most of them are mixtures of nitrogen, phosphorus, and potassium. Such fertilizers, called mixed or complete fertilizers, are referred to by the percentage of the three elements that they contain. For example, a mixed fertilizer that is labeled "6-24-12" contains 6 percent of nitrogen (N); 24 percent of phosphorus, expressed as phosphate (P₂O₅); and 12 percent of potassium, expressed as potash (K₂O). Usually small amounts of other elements are also included.

Fertilizers and Food Shortages

Currently the use of about 80 million tons of nitrogen, phosphate, and potash accounts for about one fourth of the world's food production. For each ton of these nutrients, grain yields increase by about 10 tons. Thus, in effect, fertilizer is one of man's most effective substitutes for land as populations keep increasing and available land becomes scarcer.

Because fertilizer is such a critical factor in food production, worldwide attention on food shortages logically focuses on fertilizer supplies. These, like food supplies, also are short. One reason is that the production capacity is insufficient. Another reason is that supplies of raw materials to match increasing population numbers are inadequate. The most severe shortages are in developing countries, especially for nitrogen fertilizers.

Like many natural resources, raw materials for fertilizers are poorly distributed on the earth. The United States, for example, has about one third of the world's known phosphate reserves, and it currently produces nearly one fourth of the world's nitrogen. Canada holds one of the world's largest potash reserves.

Producing nitrogen requires energy. Each ton of ammonia requires about 40,000 cubic feet (1,100 cubic meters) of gas, a ton of oil, or nearly two tons of coal. Natural gas is the major source of ammonia worldwide. However, the depletion of natural gas in countries such as the United States and its absence in many developing countries places increasing pressure on oil and coal. As a result, the "energy crisis" translates directly into a "nitrogen crisis" and thus into lower food production.

Shortages of energy, such as the shortage of electricity in India, have a double impact on fertilizer supplies. First, such shortages deter the construction of new plants to produce fertilizer. Secondly, the shortages reduce the rates at which existing plants operate. As a result, energy shortages are cutting sharply into present and future fertilizer supplies.

With fertilizer, as with any essential product, short supplies lead to higher prices. Such higher prices attract investments in the form of new plants and additional raw material. The result is a cycle in supply and demand. In this cycle, periods of short supplies and high prices lead to expansion of production capacity; this expansion, in turn, leads to increased supplies, which causes prices to go down. The deeper the downward pressure, the less the incentive to expand and produce fertilizer. As a result, there is another period of shortage as the market demand for fertilizer overtakes the market supply, and once again the cycle starts. In the mid-1970's there was a world shortage of fertilizer. When supplies would again be abundant, relative to demand, was unknown. William C. White

fescue (fes'kū), any of a large group of grasses that have long narrow leaves and often grow in dense tufts or clusters. Fescues are found in temperate and cooler regions throughout the world, and some species are cultivated as lawn grass or pasture for livestock.

A common pasture species is the tall, or meadow, fescue (Festuca elatior). It grows to a height of 2 to 5 feet, and it has slender leaves about 12 inches long. Another well-known pasture fescue is the sheep fescue (F. ovina), a smaller plant with threadlike leaves.

The blue fescue (F. ovina, variety glauca), which has silvery-blue leaves, is occasionally grown as a border plant. Chewing fescue (F. rubra, variety commutata), which forms a low dense mat, is often planted on outdoor areas that require a durable covering.

Fescues are classified as genus Festuca of the family Gramineae (grass). Annual or perennial.

*Reed C. Rollins

Fessenden, Reginald Aubrey (fes'ən dən, rej'i nəld ô'bri), American physicist and electrical engineer. Born East Bolton, Quebec, Canada, Oct. 6, 1866. Died Bermuda, July 22, 1932.

Fessenden broadcast the first radio program in the United States on Christmas Eve, 1906. The broadcast, which was made from his experimental station at Brant Rock, Mass., was received by ship's radio as far away as several hundred miles. Fessenden's research led to the development of continuous wave transmission and the heterodyne system for radio reception. He was granted 300 patents for various inventions.

*Lyman Mower

Fessenden, William Pitt, American statesman. Born Boscawen, N.H., Oct. 16, 1806. Died Portland, Me., Sept. 8, 1869.

Fessenden served in the Maine legislature, the U.S. House of Representatives, and the U.S. Senate. From 1864 to 1865 he was Secretary of the Treasury under President Abraham Lincoln. After the Civil War he became chairman of the joint Senate and House Committee on Reconstruction. He advocated treating the seceded states as conquered provinces.

*Sidney Fine

festival (fes'tə vəl), a public feast or celebration that may accompany either religious or secular observances. In addition to the many religious festivals, there are also festivals to celebrate agricultural, athletic, historical, and cultural events. While many festivals are serious occasions, some are accompanied by merrymaking. A sharp distinction between feasts and festivals cannot be drawn. Feasts are celebrations at which food and drink are served, yet banquets may also be part of festivals.

Religious Festivals. Many festivals have been inspired by religion. In the Christian faith both Protestants and Catholics observe certain festivals commem-

orating events in the life of Christ. Of these, the two most important are Christmas, which is the Feast of Christ's Nativity, and Easter, which marks the anniversary of Christ's Resurrection. Among Catholics there are also many festivals in honor of saints. One of the most picturesque Italian religious festivals is that of Santa Rosalia in Palermo, Sicily. She is credited with ending the plague of 1225.

Other important festivals celebrating the feast days of saints include the Festival of St. Catherine in Paris, France, during November and St. Patrick's Day in Ireland on March 17. Spanish feasts in honor of saints are often colorful. Both St. Joseph's Day in Valencia and the Feast of St. John in Alicante are accompanied by fireworks. The Feast of St. John in Valls, Spain, features gymnastic displays.

One of the most unusual festivals associated with religion is celebrated in Oberammergau, West Germany. Every ten years the villagers of Oberammergau stage their famous Passion play depicting the sufferings and martyrdom of Christ. The festival has been held almost every decade since 1634 to commemorate the sparing of their town from a plague in 1633.

In some countries spectacular festivals precede the Lenten period of fasting and penitence. Called *carnival* (or something very similar) in many places and *Fasching* in Germany, these festivals include parades, masquerades, and noisy merrymaking. The height of carnival festivity in modern times occurs during the three days before Ash Wednesday, which is the first day of Lent.

Carnival celebrations developed during the Middle Ages. One of the largest modern carnivals is held before Lent in Nice, France. It features processions and a battle of flowers, and it ends with the burning of an effigy of the King of the Carnival.

Carnival celebrations are found in sections of the United States that were settled by French and Spanish immigrants. The best-known North American car-





nival is the Mardi Gras of New Orleans, La. Colorful floats are created for its elaborate street pageant, which is presided over by Rex, the King of the Mardi Gras. One of the most notable South American carnivals is held in Rio de Janeiro, Brazil.

Festivals Associated With the Arts. Some festivals have resulted in outstanding cultural developments. For example, the drama originated in the ancient Greek festivals in honor of Dionysus, the god of wine. However, modern festivals devoted to the arts have usually been secular attempts to promote cultural activities. Some of these festivals honor several of the arts together, such as music, drama, and dance. Others, however, are restricted to a single art.

One of the world's largest arts festivals is held annually in the late summer in Edinburgh, Scotland. Known as the Edinburgh Festival of music and drama, it presents concerts, operas, ballets, and plays. The performers are world-famous artists. An important Scandinavian event is the Stockholm Festival of Sweden, which takes place every year in the early summer and offers drama, concerts, opera, and ballet. It displays mainly the talents of Swedish performers. On the other hand, the Israel International Festival of Music and Drama combines native artists with guests from other countries. Sometimes, as at the Festival of Two Worlds in Spoleto, Italy, special companies are assembled to present new or unusual works in such fields as drama and dance.

Festivals devoted primarily to music are numerous. In Salzburg, Austria, there is an annual music festival that emphasizes Mozart's works, but also presents modern compositions. The operas of Richard Wagner are performed every year at the Bayreuth Festival in Germany. Probably the best-known music festival in the United States is the Berkshire Festival, held every summer at Tanglewood in Massachusetts. It features the Boston Symphony Orchestra.

Drama festivals sometimes present plays of other eras in theaters that are particularly suited to them. For a number of years ancient Greek plays have been revived in Greece at the theater of Epidaurus, which was constructed in the 4th century B.C. Greek tragedy assumes its full grandeur when presented in this way.

Similarly, at some of the annual Shakespearean festivals, plays are performed on stages modeled after those of Shakespeare's day. Two such festivals are those held in San Diego, Calif., and at Hofstra University on Long Island. Probably the most famous Shakespearean festival is that in Stratford-on-Avon, England. Those who attend are able to visit Shakespeare's birthplace and hear lectures on his work, presented as part of the festival. Other popular Shakespearean festivals are held in Stratford, Ontario, Canada; in Stratford, Conn.; and in Central Park in New York City.

There are also festivals devoted to the dance. Ballet companies perform at an international festival in Nervi, Italy, in July. Also held during the summer is the international ballet festival in Lausanne, Switzerland. In the United States the Jacobs Pillow Festival in Lee, Mass., includes a varied program of ballet and modern and ethnic dance. The American Dance Festival, which is held in New London, Conn., presents performances of leading modern dance companies.

International film festivals combine elements of art festivals and of trade fairs. While film makers com-



The annual summer art festival in Boston, Mass., combines outdoor recreation, such as boat rides, with concerts and art exhibits.

pete for prizes, they also seek publicity that will aid them in the distribution of their films. Two outstanding film festivals are those presented in the spring in Cannes, France, and in the late summer in Venice, Italy. Other important film festivals are held in Berlin, Germany; San Sebastián, Spain; and Edinburgh, Scotland. There are also film festivals in San Francisco, Calif., and Boston, Mass., but they do not yet rank in importance with the European festivals.

Historical and Traditional Festivals. Many communities celebrate their history with festivals at which they display their traditional songs, dances, and costumes. Each year there are festivals in Italy recalling the period of Saracen occupation, which ended in the Middle Ages. In Positano a Saracen landing is reenacted, and in Arezzo there is a performance of a Saracen tournament. The Arezzo festival dates back to the 14th century.

A two-day festival in May in Orléans, France, honors Joan of Arc, who saved Orléans from an English siege on May 8, 1429. In England a number of official occasions have become festivals of historical pageantry. For example, the traditional parade celebrating the installation of the lord mayor of London is more than 700 years old. There are also a number of historical festivals in Spain. The Fiesta de la Toma on January 2 commemorates the conquest of Granada and has been held every year since 1492. A Spanish festival of more recent origin marks the anniversary of the 1808 revolt against the French occupation of Spain.

In recent years, "sound-and-light" festivals have recreated the history of famous buildings through illuminations accompanied by music and by recorded dramatic or narrated presentations. Some of the beautiful châteaux of the Loire region of France are the scenes of such programs, which are also held at the Acropolis of Athens, Greece, and at the Roman Forum and Pompeii in Italy.

Agricultural Festivals. Many festivals accompany the planting or harvesting of important crops. In modern Europe, as in ancient Greece, colorful festivals celebrate the harvest of wine grapes. Such celebrations are held in the wine-producing districts of France, Germany, Austria, Italy, and Greece. During the fall grape festival at Cagliari, Sardinia, there is a parade of ox-drawn farm carts decorated with Sardinian carpets, grapes, and flowers. At Daphne, Greece, the wine-festival celebrations include shows and folk dances. Beer festivals, such as the Oktoberfest of Munich, Germany, are also usually held in the fall.

Other food and agricultural products honored at European festivals include lemons in Menton, France; truffles in Alba, Italy; almond blossoms in Agrigento, Sicily; shrimps in Oostduinkerke, Belgium; and fish in Camogli, Italy, where many are fried in the world's largest frying pan during the celebration.

Agricultural festivals are also popular throughout the United States. At a number of them, such as the Cotton Carnival or the Tournament of Roses, a queen is selected to preside over the celebration, which often includes a parade. The Tournament of Roses, held in Pasadena, Calif., is one of the oldest of American agricultural festivals. It originated in 1886 as a parade to celebrate the ripening of the orange crop. Since 1916 the Rose Bowl football game has been a permanent part of the program.

The Cotton Carnival of Memphis, Tenn., which was first held in 1931, features elaborate parades, floats, balls, and general revelry. Apple blossom festivals are held in the Shenandoah Valley, Virginia, and in Brown County, Indiana. Among the nation's rose festivals are those held in Portland, Ore., and Hillsdale, Ind. A rhododendron festival is celebrated in Asheville, N.C., and a daffodil festival in Sumner, Wash. Festivals honor the tomato crop in Jacksonville and Yoakum, Texas, and in Elwood, Ind. The Cherry Festival

of Traverse City, Mich., has religious associations. A procession to the orchards is led by priests and ministers, who bless the cherry blossoms.

Ancient Festivals. The principal feasts of the ancient Egyptians were dedicated to their gods and goddesses. One of the most beautiful Egyptian feasts was in honor of the resurrection or rebirth of the god Osiris. According to legend, the dead body of Osiris floated ashore at Byblos in Phoenicia and was then revived as a green tree. Every year, therefore, a fallen tree was raised and replanted with much ceremony. Another annual festival celebrated the overflowing of the Nile, which was the source of the fertility of the land.

Among the festivals of the ancient Babylonians were a new year's feast and several celebrations in honor of Ishtar, their goddess of love. The ancient Hebrews were influenced in their feasts and festivals by the customs of both the Egyptians and the Babylonians. Some of the ancient Hebrew celebrations were originally agricultural festivals that were transformed into feasts commemorating historical occasions. For example, the Sukkot, or Feast of Tabernacles, at first celebrated the fall harvest. Later, however, the feast came to be associated with the wanderings of the Hebrews in the wilderness. Many of the ancient Hebrew festivals are still observed by present-day Jews.

The feasts and festivals of the Greeks and Romans were usually dedicated to a god or goddess and featured athletic or literary contests. The festival of the Olympic Games, in honor of Zeus, was important to all Greeks. It took place every four years in Olympia and offered a program of athletic competitions in which all Greeks might take part. The Athenians had a series of festivals in honor of Dionysus, the god of wine. At some of these, dramatic contests were held, for which the great Greek tragedians Aeschylus, Sophocles, and Euripides wrote plays.

Many Roman festivals were public events in honor of the state gods, but there were also numerous festivals observed by private families and by the Roman tribes or clans. The public festivals were often celebrated with games and entertainment. Among the most important Roman holidays was the Lupercalia on February 15 in honor of Lupercus, a god of fertility. Another was the Saturnalia, held in honor of Saturn, the god of agriculture, from December 17 to 23. Many Christmas customs have been derived from the Saturnalia, including the exchange of gifts. See also HOLIDAYS AND HOLY DAYS; MUSIC FESTIVALS.

Cecil Golann

festivals, music. See MUSIC FESTIVALS.

feterita (fet'ə rē'tä), a variety of sorghum raised for its grain. See also sorghum.

fetishism (fē'tish iz əm), in anthropology, the veneration of an object that is believed to have supernatural power. Various kinds of fetishes are found in many societies throughout the world. Some fetishes are thought to contain spirits. Others, such as charms and talismans, are considered to be powerful and lucky without being the abodes of particular spirits. Some fetishes are small and are carried on the person as amulets. Good luck pieces, like the rabbit's foot, are

fetishes in some societies. West Africa is famed for fetishism associated with the highly developed art of wood carving.

In psychology, fetishism is an abnormal attachment to any object. Young children who cannot be separated from their blankets and adults who are enamored of items of clothing usually worn by the opposite sex are said to be fetishists.

*Morton H. Fried

fetterbush (fet'ər bush'), an evergreen shrub that grows chiefly in damp areas of the southeastern United States. The fetterbush has shiny green leaves and bears clusters of small pink or white flowers.

The fetterbush, Lyonia lucida, is classified in the family Ericaceae (heath). *Richard A. Howard

fetus (fē'təs), the unborn offspring of a placental mammal during the later stages of development. In earlier stages it is called an embryo. See also EMBRYO.

Feuchtwanger, Lion (foiht'väng'ər, lē'on), German-American author. Born Munich, Germany, July 7, 1884. Died Los Angeles, Calif., Dec. 21, 1958.

Feuchtwanger wrote many historical and political novels and several successful plays. In his historical novels he used modern psychology to interpret impor-



Lion Feuchtwanger

tant personalities and subjects of the past. Among Feuchtwanger's best-known historical novels are Power (1925), which is set in 18th-century Germany; the Josephus trilogy (1932 -1942), which is set in ancient Rome; and This Is the Hour (1951), which is about the Spanish painter Goya. He also wrote several novels about modern Germany. These novels include Success (1930), which is about the rise of Hitler, and The Oppermanns (1933).

Feuchtwanger was forced to leave Germany in 1933, when the Nazis came to power. In 1940 he settled in the United States. Feuchtwanger's later popular novels include 'Tis Folly to Be Wise (1953) and Raquel (1956).

*Claude Hill

feudalism (fū'dəl iz əm), a form of political and social organization, particularly that of western Europe in the Middle Ages. Similar political systems have existed at different times in Moslem countries, China, and Japan. The essential element in European feudalism was an agreement between two nobles that usually involved a pledge of land (feudum in Latin) by the lord in exchange for a pledge of military service by the vassal. The land that supported both lord and vassal was worked by a lower class of freemen and serfs under the manorial system, which is distinct from the feudal system proper.

European Feudalism

Early Development. Feudalism, which developed in the early Middle Ages, had its origins in earlier cus-



Holy Roman emperor Otto III is surrounded by his vassals, both churchmen and soldiers, in a medieval miniature painting.

toms stressing the mutual interdependence of men of different social rank. Among the ancient Romans a patron, or important man, was usually surrounded by crowds of poorer men, called clients, who commended themselves to him for economic support and protection in exchange for their loyalty and service. Among the Germanic tribes of northern Europe each chief of a comitatus, or band of fighters, supplied his men with food, shelter, and fighting equipment in return for their loyalty.

In the 4th and 5th centuries A.D., as the Roman Empire crumbled and Germanic tribes pressed in, many freemen turned to more well-established persons, who could defend them from attack and give them a means of livelihood. This arrangement became the basis of medieval society. Freemen who had no land gave up their freedom to become serfs, bound to ignoble manual labor in the fields surrounding the lord's manor house or castle. This arrangement was the manorial system. Those who had land gave it to the lord and received back the right to use it and keep part of its produce. If they had little land, they became almost the same as serfs, although they remained technically free. If they had much land, they became vassals owing military service. Many landless freemen with military experience also became vassals. At first the lord usually fed and lodged landless vassals in his own house, but sometimes he granted them land. By this time the basic pattern of feudalism had already

The feudal relationship began with a formal ceremony, called homage, in which the future vassal knelt and placed his hands between those of his suzerain, or lord, and promised to become his man (homme in French). The two men then kissed each other, and the vassal took an oath of fealty, or loyalty, to his suzerain on the Gospels or some Christian relic. In the investiture ceremony that followed, the vassal received a

stick, clod of earth, or ear of grain as a symbol of the land he was granted. Such land was called a benefice, or fief. This term also applied to an office or privilege granted by the lord. The feudal bond ceased if one of the participants died.

In addition to fighting at the lord's command, the vassal was expected to advise him and give him certain amounts of produce or money. The lord's chief obligation was to come to the vassal's aid in case of attack by barbarians or other lords. He also avenged the vassal's wrongs and settled his legal problems. In the event of the vassal's death, the lord was under an obligation to care for the vassal's widow and orphans.

Full Development. Beginning in the 8th century A.D. a number of developments occurred that, within 200 years, made the feudal system the prevailing form of government in France. First, the giving of land for military service became even more widespread because vassals had to have some wealth in order to afford the horses and armor then coming into general use in warfare. In France the office of king was successfully grafted into the system by the 8th-century Frankish ruler Charles Martel and his Carolingian successors, Pepin the Short and Charlemagne. They strengthened their power by building armies of vassals, many of whom were lords in their own right, who swore fealty to the king as highest suzerain. Often the king made his vassals counts, or royal officials, granting them control of entire provinces as fiefs. The counts collected taxes for the king, held territorial courts, and were responsible for keeping the peace. However, when the Carolingian Empire collapsed in the 9th century A.D. because of civil war and Norse invasions, many kings' vassals became independent lords in their lands. Under these unsettled conditions more and more freemen became vassals of lords. Churchmen also became vassals, receiving land from lords to support churches and abbeys. In addition, many townsmen owed dues to the lords on whose land the towns developed.

The personal agreement between lord and vassal eventually became a formal legal contract, and the obligations accepted by custom became stated by law. For example, military service was limited to 40 days a year, and the vassal's payments were restricted to certain occasions, including the knighting of the lord's eldest son, the marriage of his eldest daughter, and the payment of his ransom in case of capture. At the same time, other changes led to even greater complexity and eventually to a weakening of the system. These changes included the gradual development of subinfeudation, inheritance, and divided allegiance.

Subinfeudation was a practice in which a vassal would subdivide a large fief and grant parts of it to other people, who then became his vassals. Theoretically, subinfeudation arranged feudal society into a pyramid of ranks with the king at the top. Under him came his royal vassals, the great lords of the land. Each of these in turn had several lesser vassals who had vassals of their own, down to a simple knight with just one manor. Each man's estate, or position in society, was determined by his occupation. The three principal estates were clergy, nobles, and commoners. In theory a vassal had to have his lord's consent before granting his own fiefs, and he was supposed to bring all his own vassals to his lord's support. In practice, however, vassals often acted quite independently of their lords and frequently fought their own wars.



Feudal agriculture was carried on by serfs, as shown in a contemporary representation of medieval harvesting.

When a vassal died, a lord usually found it easiest to allow a family member to do homage and be invested and keep the fief in the family. Thus, in time, the feudal bond became hereditary. If a woman inherited a fief, the suzerain had the right to choose her husband, since the latter would become a vassal. If there were no heirs, the fief escheated, or reverted, to the suzerain. Nevertheless, the principle of inheritance meant that the vassal tended to look upon the fief as his own personal property and to begrudge his obligations to the lord. Great vassals in large areas, such as Flanders or Aquitaine, were often far more powerful than their suzerain, the French king, who held directly only the small area around Paris.

Each vassal tried to obtain as many fiefs as possible in order to increase his own power and prestige. He might also gain an additional fief through inheritance. The result was that, although in theory he was supposed to have only one suzerain to whom he owed complete devotion, in practice he might have two or more lords, all competing for his loyalty. If they happened to be enemies, he was in a difficult position.

Decline. By the 13th century fundamental changes in economic, social, and political conditions were leading to the decline of feudalism and the rise of national states. As trade increased and cities grew up, a rising urban middle class of merchants and manufacturers produced an economy increasingly based on money. Feudal lords began to accept more and more of their vassals' obligations in the form of money instead of military service, and in some areas the economic bondage of serfs on manors began to be modified by the practice of paying money rents.

Kings and townsmen had needs that encouraged mutual cooperation. The townsmen wished to be free of the dues they had owed feudal lords. The kings

wanted to weaken the lords, who individually and in advisory councils withheld taxes and blocked royal efforts to create a strong centralized government. Cooperation began when kings sold charters to towns, which enriched the kings and freed the townsmen of feudal obligations. Kings also hired townsmen as officials dependent on royal salaries, instead of relying on vassals who were virtually independent on their fiefs. Finally, both kings and towns hired mercenary armies, that would fight as long as they were paid. The large mobile infantry force armed with crossbow and pike proved superior to the lord's small, 40-day army of heavily equipped mounted knights. Thus, as time passed, the commercial middle class helped the kings build national states, while the feudal nobility grew progressively weaker.

Continued Influence. The influence of feudalism can be seen in many modern institutions. Representative assemblies arose from the gathering of vassals to advise the king. Certain English laws of landholding, such as the law of primogeniture, or inheritance by the firstborn, originated in feudal laws. Perhaps most important, the feudal contract was the forerunner of modern constitutional ideas of limited government and government by the consent of the governed.

Feudalism in Non-European States

The conditions under which feudalism arose outside Europe were often quite different from those in Europe. In Moslem countries feudalistic societies developed in a money economy from the need of the central government to administer its conquered provinces. At first, Arab rulers appointed officials to rule and collect taxes in exchange for unoccupied land. Later, Turkish generals began taking over land from the weak central government and granting fiefs to their soldiers. Then

new Turkish rulers legally granted fiefs for military service.

Chinese feudalism developed at least as early as 1100 B.C., when Wu Wang, founder of the Chou dynasty, granted fiefs to relatives and generals in exchange for taxes and armies. This feudal arrangement was based partly on the ancient tradition that the head of the clan must divide clan property among the members and partly on the practical need for assistance in protecting and administering a large empire.

In neither the Moslem nor the Chinese system was there any idea of mutual contract, since the ruler was believed to be, in the one case, a successor of God's prophet, Mohammed, and in the other, the "son of Heaven." When the ruler was strong, the feudal lords were closely regulated, but when the central government declined, they behaved more or less as they pleased. The system lasted until the breakup of the Ottoman and Chinese empires in the 20th century.

Japanese feudalism for many hundreds of years developed after the 10th century A.D., as provincial clan leaders seized power from the emperor and court nobility. These feudal lords, called daimyo, controlled warriors known as samurai, who took an oath of loyalty in return for protection. In the 12th century one daimyo became so strong that the emperor appointed him shogun, or military dictator. Although the emperor retained his title, the shoguns actually ruled Japan until the Meiji restoration of the emperors power in 1868 and the abolition of feudalism in 1871.

Books for Further Study

Mediaeval Feudalism by Carl Stephenson (Cornell, 1967). Feudalism by Joseph R. Strayer (Van Nostrand, 1965). Feudalism by F. L. Ganshof (3d ed., Harper, 1964).

*Samuel J. Miller

Feuerbach, Ludwig Andreas (foi'ər bäн, lüt'viн ändrā'as), German philosopher. Born Landshut, Germany, July 28, 1804. Died near Nuremberg, Germany, Sept. 13, 1872.

At first a follower of the idealist philosopher G. W. F. Hegel, Feuerbach later rejected Hegel's view that reality consists ultimately of ideas. As a materialist, Feuerbach believed that only matter has reality. He attacked orthodox religious teachings, denied personal immortality, and held that the idea of God is merely created by the mind to meet the psychological needs of human nature. Feuerbach's major work is The Essence of Christianity (Das Wesen des Christentums, 1841). His philosophy influenced Karl Marx and Friedrich Engels in the development of dialectical materialism, which became the official philosophy of Communism.

Feuermann, Emanuel (foi'ər män, i man'ū əl), Austrian cellist. Born Kolomyya, Austria (now in USSR), Nov. 22, 1902. Died New York, N.Y., May 25, 1942.

Feuermann was one of the world's great cellists. He was famous both for his interpretations of chamber music and for his solo performances. He also taught music at conservatories in Cologne, from 1917 to 1923, and Berlin, from 1929 to 1933. A child prodigy, Feuermann made his debut with the Vienna Philharmonic Orchestra at the age of 11. In 1938, after the Nazi rise to power in Europe, he settled in the United States.

*Sigmund Spaeth

fever (fē'vər), a condition in which the temperature of the body is more than its normal 98.6° F. The term is also used as part of the name of certain diseases, such as typhoid fever and scarlet fever, in which a prominent symptom is a high temperature. Fever is not a disease, but a symptom of many disorders. Although people have survived temperatures of more than 110° F., a fever of 106° F. may have serious effects, particularly in babies or elderly people.

The first signs of fever may be chilly sensations, frequently associated with flushed or warm feelings. The temperature may rise slowly or rapidly, and it may stay up or may fluctuate. As it rises, it may be associated with shaking chills. If it falls quickly, profuse sweating may occur.

Causes of Fever. As its cells burn foodstuffs for energy, the body constantly produces heat. At the same time the body constantly loses heat to its surroundings through the skin, through breathing, and in other ways. The temperature of the body is a measure of the balance between heat produced and heat lost.

Under normal circumstances the heat produced is balanced by the heat lost, keeping the body temperature at the best level for the cells to carry out their chemical activities. The temperature is controlled by the hypothalamus, a small area of the brain that functions as a thermostat. When the functioning of the hypothalamus is disturbed, fever may result. Such disturbances are sometimes caused by a disease of the brain. In other cases the cause of fever is not clear. However, it is believed that in an infectious disease the bacteria release chemical substances that upset the hypothalamus, causing the body temperature to rise. While the temperature is rising, the blood vessels supplying the skin may be constricted, and sweating may not occur. The body will thus produce more heat than it can lose, and fever will result.

What Fever Does. Fever appears to be one of the body's defenses against infectious disease. In some infectious diseases the high temperature of fever may kill or adversely affect many of the bacteria that cause infection. A rise in temperature may also increase the body's ability to fight infection.

Although fever is basically a protective mechanism, it often weakens a person or makes him feel tired and dry. During a fever the body loses large amounts of salts and water through sweating. The body also uses foodstuffs at a faster rate than it normally does. At the same time a feverish person does not usually feel like eating very much or having very much to drink.

Treatment. Fever is generally treated by treating the disorders that cause it. Giving aspirin or applying cool compresses or alcohol sponges may help lower the temperature. To replace the fluids lost from the body by sweating, patients are usually given large quantities of liquids to drink. If the fever is very high, ice may be rubbed on the body, or the patient may be placed in a tub of cold water.

Louis J. Vorhaus, M.D.

fever blister, also called cold sore, a group of small watery blisters that form on the skin or mucous membranes, especially near the lips. Fever blisters are caused by a virus and often occur during colds or fever-producing illnesses. See also COLD SORE.

feverfew (fē'vər fū'), a bushy garden plant once widely used to treat fever. The feverfew grows to a height of 3 feet (90 cm). It has deeply lobed leaves with a strong acrid odor, and it bears small daisy-like flower heads. Native to Europe, the feverfew now grows wild in eastern North America. A related plant, the wild quinine (*Parthenium integrifolium*), is sometimes called the American feverfew.

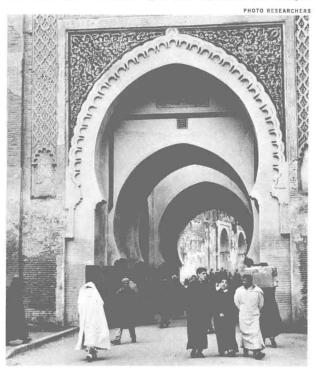
The feverfew, Chrysanthemum parthenium, is classified in the family Compositae (composite). Perennial.

*Reed C. Rollins

Feynman, Richard Phillips (fin'mən), American physicist. Born New York, N.Y., May 11, 1918.

Feynman shared the 1965 Nobel Prize in physics with the American physicist Julian S. Schwinger and the Japanese physicist Sin-itiro Tomonaga. The prize was awarded for contributions the three men made independently, in the 1940's, to the theory called quantum electrodynamics. Quantum electrodynamics describes the interactions of electrons (and their antiparticles, positrons) with photons-particles of light or other electromagnetic radiation. Feynman, making use of the idea that a positron can be described mathematically as an electron travelling backward in time, introduced diagrams that trace out the steps of processes involving these particles. Rules based on the diagrams allow one to calculate the probability of any such process. Feynman's method not only removes disagreements with experimental facts that existed in earlier versions of quantum electrodynamics, but it is much simpler. "Feynman diagrams" have also had a great influence on the way physicists think about other kinds of elementary-particle processes. The formulations of Tomonaga and Schwinger are mathematically equivalent to Feynman's, but do not use diagrams. Feynman has also done important work in the theory of weak (beta-decay) interactions and in the theory of superfluidity. R. A. Reinstein

A view from inside the oldest section of Fez, which was built in the Middle Ages. The Moorish gate is ornamented in mosaic style.



Fez (fez), a city in north-central Morocco; on the Fez River; 108 miles (174 km) east of Rabat. Pop. (1971) 325,327.

Fez, or Fès, is a commercial center on trade routes from the Mediterranean Sea to the Sahara and west from Algeria to the Atlantic Ocean. Roads and railroads link Fez with Morocco and nearby countries.

Agricultural products, such as citrus fruit and olives, grown in the surrounding area, are marketed in Fez. Manufactures include carpets, leather goods, processed palm fibers, flour, and native handicrafts, such as pottery and tile. The brimless red cloth cap known as a fez was originally manufactured in the city.

Fez is the chief religious center of Morocco. Al Qarawiyin University, a center of Islamic, or Moslem, studies, is located in Fez. The city is also the site of the Qarawiyin Mosque, the largest in Africa, and the Mulai Idris Mosque, a very sacred center of Islamic worship that dates from the 9th century A.D.

The city of Fez was formed in the 11th century by the union of two small towns that dated from the 7th and 8th centuries A.D. Fez served as the capital of Moroccan sultans from the 13th century to the 16th century, when the capital was transferred to Marrakesh. In 1911, Fez was occupied by the French, who in 1912 made Morocco a protectorate. Morocco became independent in 1956.

*George H. T. Kimble

fiber (fi'bər), a threadlike strand that can be spun or woven. Fibers are usually divided into two basic groups: synthetic, or man-made, fibers, and natural fibers, obtained chiefly from plants and animals. Asbestos is the only natural mineral fiber of importance.

Natural Fibers. Plant fibers are grouped according to the part of the plant from which they are taken. Fibers from the inside of the stem are called soft, or bast, fibers. Such fibers include flax, jute, hemp, and ramie. Generally, soft fibers are durable and stand up well under harsh treatment or bleaching.

Fibers obtained from the leaves of certain tropical plants are known as leaf, or hard, fibers. Leaf fibers are coarser and less durable than soft fibers. Among the well-known leaf fibers are sisal, abaca, and henequen. Fibers obtained from the surface of a stem, seed, leaf, or fruit are called surface fibers. Cotton and kapok are among the best-known surface fibers.

Except for silk, all animal fibers are obtained from the furry coats of various animals. Probably the most widely used animal fiber is wool, or sheep hair. Other valuable animal fibers include the hair of goats, alpacas, camels, horses, rabbits, and beavers.

Man-made Fibers. Most man-made fibers are grouped according to the raw material used in their manufacture. Cellulose fibers, such as rayon, Arnel, and Chromspun, are made chiefly from wood pulp. Synthetic fibers are manufactured entirely from chemical substances. Dacron, Orlon, nylon, and Acrilan are among the best-known synthetic fibers.

Uses

Because fibers vary in strength, durability, and other characteristics, different fibers are best suited for different purposes.

Textiles. The most important textile fiber is cotton. It is woven into a wide variety of fabrics, including denim, calico, and muslin. Flax, another major textile

fiber, is used to make linen, thread, and carpets. Jute and hemp, which are coarser fibers, are made into rough fabrics, such as burlap. Many animal fibers are woven into sweaters, coats, and other wearing apparel. The strongest of all natural fibers is silk.

Many artificial fibers are woven into blends with natural fibers to make fabrics for clothing, tents, parachutes, blankets, curtains, and other products. Many fabrics are also made only of artificial fibers.

Cordage and Netting. The most important of the cordage fibers is abaca, which is used to make underwater cables and other kinds of heavy rope. Lighter cordage, nets, and twine are frequently made of jute, cotton, flax, or hemp. Sometimes nylon is combined with other fibers to make strong cord.

Filling. The fibers most used as stuffing in upholstered furniture, mattresses, and life preservers are kapok, cotton, jute, and Spanish moss. Some animal fibers, such as horsehair, are also used.

Other Uses. Various wood fibers are used in the manufacture of paper and products such as hardboard and fiberboard. See also FIBERBOARD. *Norma R. Hollen

fiberboard (fi'bər bôrd'), a stiff sheet material made from processed cellulose fiber, particularly wood fiber. It is strong and also provides good insulation against heat and sound. Fiberboard is thus well suited for panels, flooring, doors, and walls. It is also used in various ways in furniture.

Made in sheets as thick as 2 inches (5 cm) and as long as 16 feet (4.8 meters), fiberboard can be fashioned with woodworking tools, and it holds paint well. The surface is generally sealed with a primer to prevent the paint from soaking into the material.

Kinds of Fiberboard. There are several kinds of fiberboard. The most flexible are the semirigid boards, which can be bent or fitted to curved surfaces. Hardboards are the strongest and most rigid of the fiberboards. They are very durable and are usually resistant to fire and moisture.

Manufacture. Fiberboard is usually made from wood pulp, but it may also be made from other fibrous materials, such as flax, hemp, straw, wastepaper, or bagasse, the fibrous residue of sugarcane. Board that is made from small chips of wood is called particle board. (See also PARTICLE BOARD.)

The manufacture of fiberboard is similar to paper-making. The raw fiber is first made into a pulp by chemical action. When the pulp has reached the proper texture, it is formed into mats, which are dried and pressed into sheets. Synthetic resins, asphalt, alum, oils, and other chemicals and binders can be added to fiberboard to strengthen it and to make it resistant to fire and moisture.

William K. Fallon

fiber glass, strands of thread made of glass. Fiber glass is very strong and flexible and is resistant to extreme temperatures, moisture, oils, and caustic chemicals. In combination with plastics, fiber glass is becoming increasingly important as a structural material.

Fiber glass is made from glass marbles that are melted and poured through tiny holes. As the molten glass drops through the holes, it forms into threads. These can be spun into yarn. Fiber glass yarn can be woven into fabrics that resemble cotton, wool, or silk.

Another kind of fiber glass, called glass wool, is drawn in short fibers directly from a batch of molten glass. Glass wool is made into blankets or matting that is used for insulation against heat and sound.

Many materials are made by combining fiber glass with various plastics. These materials, generally also called fiber glass, can be pressed into sheets or molded into various shapes. They are used for acoustical ceilings, roofing shingles, tile, and construction boards in a wide range of texture and flexibility. Thin fiber glass sheets are suitable substitutes for metal in making storage tanks, air ducts, and similar products.

Fiber glass composition material has become increasingly important in the construction of automobile bodies and boat hulls. Automobile bodies and some boat hulls of this material are formed by a hydraulic press in a single operation. Most such boat hulls, however, are made by pressing many sheets of fiber glass onto a mold by hand.

*Donald Doctorow

fiber optics, the use of light waves to send information. The light travels in tubes as thin as a human hair. The tubes, called fibers, are made of glass or other transparent material.

Scientists have long dreamed of using light waves to transmit voice or other signals. Light waves could carry thousands of times more information than radio waves, or current flowing in a wire. There were, however, enormous problems to be solved. Light cannot be transmitted through the air because it is blocked by dust, fog, and clouds. Scientists tried to build long hollow pipes to carry beams of light. Lenses and mirrors inside the pipes guided the light. The pipes were then buried in the earth to protect them. Unfortunately, the slightest movement of the earth itself was enough to shift the lenses and mirrors, and destroy the beam.

A more successful way of carrying light beams is to use an optical fiber. A beam of light shined into one end of an optical fiber reflects along the inside of the fiber to the other end. A marble rolling down a long hallway, glancing off the walls, gives an idea of the effect. Even if the fiber is bent, the light still follows along its length for long distances.

An optical fiber used for communications is like an arm in a sleeve. It consists of an inner core and an outer covering, or "cladding." The core is made of extremely pure glass. The cladding is also of glass, but of a different type. The cladding acts as a mirror. Light waves travelling along the core are reflected by the cladding back into the core. Most optical fibers are made by first placing the core material inside a glass tube. The tube is then melted and collapses onto the core. Tube and core are then drawn out into an extremely thin filament no thicker than a hair. A piece of collapsed tube, 25 centimeters long and 2 centimeters in diameter, can be drawn out into a fiber about 2 kilometers long.

Optical fibers made of glass or plastic have long been used in medical instruments. Inserted into the body, the fibers transmit the image of an internal organ to a camera outside. In automobiles, they carry light from a central source to various instrument panels. Such fibers, however, are not nearly as transparent as those needed for communication. Light in a communications cable must travel for long distances without interference. Flaws, impurities, or bubbles in a fiber would absorb or reflect the tiny beam. If seawater were as transparent as optical fiber material, an observer could see to the bottom of the deep-