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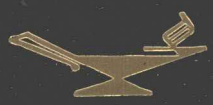

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MIRIAM BUCHER, FROM PHOTO RESEARCHERS, INC.

A small community hugs the Musi River near Palembang, Sumatra.

SUMATRA, sōō-mä'trə, is the westernmost of the major islands of Indonesia and, after Borneo, the largest of the Greater Sunda group. It is situated between the Indian Ocean and the Malay Archipelago's interior seas. Sumatra is separated from the Malay Peninsula to the northeast by the Strait of Malacca and from Java to the southeast by the Sunda Strait. Extending about 1,100 miles (1,750 km) from northwest to southeast, the island reaches a width of 250 miles (400 km) at the equator, which bisects it. Its area is about 167,000 square miles (433,000 sq km); exclusive of fringing islands.

The Land. Sumatra is divided lengthwise into two main topographic zones. One, the Barisan mountains, actually consists of two parallel mountain chains that closely flank the entire west coast. These chains contain some 80 volcanic peaks, another dozen active volcanoes, and several enclosed plateaus. They reach their maximum elevation of almost 12,500 feet (3,800 meters) atop Mt. Kerintji. They also contain five major lakes, the largest being Toba, a crater lake, in the north. Extending inland from the east coast is the second major topographic zone, a lowland plain occupying some 60% of the island. A narrow coastal strip in the north, this zone widens to over 150 miles (240 km) in the south.

Most of the rivers draining the west coast are short, with steep gradients, and are little used for transportation. The rivers draining the eastern slopes are longer, tap extensive watersheds, and are generally navigable by large ships. Several of Sumatra's chief ports—Palembang, Djambi, Pakanbaru—are located along these rivers at a considerable distance from the sea.

Sumatra has a tropical climate with little seasonal temperature variation. The mean annual temperature at 4,000 feet (1,200 meters) in the north is 68° F (20° C), as against 80° F (27° C) in lowland south Sumatra. Annual rainfall averages 95 to 140 inches (2,400–3,550 mm) with an October-November maximum north of the equator and a December-January maximum south of it.

Vegetation is luxuriant and highly diversified, especially according to altitude. Along the east coast are huge tidal bush-mangrove marshlands. Extensive stretches of savanna, supporting imperata grasses, palms, and bamboos, range upward from 200 feet (60 meters), and vast stands of equatorial forest stretch from 400 feet (120 meters) to the highest peaks. Besides deciduous trees like chestnuts and oaks, this forest contains valuable tropical hardwoods such as teak, ebony, and ironwood, as well as lianas, resin trees, camphor, and sandalwoods.

Sumatra's wildlife includes two types of apes (the gibbon and orangutan), members of the lemur and tarsier families, Malayan bears, elephants, tigers, tapirs, two almost extinct varieties of rhinoceros, civet cats, and many kinds of reptiles and birds.

The People. Sumatra and its fringing islands supported about 20 million inhabitants in 1970, or 16% of Indonesia's total population. Some 15 languages are spoken, excluding dialects. Yet about 75% of the people belong to one of the four major ethno-linguistic groups—the Malay (7 million), Menangkabau (4.4 million), Batak (2.3 million), and Achinese (over 2 million).

The Malays occupy the coastline and river basins of the eastern lowlands but are widely scattered elsewhere as well. The Menangkabau

inhabit the densely settled Padang highlands of west central Sumatra. Farther northwest in the interior uplands surrounding Lake Toba live the Bataks. The Achinese dwell farthest northwest, along the coastal plain encircling Sumatra's northern end. Minor groups include the Alas and the Gajo, who are mountaineers living between the Batak and Achinese; the Rejang-Lampung-Kubu speakers of the south; and the peoples of the eastern and western offshore islands.

Except within the minority European and Chinese communities, Sumatra's peoples are physically of a generalized Malayan phenotype. Their languages, while mutually unintelligible, reveal a definite common ancestry within the west Austronesian language family. Most Sumatrans are Muslim, except for the Batak, almost half of whom are Christian. Local customs continue to modify religious identities. For example, Menangkabau matrilineal clan duties still counteract orthodox Muslim family law, and the Christian Batak still observe pagan rites.

Economy. Agriculture is the primary economic activity, with rice the staple food crop. Corn (maize) and root crops, especially cassava, are important secondary staples in many areas. Cash crops grown by farmers with small holdings are peanuts, rubber, pepper, cotton, tobacco, copra, cloves, nutmeg, kapok, coffee, and betelnuts. Sumatra accounts for over 50% of Indonesia's smallholder rubber export, but rice must be imported to feed the urban population and plantation workers. Large estates produce the bulk of the island's agricultural exports. Plantation crops include rubber, tobacco, palm oil, tea, coffee, and fibers such as sisal and ramie. Tobacco and rubber estates are concentrated in the northeastern coastal region.

Petroleum, tin, and bauxite are the leading mineral products of Sumatra and its offshore islands. Over 70% of Indonesia's crude oil comes from the coastal plains around Palembang, Djambi, and Pakanbaru. The tin mines of Bangka, Billiton, and Singkep islands make Indonesia the world's second-largest tin exporter. Bauxite is mined in the Riouw (Riau) islands, and 75% of Indonesia's coal production comes from the Padang highlands and southern Sumatra.

Primary trading centers, shipping points, and associated land transport systems are found in the Medan-Belawan area of the north, in the Padang highlands, and in the south. Outside of these network areas and the oil company roads of the central plain, transport by river and by mountain trail remains the rule. Sumatra's major cities are also linked by air.

History. During the early centuries of the Christian era, Sumatra was known to the Indians and Chinese because of its position astride the maritime trade routes between India and China. The spread of Indian cultural influence in the island is attested by Sanskritic archaeological remnants in Sumatra. By the 7th century at least two Indianized states were flourishing on the east coast: Melayu (Malayu), with its capital at Djambi, and Srivijaya, with its capital at Palembang. By about 1000, Srivijaya not only controlled the lucrative Malacca Strait trade route but most of Sumatra, western Java, and the Malay Peninsula with its Kra Isthmus overland routes. When Marco Polo visited Sumatra in 1292, Srivijaya was a center of Buddhist learning, but its maritime power had waned and it faced growing religious opposition from newly converted Muslim chieftains in north Sumatra. During the 15th century, Islam became established in Acheh (Atjeh), and the Achinese spread their faith south among the Menangkabau and other groups.

Portuguese traders and missionaries reached Sumatra in the 16th century, and the Dutch began their penetration of the island in the 17th. By the early 18th century the Dutch East India Company had established numerous trading forts along both coasts of Sumatra and had concluded defense and trade monopoly agreements with local chieftains. Competition from the British continued until 1824, when Britain ceded to the Dutch its last Sumatran trading footholds on Billiton island and at Bengkulu in return for Malacca and for Dutch recognition of British Singapore. By 1900 there were Dutch mission stations throughout the Batak highlands, and estate, mining, and transportation activities were well established. The Achinese, however, resisted the Dutch until 1908.

During World War II, Sumatra was occupied by the Japanese. Following Japan's surrender in 1945, Sumatrans took part in the struggle against the returning Dutch. Sumatra joined the newly established Republic of Indonesia in 1950. Since then, the island's exports have provided a disproportionately large share of the national income. The Java-centered economic policies of President Sukarno before 1965 generated local dissatisfactions with the central government and contributed to the outbreak of several rebellions and regional movements. Since 1965 the economic policies of President Suharto's government have attracted new foreign investment to Sumatra.

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SUMBA, sōōm′bə, is one of the Lesser Sunda Islands in Indonesia. It was formerly known as *Sandalwood Island,* from the once abundant trees that furnished its chief export. The island, south of Flores and west of Timor, is about 145 miles (230 km) long and 50 miles (80 km) wide and has an area of 4,305 square miles (11,150 sq km).

Most of the Sundanese are farmers. Corn (maize) is their chief crop. Horses and water buffalo are bred, many for export. The people live in villages of houses with steeply pitched roofs. Many of them are animists. The chief town is Waingapu on the north coast. Population: (1961) 251,126.

SUMBAWA, sōōm-bä′wə, is one of the larger islands of the Lesser Sunda group in Indonesia. It lies between Flores to the east and Lombok to the west. Irregularly shaped, Sumbawa (Soembawa) has a length of 175 miles (280 km) and a maximum width of 55 miles (85 km). The island is very mountainous, with a few narrow plains along the coast. The highest peak is a volcano, Mt. Tambora, 9,350 feet (2,850 meters) high. Saleh Bay on the north coast almost bisects Sumbawa. On Bima Bay, farther east, lies Raba, the largest town, the administrative center, and a port of call for interisland shipping.

Sumbawans, most of whom are Muslims, are of mixed Malay and Papuan stock. They grow rice, corn (maize), coffee, tobacco, fruits, and vegetables, moving to new fields as the old ones are exhausted. Livestock raising is important to the export economy. Population: (1961) 507,596.

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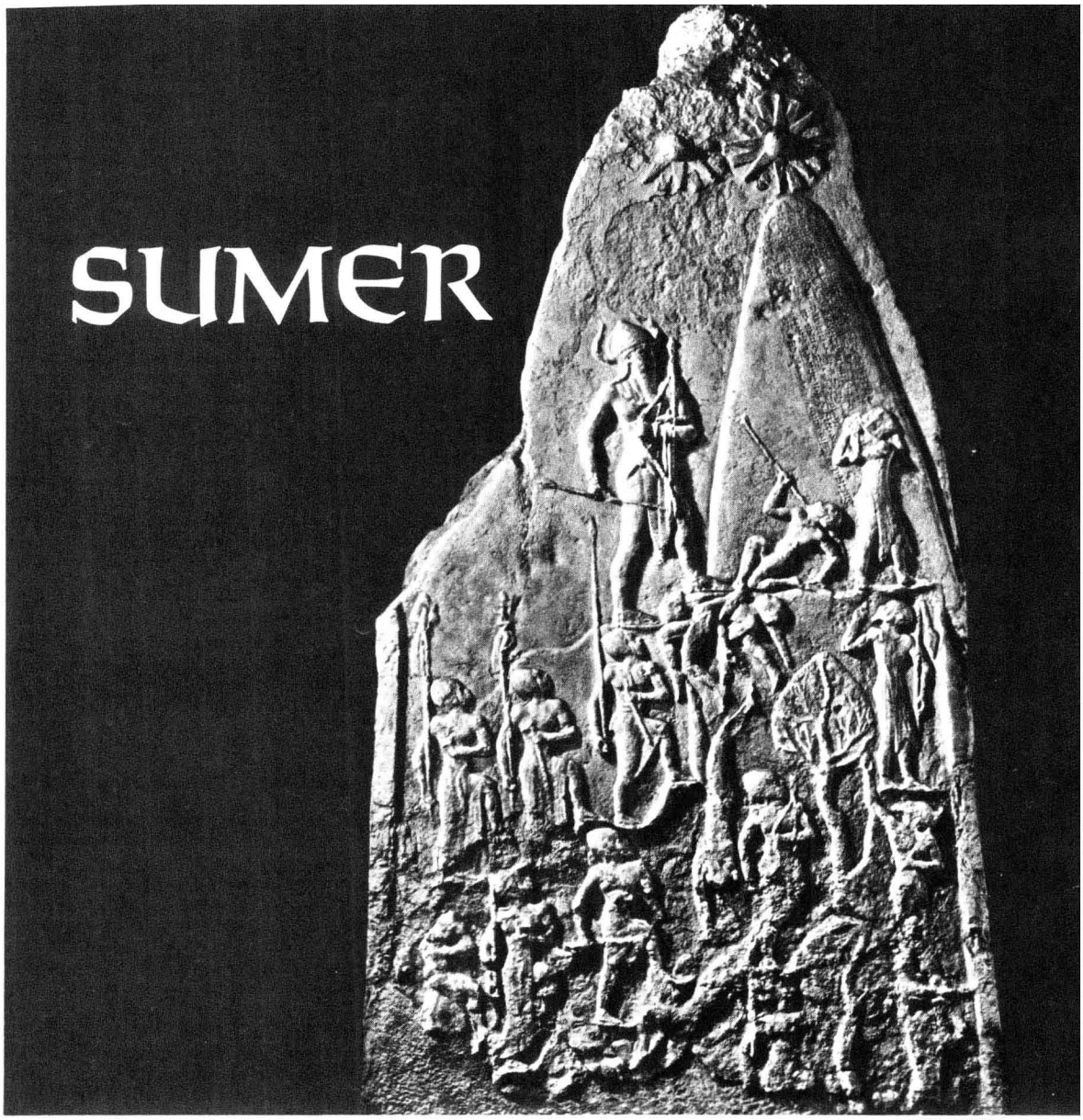
SUMER



TEL-VIGNEAU

Stele commemorating Naramsin's victory over a west Iranian chieftain dates from the 3d millennium B. C.

SUMER, sōō'mər, the homeland of the world's earliest known civilization, was roughly the same territory as modern southern Iraq from around Baghdad to the Persian Gulf. It consisted largely of a bleak, windswept, but potentially fertile plain formed over thousands of years by silt deposits from the Tigris and Euphrates rivers. Its climate was hot and dry, but with the help of irrigation the people of Sumer made the land so productive that modern scholars tend to identify it with the Biblical Garden of Eden.

HISTORY

Sumer was first settled about 4500 B. C. by the Ubaidians, a people whose stone farming implements and clay artifacts were first uncovered in the ruins of al-Ubaid and later in the lowest levels of other archaeological sites in southern Iraq. The Ubaidians founded villages that later became important Sumerian urban centers. In the course of the next 1,000 years these settlements were infiltrated by Semitic nomads from the Arabian and Syrian deserts. From this cross-fertilization of peoples evolved a relatively high culture in which the Semitic element was predominant.

The Sumerians, whose original home may have been in the region of the Caspian Sea, probably did not reach Sumer before 3300 B. C. Their arrival and subsequent ethnic and cultural fusion with the existing population led to the creation of man's first high civilization, now commonly known as Sumerian primarily because Sumerian was the prevailing language of the land.

City-States. The first notable ruler of Sumer was Etana, a king of Kish in northern Sumer who lived about 2800 B. C. The Kish dynasty succeeded to some extent in unifying the rival city-states that had developed in Sumer.

Not long after Etana, however, a king named Meskiagsher founded at Erech (Biblical Uruk;

modern Warka) a dynasty whose martial exploits ushered in a "heroic age." From this city in southern Sumer, Meskiagsher is said to have extended his rule to the Zagros Mountains (on the eastern border of modern Iraq) and the Mediterranean Sea. His son Enmerkar and the latter's successor, Lugalbanda, were noted for the conquest of Aratta, a city-state in Iran that was renowned for its wealth of metal and stone, resources lacking in Sumer.

Following Lugalbanda's reign, Erech's power was seriously threatened by the last two rulers of Kish, Enmebaraggesi and Agga, who were not only military figures of note but outstanding religious leaders as well. At Nippur, in central Sumer, they founded the Ekur, or temple of Enlil, Sumer's leading deity. Thus they helped make Nippur the religious and cultural center of the land.

Meanwhile, a third power, Ur (Biblical Ur of the Chaldees) had arisen in the south under its ruler, Mesannepadda. The royal tombs of Ur may date from the time of the dynasty he founded. Shortly after his death Erech again became the leading city-state of Sumer, this time under the rule of Gilgamesh, the supreme hero of Sumerian story and legend. See also GILGAMESH EPIC.

As a result of the destructive struggle of Kish, Erech, and Ur for control of Nippur and hegemony over all Sumer, the land was subjugated by the Elamites to the east. But around 2500, it was restored to its former power by Lugalannemundu of Adab, in central Sumer. He is said to have controlled an empire extending over much of the ancient world. Not long after him came Mesilim of Kish, a ruler noted for his building activities and for settling a bitter territorial dispute between two rival southern city-states, Lagash (Telloh) and Umma. This was history's first recorded case of peaceful political arbitration.

In time, Eannatum of Lagash extended his sway over all of Sumer, but the power he established did not last more than a generation after his death. Urukagina, the last king of the Lagash dynasty, was a notable political reformer, and in one of his inscriptions the word "freedom" appears for the first time in written history. He curtailed the oppressive practices of a greedy bureaucracy, reduced taxes, and put an end to gross injustice and exploitation. But Urukagina was overthrown by Lugalzaggesi, the ambitious ruler of Umma, who burned much of Lagash.

Akkadian Dynasty. About 2350 a Semitic leader named Sargon toppled Lugalzaggesi from power and went on to conquer all of Sumer. He established a powerful Semitic dynasty that lasted over 100 years and made its influence felt as far as India and Ethiopia. Sargon founded in northern Sumer a new capital named Agade (Biblical Akkad), which for a brief period became the wealthiest and most powerful city in the ancient world. After Sargon's death, two of his sons were successful rulers. But during the reign of his grandson Naramsin, the Gutians, a semibarbaric people from the Zagros Mountains, invaded Sumer and left it desolate.

It took the Sumerians generations to recover. From about 2150, Lagash was again prominent, especially under its pious governor Gudea, whose features are well known from numerous statues of him excavated in Lagash. Gudea figures prominently in the history of literature. A long hymn celebrating his restoration of the Eninnu, or main temple of Lagash, is a literary masterpiece.

Neo-Sumerian Period. Sumer was finally delivered from the Gutians by Utuhegal of Erech. About 2100 one of his generals, the ambitious Ur-Nammu, made himself master of Ur. After defeating Lagash, Ur-Nammu made Ur once again the capital of Sumer. Parts of his law code, the first in history, have been identified and translated.

Ur-Nammu's son Shulgi was one of the great monarchs of the ancient world—a rare combination of soldier, statesman, and patron of learning and letters. Throughout his reign Sumer prospered and dominated the neighboring lands. But after his death, hordes of Semitic nomads—the Amorites of the Bible—streamed in from the west. About 2000 B. C. the Elamites, Sumer's perennial enemies on its eastern flank, attacked and destroyed Ur and ravaged much of Sumer.

In the following two centuries there was a constant power struggle involving several Sumerian city-states, which were now largely Semitized. Finally, about 1760, the Amorite king Hammurabi succeeded in unifying the land, with Babylon in the north as its capital. With the reign of Hammurabi the history of Sumer comes under the history of Babylonia.

SUMERIAN CULTURE

In its heyday Sumer consisted of more than a dozen city-states. Each was a walled city surrounded by numerous villages and hamlets.

The City. Sumerian cities had from 10,000 to 50,000 inhabitants. Their streets were narrow and winding, without paving or drainage. Traffic moved either on foot or by donkey.

The outstanding feature of each city was the temple, situated on a high terrace and enclosing a high tower, known as a ziggurat. Its central room, or cella, had a niche for the god's statue as well as an offering table and was surrounded by rooms for the use of the priests. The temple's outer walls were built largely of mud brick. The columns of its courts and porticos were resplendent with colored geometric patterns composed of the painted heads of innumerable clay cones inserted in them. The shrine was at times decorated with wall paintings.

The average house was a small one-story mud brick structure with several rooms around an open court. There were also larger, two-story houses, the ground floor of which contained a reception room, kitchen, lavatory, servant quarters, and, sometimes, a private chapel.

Furniture consisted of low tables, stools and high-backed chairs, and beds with wooden frames. The household pots and pans had various shapes and were made of clay, stone, copper, or bronze. Baskets and chests were made of reed and wood. Floors and walls were adorned with reed mats, skin rugs, and woolen hangings. Below the house might be the family mausoleum, where the dead were buried with some of their belongings for use in the Nether World.

Political Power. In theory the entire city belonged to the god to whom it had been assigned on the day the world was created. In practice, however, most of the land belonged not to the temple but to the citizens—farmers and cattle breeders, boatmen and fishermen, merchants and scribes, artisans and craftsmen. Political power originally lay in their hands, and the city governor was no more than a peer among peers.

As the danger of attack by the surrounding peoples increased, kingship came into being, and the king acquired paramount importance. The

Sumerian ruler was a vicar of the gods. His duties were to defend the land from its enemies and enlarge its territory and influence, to improve the irrigation system so essential to its prosperity, to build and repair roads, and to preserve law and justice.

Society. The basic unit of Sumerian society was the family, and marriages were arranged by parents. The betrothal became legal as soon as the groom presented a bridal gift to the father. A wife could hold property, engage in business, and qualify as a witness. But she might be divorced on light grounds, or, if she should have no children, the husband could take a second wife. Children were under the absolute authority of their parents and could even be sold into slavery.

Slaves, originally prisoners of war or impoverished fellow citizens, could be flogged and branded. But they could engage in business, borrow money, buy their freedom, and marry a free person, thus ensuring the freedom of their children.

Technology. Some of Sumer's most far-reaching achievements involved irrigation and agriculture. Engineers constructed intricate systems of canals, dikes, weirs, and reservoirs, and they used leveling instruments, measuring rods, and maps in preparing plans and surveys. Their arithmetic was based on the number 60 rather than 10 and had a form of place notation. Measures were standardized.

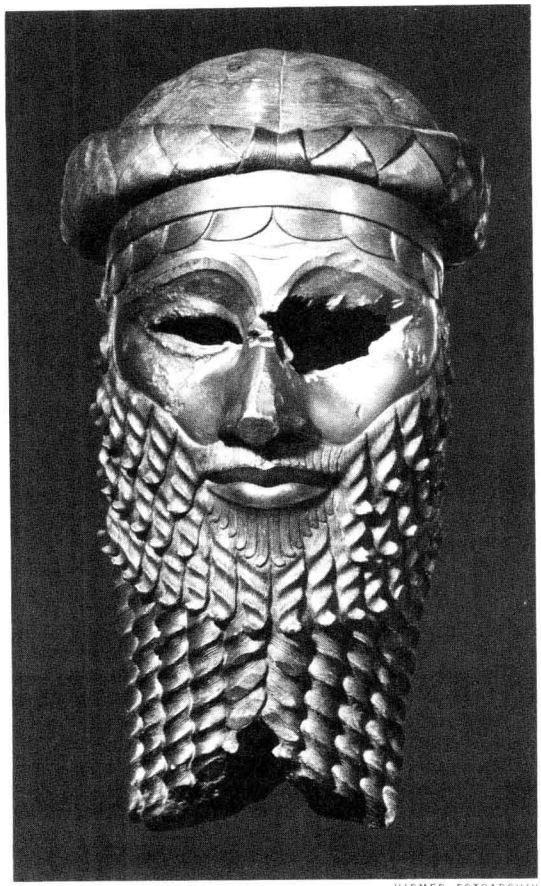
Farming developed into a complex, systematized technique. Farmer almanacs were prepared and used as texts in Sumerian schools. Sumerian craftsmen were skilled in metallurgy, fulling, bleaching, dyeing, and preparing paints, pigments, cosmetics, and perfumes. The Sumerian physician made use of an assortment of botanical, zoological, and mineralogical ingredients as *materia medica* in his prescriptions.

Religion. The Sumerians worshiped a pantheon of gods of diverse rank and character. The four leading deities were An (Heaven), Ki (Earth), Enlil (Lord Air), and Enki (Lord of the Deep). Ranking lower in the hierarchy were the gods in charge of the sun, moon, stars, and planets, and of wind, rain and tempest. In addition, there were many lesser deities in charge of the numerous natural and cultural phenomena that constitute the cosmos. The great gods' chief instrument of creation was the divine word, which once pronounced could not be altered. The *me*, or universal laws that even the gods had to obey, kept the universe in continuous, harmonious operation.

The Sumerian believed that man had been fashioned of clay and created solely to provide the gods with food and shelter. Ignorant of his destiny and haunted by insecurity, he sought salvation by praying to his personal god, a kind of good angel. In death, the ghostlike spirit descended to the Nether World, where existence was a dismal reflection of life on earth.

Prayers, offerings, and sacrifices were rendered to the gods at the temple, which had a large priestly personnel. The most joyous festival was the prolonged New Year celebration, which culminated in a sacred marriage—actually a fertility rite—between the king, in the role of the god Dumuzi, and Inanna, goddess of love and procreation.

Mythology. The gods of Sumer resembled men in appearance and behavior, and a rich mythology concerned their deeds and misdeeds. One of the most striking myths is about the god Enlil and his beloved, Ninlil. She followed him to the Nether World, to which he had been banished by the other gods. Several myths concern Enki, the divine culture hero, who brought civilization to mankind and saved man from destruction by the Flood, but who almost suffered death after eating the forbidden plants of Dilmun, the paradise of the gods. The deity that most inspired poets was Inanna, the ambitious and cruel but not unattractive goddess who descended to the Nether World in disregard of the divine laws. She reascended to the earth only after her husband, Dumuzi, took her place in the "Land of No Return"—hence the wailing for Dumuzi prevalent throughout the ancient Middle East.



HIRMER FOTOARCHIV

BRONZE HEAD from Nineveh is believed to represent King Sargon, founder of the Akkadian dynasty.

The Arts. Religion inspired much of Sumerian art, such as temple statues, plaques, friezes, decorative inlays, and engraved cylinder seals. The sculptors modeled the temple statues in both abstract and naturalistic styles. Men were bearded or clean-shaven and wore a flounced skirt, sometimes covered by a long cloak, or a long shirt with a fringed shawl wrapped over it. Women had pigtails wound about the head and wore long tufted dresses that left the right arm bare.

Music, too, was largely temple-inspired, but song accompanied by instrumental music also resounded in the palace during feasts and celebrations. Beautifully constructed harps and lyres have been recovered from the royal tombs.

UNIVERSITY MUSEUM, PHILADELPHIA

GIRAUDON

Bull's head (*above*) is a detail of a harp from Ur. Seated statue (*right*) is of Gudea, governor of Lagash.

Of thousands of Sumerian clay tablets that have been recovered, the majority are administrative, legal, and economic documents. About 5,000, however, are Sumerian literary works, such as myths, epics, hymns, laments, proverbs, precepts, fables, dialogues, and disputations.

Language, Writing, and Education. Sumerian was an agglutinative language, resembling Turkish and Hungarian in some of its structural and grammatical features. The most important Sumerian contribution to civilization was the development of the cuneiform system of writing this language. Later, other languages also were written in cuneiform.

The writing, which was done on clay tablets, originated about 3000 B. C. with a series of pictographic signs devised by Sumerian temple administrators for the purpose of keeping their accounts. It was used at first only to inscribe the simplest memoranda and notations. Over the centuries, however, it became a phonetic system of writing in which each sign stood for one or more syllables. See also CUNEIFORM.

Learning to read and write the complex cuneiform syllabary required years of attendance at the Sumerian school, called the "tablet-house." The head of the school was the "school father," the professor was known as the "expert," and assistants were "big brothers." The students, or "school sons," came from well-to-do families, but the tuition was probably minimal.

Teaching methods were dull and uninspiring. Discipline was harsh, and "drop-outs" were numerous. The curriculum consisted primarily of copying and memorizing long lists of words and phrases. Other major subjects were mathematics and literature.

Sumerian Character. A psychological drive for power and prestige colored the Sumerian character and was responsible in large part for the civil and foreign wars that finally destroyed Sumerian political power. Polarized into poor and rich and weak and strong, Sumerian society professed such ideals as justice, equity, and compassion, but injustice, inequity, and oppression abounded. The short-sighted Sumerians upset nature's delicate ecological balance by overirrigating their fields and orchards and thus "salted" and "silted" them into sterility. There is evidence also that Sumer suffered from cheating merchants and the "generation gap" between parents and children, teachers and students.

Despite these failings and shortcomings, Sumer dominated the ancient world spiritually and culturally for more than a millennium. Observant, reflective, and pragmatic, the Sumerians evolved a way of life that struck a balance between reason and fancy, freedom and authority. As a consequence, they made outstanding technological and ideological breakthroughs.

The Legacy of Sumer. It is now generally agreed that Sumer was in some respects the cradle of civilization. Among the Sumerian contributions to human development are such technological devices as the potter's wheel, the wheeled vehicle, the sailboat, and the seed plow. Sumerian temples and ziggurats are architectural prototypes of the synagogue, church, and mosque. The Sumerians were the first to develop a system of writing. The first coherent musical system centering on a diatonic scale can also be traced back to Sumerian sources. The city-state originated in Sumer, and Sumerian written law is the forerunner of Biblical, Greek, and Roman law. The division of the circle into 360 degrees and of the hour into 60 minutes of 60 seconds goes back to the Sumerian sexagesimal (base 60) system of numbers.

Judaeo-Christian ideas about the creation of the universe and man, the creative power of the divine Word, the Flood, the confusion of tongues, man's personal god, suffering and submission, death and the Nether World—all have their counterparts in Sumerian religious thought. Such Biblical books as Psalms, Lamentations, Proverbs, and the Song of Songs have their forerunners among the Sumerian literary works.

DISCOVERY OF SUMERIAN CIVILIZATION

The existence of the Sumerians is entirely a discovery of modern archaeology and scholarship. The ancient Hebrews and Greeks knew the land of Sumer as Babylonia, the home of the Semitic-speaking Babylonians. This was also the belief of

the explorers and archaeologists who began excavating in the area in the early 1800's.

Most of the cuneiform documents excavated in those early days were written in the Semitic tongue now known as Akkadian, and the Semites were therefore assumed to have been the original inhabitants of the land and to have invented cuneiform. As study of the documents progressed, it became apparent that there were no signs for certain characteristic Semitic sounds, such as guttural and emphatic stops. Moreover, some of the excavated tablets were recognizably bilingual, with Semitic translations of words and phrases of a language that was not Semitic in vocabulary or structure.

In 1869, the French scholar Jules Oppert suggested that the name of the people who spoke this strange tongue was found in the inscriptions of the early rulers, who were designated "kings of Sumer and Akkad." Since Akkad, he argued, certainly referred to a Semitic land, Sumer must be the name of the non-Semitic land whose people, the Sumerians, originated cuneiform.

Not all scholars accepted Oppert's identification, but soon the French excavations at Lagash, which began in 1877, started to unearth what were to be thousands of Sumerian clay tablets and many statues and plaques. Twelve years later the Americans began digging at Nippur, where some 3,000 Sumerian literary tablets and fragments were unearthed. Since then excavations in various sites have uncovered Sumerian temples, palaces, and other buildings, as well as innumerable artifacts and inscriptions. As a result, the Sumerians are becoming one of the best-known peoples of the ancient world.

SAMUEL NOAH KRAMER
Author of "History Begins at Sumer"

Bibliography

Edwards, I. E. S., and others, eds., *The Cambridge Ancient History*, 3d ed., vol. 1 (Cambridge 1980).
Kramer, Samuel Noah, *History Begins at Sumer* (1959; reprint, Univ. of Pa. Press 1981).
Kramer, Samuel Noah, *In the World of Sumer: An Autobiography* (Wayne State Univ. Press 1986).
Kramer, Samuel Noah, *The Sumerians: Their History, Culture, and Character* (Univ. of Chicago Press 1971).
Lloyd, Seton, *The Archaeology of Mesopotamia: From the Old Stone Age to the Persian Conquest*, rev. ed. (Thames & Hudson 1984).

SUMMARY COURT-MARTIAL. See COURT-MARTIAL.

SUMMARY JUDGMENT, in law, a means of obtaining a judgment in a civil lawsuit where there appears to be no triable issue. This avoids waiting the usual period of months, or even years, for the case to be reached on the regular trial calendar. The procedure is often used in the United States in both state and federal courts. It was developed to prevent a defendant who had no defense from delaying judgment—often in an effort to put his property out of reach of the plaintiff—by filing a sham answer and demanding a jury trial. The procedure was later expanded to include the much rarer case in which the defendant proved that a plaintiff had stated a sham claim for some ulterior purpose.

Defenses: Sham or in Good Faith? In a typical case, the plaintiff who claims a right to an immediate judgment without waiting for the case to be reached on the regular trial calendar makes a motion for a summary judgment. It is not enough for the plaintiff merely to charge that the other party's defense is without merit; to expose a sham denial he must first produce evidence, usually by means of affidavits, tending to prove that the facts alleged in his own statement are probably true. If the defendant making the denial produces evidence tending to show that the facts adduced by the plaintiff are not true, the motion is denied and the case must await its turn on the trial calendar. If, however, the defendant does not produce evidence to support his denial, the motion for summary judgment is granted.

In order to expose a sham statement of claim or defense, the party making the motion must produce evidence tending to prove that the other side's statement is false. If he fails, the motion is denied, and the case must be tried in regular course. If he succeeds, the party making the statement must then produce evidence to support its truth. If no such proof is forthcoming, judgment will be rendered immediately.

Basis for Summary Judgment. In summary judgment proceedings, supporting and opposing affidavits must be made on personal knowledge by persons competent to testify and must contain facts admissible in evidence. Generally a summary judgment is justified only if no material issue of fact survives the pleadings, affidavits, and depositional proof. If questions of fact appear, a trial is required.

English and American Legislation. Application of an 1855 English statute on summary judgments was limited to action on bills of exchange and promissory notes. Before the adoption in 1938 of the federal rules of civil procedure for the district courts of the United States, summary judgment procedure was not available in all types of cases. The first provision in California, for example, authorized the procedure only "in an action to recover upon a debt or upon a liquidated demand including an action to enforce or foreclose a lien or mortgage." The federal rules were the first to provide that the procedure should be available in every type of action without restriction.

WILLIAM WIRT BLUME
Author of "American Civil Procedure"

SUMMARY JURISDICTION. See SUMMARY JUDGMENT.

SUMMER, one of the four seasons. The seasons result from the tilt of the earth's axis to the plane of its orbit. As the earth moves around the sun, the relative lengths of day and night at a given latitude on earth—and hence the amount of solar heat received there—go through a yearly cycle of changes that man has divided into four periods, or seasons. Summer, on the average, is the warmest of these periods.

In the Northern Hemisphere, summer begins on the summer solstice (about June 22), when the hemisphere faces the sun most fully. Because the earth stores summer heat, the hottest days tend to occur about two months later. The season ends on the autumnal equinox (about September 22), when the hemisphere begins to be tipped away from the sun. In the Southern Hemisphere, summer begins about December 22 and ends about March 21.

SUMMER SOLSTICE. See SOLSTICE; SUMMER.

SUMMER SQUASH. See SQUASH.

SUMMERSIDE is a town on the south shore of Prince Edward Island, Canada, on Bedeque Bay of Northumberland Strait, about 40 miles (64 km) west of Charlottetown. It is the center of an agricultural region in which fox farming is important.

Daniel Green, a Quaker Loyalist from Pennsylvania, was the first settler (1780), and the growing community was called Green's Shores. In 1840 an inn, the Summerside House, was opened, and its name was stamped on mailbags for the town, which became known as Summerside. Population: 7,828.

SUMMIT, a village in northeastern Illinois, in Cook county, is about 10 miles (16 km) southwest of the center of Chicago. The village has a large corn refinery and makes corn products. Summit is situated on the low divide between the Great Lakes and the Mississippi River. It was incorporated in 1890. Government is by mayor and council. Population: 10,110.

SUMMIT, a city in northeastern New Jersey, in Union county, is about 10 miles (16 km) west of Newark. It includes the crest of First Watchung Mountain, a ridge that was an observation point for the Americans during the Revolution. Summit is a residential community and a shopping center for a large area. It also has chemical, pharmaceutical, and synthetic-fabrics laboratories. Publishing and insurance are also important to the economy.

Summit was settled in 1795. It was incorporated as a township in 1869 and as a city in 1899. Government is by mayor and council. Population: 21,071.

SUMMONS, in American law, a formal document that gives notice to a person, in a criminal case, to appear in court to answer a charge against him or informs him, in a civil proceeding, that an action is being started against him.

Although, in form, it often resembles a court order, a summons is rarely issued by a judge. Policemen usually issue criminal summonses, and lawyers usually issue civil summonses.

Although a criminal summons is best known for its use in traffic cases, in which it is called a "ticket," it is also used for alleged violations of municipal ordinances, such as those relating to sanitation and building safety. Experimental projects, such as one conducted in 1964 by the Vera Institute of Justice in association with the New York City Police Department, have established the utility of issuing summonses in other minor criminal matters, for example, in shoplifting. This avoids unnecessary incarceration and allows the policeman to remain on his beat. See ARREST.

A civil summons usually contains notice of what will happen if the person served fails to contest the action. In most cases the consequence is entry of a judgment for the amount of damages claimed. This requires proof that the summons was served as required by law. Sometimes corrupt professional process servers are shown to have engaged in "sewer service," the term given to the practice of filing false affidavits when actually the summons was never served on the designated person.

RICHARD A. GREEN, *Director, American Bar Association Project on Standards for Criminal Justice*

SUMNER, Charles (1811–1874), American political leader. In a long career in the U.S. Senate, he was a powerful, articulate opponent of slavery, and he labored devotedly to secure the equal rights of black men. Always guided by moral conviction, Sumner embodied the Puritan spirit in politics.

Early Career. Sumner was born in Boston on Jan. 6, 1811. He was brought up in an atmosphere of frugality, industry, and piety and was given the best education available—at the Boston Latin School, Harvard College, and Harvard Law School, receiving his law degree in 1833. Admitted to the bar in 1834, he was more interested in legal theory than in his practice, and in 1837 he went to Europe to study judicial institutions.

Returning to America in 1840, Sumner found Boston provincial and his law practice tedious. Friends sought to interest him in civic affairs. Sumner eagerly embraced humanitarian causes and in 1845 proclaimed himself a reformer in an Independence Day address attacking all war. The social ostracism that followed had its compensations. His dedication to principle won the admiration of such reformers as Theodore Parker and William Lloyd Garrison.

Election to the Senate. The issues of slavery and territorial expansionism led Sumner into politics. He became one of the "Conscience Whigs," who tried unsuccessfully to pledge the Massachusetts Whig party to a strong antislavery stand, but bolted the party in 1848 and supported Martin Van Buren, the presidential candidate of the Free Soilers. A coalition of Democrats and Free Soilers gained control of the Massachusetts legislature and in 1851 elected Sumner to the U.S. Senate seat he was to occupy until his death.

In the Senate, Sumner was a member of a tiny antislavery minority. In 1852 he proposed repeal of the Fugitive Slave Act of 1850, arguing that while freedom was national, slavery was sectional and no federal act should give it recognition. Stephen A. Douglas' Kansas-Nebraska bill of 1854 revived the slavery issue in Congress, and Sumner was among those who fought what they considered a new example of proslavery aggression. Though unable to defeat the bill, they aroused the North and organized the antislavery men into the newly formed Republican party.

Assault by Brooks. On May 19 and 20, 1856, Sumner delivered an oration in the Senate called "The Crime Against Kansas." He characterized Sen. Andrew Pickens Butler of South Carolina as a Don Quixote paying his vows to "the harlot, Slavery," and branded Douglas as Sancho Panza, "the squire of Slavery . . . ready to do its humiliating offices." On May 22, after the close of the day's session, Sumner was confronted at his desk by a tall stranger, who said, "I have read your speech twice over carefully; it is a libel on South Carolina, and Mr. Butler, who is a relative of mine." Down on Sumner's head crashed a heavy cane. Sumner tried to rise while blows rained upon him. At length he fell bleeding and unconscious in the aisle. His assailant was Rep. Preston Smith Brooks of South Carolina. See also BROOKS, PRESTON SMITH.

The assault evoked sympathy for Sumner throughout the North, even among those who had hitherto deplored his extremism. Sumner visited doctors in Europe and America and underwent a cauterization of the spinal skin tissue.

Not until 1859 was he able regularly to resume his Senate seat. To many Northerners his vacant chair spoke eloquently of the evils of slavery; to most Southerners, his illness seemed "shamming" for political purposes. There is some medical opinion that his ailments were psychosomatic.

Civil War. On June 4, 1860, Sumner delivered before the Senate a massive indictment of "The Barbarism of Slavery." When Lincoln's election precipitated secession, Sumner at first welcomed this opportunity to rid the nation of slavery. But when secession led to war, he strongly supported the Union effort.

Sumner was made chairman of the Senate Committee on Foreign Relations in 1861. During the war his personal acquaintance with European leaders helped him plead the Northern cause abroad and transmit, unofficially, the views of European statesmen to President Lincoln. His moderating role was seen in the *Trent* affair of November-December 1861, when he persuaded Lincoln to release two Confederate envoys seized from a British vessel. Sumner, however, could not forgive the English for their allegedly pro-Southern conduct, and after the war he pressed for claiming a staggering amount in wartime damages.

A Radical Republican, Sumner sought to repeal all fugitive slave laws, to abolish slavery in the District of Columbia, and to create a Freedmen's Bureau as "a bridge from slavery to freedom." Though he respected Lincoln's good intentions, he thought the President dilatory.

Postwar Career. Toward Lincoln's successor, Andrew Johnson, Sumner felt neither loyalty nor respect. Attacking Johnson's moderate reconstruction plans, he declared that the Southern states in seceding had committed suicide, and called for a thorough reorganization of Southern society. He proposed that the freedmen should be given homesteads carved out of their former masters' estates and that state legislatures should be required to maintain a system of public schools open to all races. Because President Johnson opposed these Radical measures, Sumner considered him "a public enemy," and he supported the impeachment proceedings against Johnson in 1868.

At the same time Sumner came increasingly to differ with members of his own party. His devotion to "absolute human equality" seemed pious eyewash to the new generation of Republicans, who considered him archaic and pedantic.

Almost from the outset Sumner opposed President Grant's administration. When Grant considered annexing Santo Domingo, Sumner said this would lead to a "dance of blood." Secretary of State Hamilton Fish learned that Sumner's extreme position regarding wartime claims against Britain was jeopardizing their settlement, and he concluded with Grant that Sumner was untrustworthy. In 1871 the executive department supported Sumner's senatorial foes, who removed him as chairman of the Foreign Relations Committee.

Sumner was now without a party. He was also alone. His wife had left him within a year of their marriage in 1866. He supported Horace Greeley against Grant in 1872, but his influence was not sufficient to help his candidate. Thereafter a heart condition prevented Sumner from taking an active part in Congressional proceedings. His motion in 1872 to strike the names of Civil War battles from the regimental colors angered Northern veterans. The Massachusetts legislature condemned the resolutions, but loyal followers succeeded in having the vote rescinded.

Sumner made his last Senate appearance on March 10, 1874. He died of a heart attack the next day. His body lay in state in the Capitol rotunda before burial in Cambridge, Mass.

DAVID DONALD, *Johns Hopkins University*

Further Reading: Donald, David, *Charles Sumner and the Coming of the Civil War* (Univ. of Chicago Press 1981); id., *Charles Sumner and the Rights of Man* (Knopf 1970); Pierce, Edward L., *Memoirs and Letters of Charles Sumner*, 4 vols. (1894; reprint, Ayer 1969); Storey, Moorfield, *Charles Sumner*, ed. by John T. Morse, Jr. (1900; reprint, AMS Press 1969).

SUMNER, James Batcheller (1887–1955), American biochemist, who was awarded the 1946 Nobel Prize in chemistry for his work on enzymes. He shared the award with two other American biochemists, John Howard Northrup and Wendell Meredith Stanley, who also worked on enzymes.

Sumner thought that enzymes were proteins and set out in 1917 to prepare a pure enzyme. Since jackbean meal (*Canavalia ensiformis*) is rich in the enzyme urease, which is easily detected because of its capacity to liberate ammonia from urea, Sumner set out to identify the various components of the meal. In 1926 he succeeded in isolating tiny crystals that showed very strong urease activity as well as satisfying the various tests for proteins. His discovery that enzymes were proteins was not accepted for several years, but in 1930, Sumner's position was confirmed when Northrup crystallized three other enzymes —pepsin, trypsin, and chymotrypsin—and showed that they were proteins.

Sumner was born in Canton, Mass., on Nov. 19, 1887, and educated at Harvard, where he received his Ph.D. in 1914. He took a biochemistry position in the Cornell Medical School, where he remained until a few weeks before his death in Buffalo, N. Y., on Aug. 12, 1955.

AARON J. IHDE, *University of Wisconsin*

SUMNER, William Graham (1840–1910), American sociologist, who was one of the first and most influential teachers of sociology in the United States. Sumner was born in Paterson, N. J., on Oct. 30, 1840, graduated from Yale University in 1863, and was ordained an Episcopal priest in 1869. His concern with economic, political, and social problems caused him to give up his parish in Morristown, N. J., and return to Yale University as professor of political science in 1872. His principal interest was in teaching. His first and most influential book, *Folkways*, was not published until 1907, three years before his death in Englewood, N. J., on April 12, 1910. His other writings were published as *The Science of Society* (4 vols., 1927–1928).

In *Folkways*, Sumner maintained that people's behavior in society is governed by two types of rules that evolved gradually through trial and error. They are called *folkways* if they tend to be obeyed routinely, as a matter of conditioning and habit. Thus folkways determine how people dress, what foods they eat, or the other things they do to conform to a certain way of life. General conformity is ensured because folkways are the socially accepted forms of behavior.

The second type, *mores*, are rules that are crucial to the very survival of the group or society. Violations of the *mores*—for example, cannibalism or incest—are strongly censured. Mores, if institutionalized, became laws.

In Sumner's view the basic problem for any

society is its continued existence. Folkways and mores protect a group. They give it coherence and security. Members of a group are loyal to it because they consider their own mores and folkways superior to that of any other group. This attitude Sumner calls "ethnocentrism."

As a theory, Sumner's approach is usually referred to as a form of social Darwinism or evolutionism. It assumes constant conflict and competition between groups. Social phenomena—for example, folkways and mores—are explained as functioning primarily for the survival of the group. This view has been criticized on two grounds. First, its assumptions are too one-sided because group relationships include cooperation as well as conflict. Secondly, its conclusions are not confirmed by fact. There are instances in which the mores of a group are detrimental to its survival. See also FOLKWAYS AND MORES.

RUTH HEYDEBRAND, *Washington University*

SUMO. See under JAPAN—*Sports and Recreation* (Traditional Sports); MARTIAL ARTS.

SUMPTUARY LAWS, sum'chə-wer-ē, are laws that attempt to regulate or restrict excessive expenditures by private individuals for food or drink, dress, personal adornment, or other luxuries. The theories behind the laws have been economic, social, moral, or religious, but all have proved difficult or impossible to enforce for long. The chief modern example was the 18th Amendment to the U.S. Constitution, which from 1919 to 1933 banned the sale of alcoholic beverages.

Early Experiments. In the 6th century B. C. the laws of Solon limited lavish Athenian funerals and weddings. Three centuries later, other edicts regulated the amount of jewelry and the quality of gowns worn by Roman matrons. But by the 2d century A.D. the Emperor Tiberius was quoted by Tacitus as confessing that "sumptuary laws are in disgrace . . . and by moderate penalties the evil could not be suppressed."

Varied Motives. The Greek and Roman laws stemmed from the conviction that extravagance was injurious to public policy, undermined the morale of the citizen, and distracted him from his public duties. In medieval Europe excessive displays of riches or exotic food and drink were considered pagan threats to the Christian's soul. Rulers strove to control even such details as lengths of robes, heights of headdresses, and points of shoes. Sumptuary laws also enforced social distinctions within the feudal system. Thus, in England, the quality of textiles permitted for wearing apparel was strictly graded. The greatest lords were entitled to finest quality linens and woolens with bright colors, yeomen could have durable but drab fabrics, and villeins could wear rough worsteds. In the 14th century a law of the English King Edward III decreed that because indulgence in costly meats was impoverishing many subjects and preventing them from meeting their feudal obligations all classes should limit such viands to two per course, with only two such courses per meal.

Moral Function. Although the modern age, under the gradual influence of democratic ideas, made many of these distinctions obsolete, the moral function of sumptuary laws remained strong. In the New World the Puritans, although primarily stressing religious conformity, had shared this view. In 1634 the Massachusetts General Court, because of "the greate, superfluous and unnecessary expenses occasioned by some new and immodest fashions," prohibited a list of luxury imports. Virginia in 1662 banned commodities such as "silk stuffe in garments" and "ribbands wrought with silver or gold." The 18th century French philosopher Montesquieu wrote that laws limiting the right to indulge individual tastes were beneficial because they preserved "the proportion between our wants and the means of satisfying them."

Frontier austerity and democracy rendered sumptuary laws largely irrelevant in 19th century America, and the rise of free enterprise capitalism and mass production of consumer goods throughout the Western world rendered them generally obsolete. See also BLUE LAWS.

WILLIAM F. SWINDLER
School of Law, College of William and Mary

SUMTER, Thomas (1734–1832), American Revolutionary officer. Sumter was born near Charlottesville, Va., on Aug. 14, 1734. He fought in the French and Indian War, and in 1765 he settled near Eutaw Springs, S. C.

When the British conquered South Carolina in 1780, Sumter organized an irregular force and aided considerably in reconquering the colony. After the war he founded Stateburg, S. C., and served in the U. S. House of Representatives and the Senate, retiring in 1810. Sumter died near Stateburg on June 1, 1832.

SUMTER, a city in central South Carolina, the seat of Sumter county, is 44 miles (70 km) southeast of Columbia. It is the commercial center of an agricultural area that raises cotton and soybeans. Sumter's industries include food-processing, chemical, lumber, furniture, and textile plants, foundries, and machine shops.

Morris College and a branch of Clemson University are in Sumter. The Iris Gardens in the city produce magnificent blooms in May and June. Poinsett State Park is nearby.

Incorporated in 1845 as Sumterville and named for Thomas Sumter, a Revolutionary War officer, it was chartered as a city in 1887 and the name changed to Sumter. Government is by council and manager. Population: 24,890.

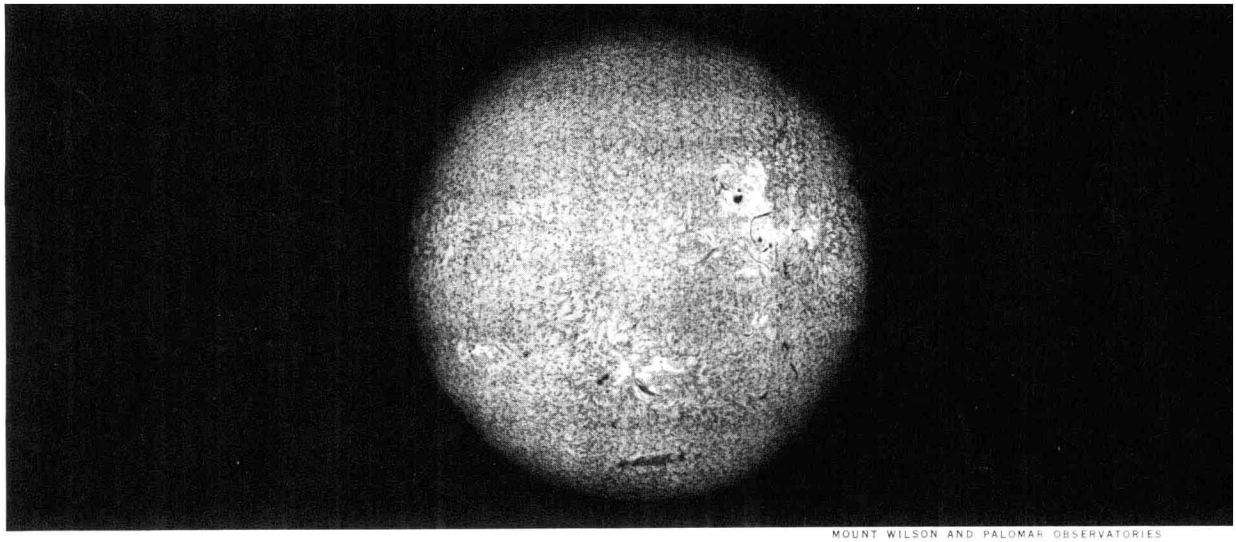
CHAPMAN J. MILLING, JR.
Sumter County Library

SUMTER, Fort. See FORT SUMTER NATIONAL MONUMENT.

SUMY, sōō'mē, is a city and oblast in the USSR. The city is on the Psel River, 90 miles (145 km) northwest of Kharkov. The capital of the oblast, it is the center of a sugar beet district and has a large sugar-refining industry. The city also produces machinery for chemical and sugar factories and manufactures woolen cloth, tobacco products, and superphosphate fertilizer.

Sumy oblast is in the northern part of the Ukrainian SSR and has an area of 9,200 square miles (23,800 sq km). It is in wooded steppe country, drained by the Sula and Psel rivers. The oblast is primarily agricultural, with wheat and sugar beets the main crops. Industry is largely limited to processing farm products, but there is a small oil field at Kachanovka. The principal cities are Sumy, Konotop, and Shostka. Population: (1979) of the oblast, 1,463,000; of the city, 228,000.

THEODORE SHABAD, *Editor, "Soviet Geography"*



MOUNT WILSON AND PALOMAR OBSERVATORIES

The sun's turbulent disk, viewed in a spectral zone showing hydrogen, is marked by several active regions.

SUN, the central controlling body of the solar system. It is by far the largest member of the system, being 740 times more massive than its nine major planets together and 10 times wider than the largest planet, Jupiter.

The sun's rays supply the earth with heat and light, contribute to the growth of plant life, evaporate water from the ocean and other bodies of water, play a role in the production of winds, and perform many other functions that are vital to the existence of life on earth.

As a star the sun is a typically yellow dwarf, inconspicuously located in a spiral arm near the outer edge of our Milky Way galaxy. In orbiting the center of the galaxy, it whirls toward the constellation Cygnus at a velocity of about 140 miles (220 km) per second. At the same time it speeds toward a point in the constellation Hercules at 12 miles (20 km) per second, in a transverse motion that is perpendicular to its galactic orbit. See STAR.

THE EVOLUTION OF THE SUN

Formation. The sun and its planets were formed several billion years ago from a cloud of interstellar matter. Because the sun contains a larger proportion of heavy elements such as iron than do many other stars, astronomers conclude that it is a second-generation star. This means that the gas cloud out of which the sun formed was itself the ashes of earlier stars that had burned out. See also SOLAR SYSTEM.

Local irregularities in the gas cloud formed the nuclei around which condensations began. After the condensations reached a certain critical density, they developed sufficient gravitational attraction to draw in ever-increasing amounts of matter from the surrounding volumes of the cloud. Eventually the proto-sun gathered in so much matter that its interior pressure and temperature became high enough for nuclear reactions to begin. Thus it became, in effect, a large hydrogen nuclear reactor, releasing energy in such quantities that condensation ceased.

By that time the sun was a stable object that could exist for a long time on its ample fuel supply. The tremendous forces produced by the release of energy within the sun, as hydrogen was transmuted to helium by nuclear reactions, were held in check by the equally strong and oppositely directed gravitational forces.

The Death of the Sun. Life cycles of stars are counted in billions of years. The sun has enough fuel to sustain its present rate of energy production for some 10 billion years. During that time it will change but little.

However, the solar fuel eventually will begin to be exhausted. At that time the sun will expand slowly, becoming cooler at its surface. Its luminosity will be greater because of the increase in size. The expansion process will accelerate until eventually the sun becomes a red giant star and then a red supergiant, perhaps 1,000 times more luminous than it is now. During this expansion phase the sun's core will be almost pure helium, but the burning of hydrogen will continue in a shell of ever-increasing radius around the core.

The core eventually will begin to collapse, igniting the helium. Theories of stellar evolution are uncertain about what will happen after the helium flash. However, it seems very probable that the flash will mark the beginning of an unstable stage during which the sun will eject a substantial portion of its mass back into space—there to begin a new life cycle as part of some future star. The remnants of the sun will ultimately collapse and condense to a relatively inert, low-luminosity state similar to that of white dwarf stars. In this form the sun will slowly burn out.

GENERAL CHARACTERISTICS

The sun is a glowing ball of gases about 865,000 miles (1,393,000 km) in diameter. In terms of relative mass, it consists of 69.5% hydrogen and 28% helium—an element first discovered on the sun. Carbon, nitrogen, and oxygen account for 2% of the mass, and magnesium, sulfur, silicon, and iron account for 0.5%. Other elements are present in the sun in trace amounts only.

Although the sun is gaseous throughout its entire structure, it appears to have a definite surface when viewed through a suitable filter. This is an illusion caused by the sun's great distance from the earth, which averages about 92,960,000 miles (149,660,000 km) from the center of the sun to the center of the earth. The distance actually varies through the year because the earth's orbit is slightly elliptical. Early in January, when the earth is closest to the sun, the distance is

about 91,400,000 miles (147,150,000 km). Early in July, when the earth is farthest away, the distance is about 94,500,000 miles (152,140,000 km).

As Galileo Galilei discovered in 1610, the sun rotates about an axis that is approximately aligned with the earth's axis. The rotational movement is from east to west, as viewed from the earth, and the speed decreases from a period of nearly 27 days at the solar equator to a period of more than 30 days near the poles. That is, the gaseous sun rotates more rapidly at the equator than at the poles.

This rotating ball of gases has a mass of 2.19×10^{27} tons (nearly 2×10^{30} kg), which is 330,000 times the mass of the earth. Its average density is 88 pounds per cubic foot (1.41 grams per cu cm), which is 1.41 times the density of water but only a little more than 0.25 times the average density of the earth. However, the sun's density increases greatly toward the interior. The gas pressure at the apparent surface is only $\frac{1}{10}$ that of the earth's standard atmospheric pressure at sea level, and its density is only about $\frac{1}{3,500}$ that of terrestrial air at sea level, but at the center of the sun the gases are highly compressed by the great mass of material above them. The gas density there is nearly 100 times the density of water, or nearly 9 times the density of lead, and the pressure is 200 billion atmospheres.

Temperature also increases toward the interior, from about 10,000° F (6,000° C) at the apparent surface to more than 18,000,000° F (10,000,000° C) at the center. Above the apparent surface the temperature first decreases to about 7,200° F (4,000° C) and then increases rapidly to more than 1,800,000° F (1,000,000° C) in the outer atmosphere of the sun.

The gravitational pull at the surface of the sun is 28 times as strong as the gravitational pull at the earth's surface. So strong is the sun's gravity that it exceeds the earth's gravitational pull for any object that is more than 160,000 miles (nearly 258,000 km) from the earth. Thus the moon experiences a stronger gravitational pull from the sun than from the earth.

SOLAR ENERGY

To appreciate the vastness of the power that is inherent in sunlight, one need only reflect that all the power represented in the winds and in dams and rivers and all the power contained in natural fuels such as wood, coal, and oil is nothing more than sunlight that has been stored up by a tiny planet 93 million miles away from the sun.

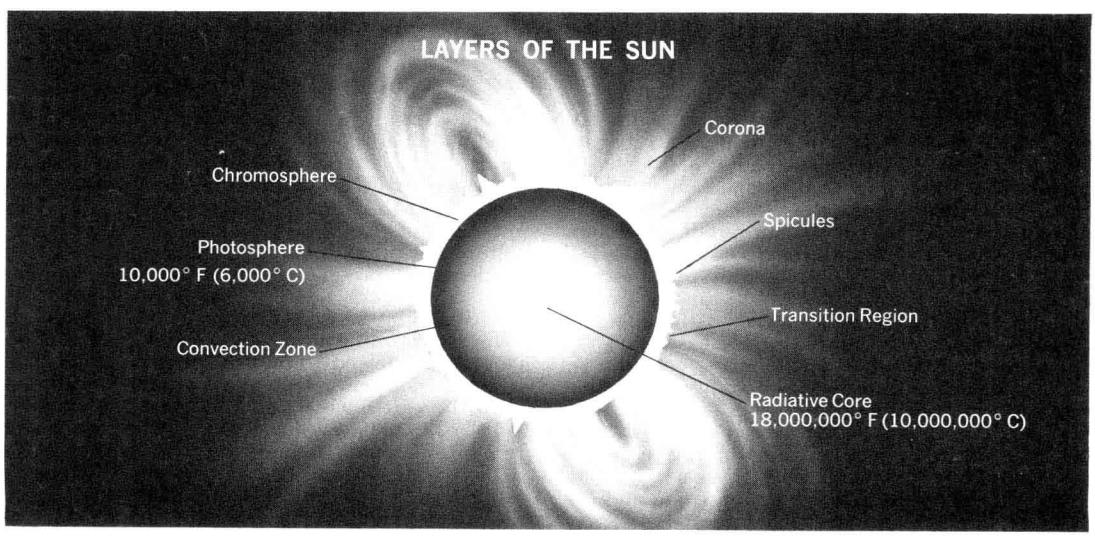
Energy Output. The sunlight received at the top of the earth's atmosphere supplies energy to the earth at the rate of about 2 calories per square centimeter (about 0.15 sq inch) per minute—a figure known as the *solar constant*. This amounts to a steady supply of 2.4×10^{14} horsepower (25.6×10^{14} kg-calories per minute) for the earth as a whole. Yet the earth intercepts only 2.2 billionths of the power generated by the sun. During observations made over a period of 50 years, this output of solar power has varied by no more than a few tenths of 1%.

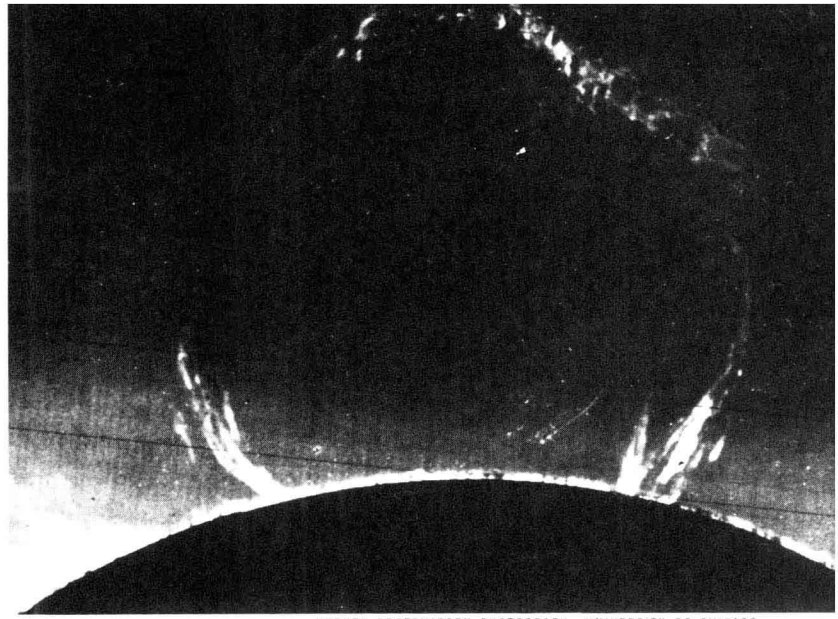
Source of the Sun's Energy. Scientists have recognized that only one known process, atomic transmutation, is capable of generating sufficient energy to maintain the sun's output of power. In fact, the first practical investigation into atomic energy was made as part of the attempt to explain the source of solar power.

The sequence of nuclear reactions within the sun was worked out independently in 1938 by the German-American physicist Hans Bethe and the German astronomer Carl von Weizsäcker. Two main cycles of reactions may be described, of which the most important is the *proton-proton reaction*. In this sequence, protons collide to form hydrogen nuclei, which in turn collide with further protons to produce unstable helium nuclei. The latter react and form stable helium nuclei, at the same time producing more protons and other subatomic particles. The net result of the cycle of proton-proton reactions is that hydrogen is transmuted into helium.

The *carbon cycle* is more complex but the net result is the same. Nuclei of heavier elements such as carbon, nitrogen, and oxygen are involved, but in the end it is the star's hydrogen

The relatively small height of the chromosphere is exaggerated. The corona extends into the solar wind.





YERKES OBSERVATORY PHOTOGRAPH, UNIVERSITY OF CHICAGO

LARGE PROMINENCE loops high into the coronal region. The material of the prominence moves along lines of force of the localized magnetic field, sinking back toward the sun.

supplies that are converted into helium. The proton-proton sequence apparently predominates in less massive stars such as the sun.

Thus the sun is a giant thermonuclear furnace that transforms hydrogen into helium, and energy released near the center of the sun continually pushes outward in an effort to escape. The force of this outward push is offset by the strong gravitational pull of the sun on the gases composing its outer layers.

Convective Cells. Most of the sun is in a highly stable configuration, and mixing of the solar gases is extremely slow. However, just below the apparent surface or *photosphere* the sun is convectively unstable. That is, it transfers heat in a circulatory process from hotter regions below to cooler regions above. Numerous convective cells in this region keep the gases in the outer layers well mixed.

The convective cells are manifest to telescopes on earth as small, bright *granules* and larger *supergranules* covering the "surface" of the sun. Because of their relatively small size and their importance in understanding the structure and interior processes of the sun, the granules present a challenging observational problem.

THE OUTER LAYERS

The most familiar solar phenomena, such as sunspots and prominences, take place in the outer layers of the sun.

Early eclipse observers were able to see the sun's extensive, pearly-white *corona* surrounding the obscuring disk of the moon. Bright, rose-colored *prominences* were sometimes seen extending above the edge of the moon's disk and into the corona. However, observational progress became more rapid after the introduction of photographic techniques at the eclipse of 1851. Thus in 1860 the Italian astronomer Angelo Secchi was able to prove that prominences in fact were part of the sun rather than of the moon, as early observers had tended to believe.

In 1869 the U. S. astronomers Charles Young and William Harkness discovered an unknown emission line superimposed on the continuous spectrum of the solar corona. Attempts to explain the processes that caused this strange new line and several similar lines discovered in following years were to lead to revolutionary concepts of the sun's atmosphere (see below, under the discussion of *Corona*).

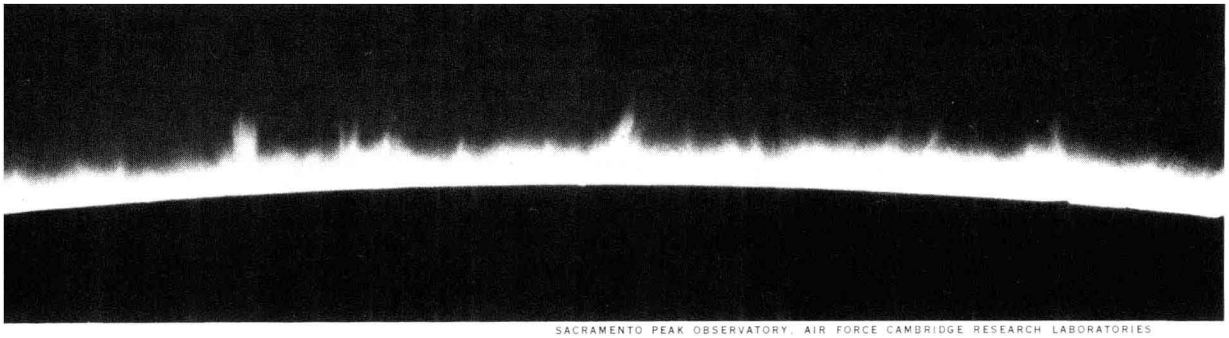
In 1870, Young also observed the spectrum of a shallow layer of gases between the photosphere and the corona—the so-called *reversing layer*—which flashed into view for a few seconds at the beginning and the end of a total eclipse. The region from which this flash spectrum arose was given the name *chromosphere*, because of its rosy-red appearance.

Since that time, eclipse observations have added a wealth of detail to the astronomer's knowledge of the chromosphere, corona, and prominences. In addition, instrument techniques have been developed that permit astronomers to observe the corona and other phenomena of the outer layers without waiting for an eclipse of the sun.

Chromosphere. The chromosphere is an irregular layer of gases, varying in depth from 1,000 to 10,000 miles (1,600 to 16,000 km). It extends upward from the visible edge of the sun—that is, the photosphere—to join with the overlying corona. At heights greater than 3,000 miles (4,800 km) above the photosphere, the extensions of the chromosphere consist almost entirely of small, high-speed jets of gas called *spicules*. These jets are ejected from the low chromosphere into the less dense corona.

A typical spicule "lives" only about 4 to 5 minutes. During this time it rises with a speed of about 17 miles (27 km) per second from its base at a height of about 1,000 miles to a maximum height of about 10,000 miles.

The spectrum of the chromosphere shows numerous bright emission lines that are produced by hydrogen and helium and by many neutral and ionized atoms of metals. Again, the temperature gradient is reversed in the chromosphere, so that temperature increases with distance outward from the sun. The exact manner of this temperature rise is fundamental to an understanding of solar processes. It can only be mentioned here that the temperature in the upper photosphere is at a minimum of about 7,200° F (4,000° C), and that it rises in the low chromosphere to about 10,800° F (6,000° C). In the high chromosphere the temperature is over 36,000° F (20,000° C).



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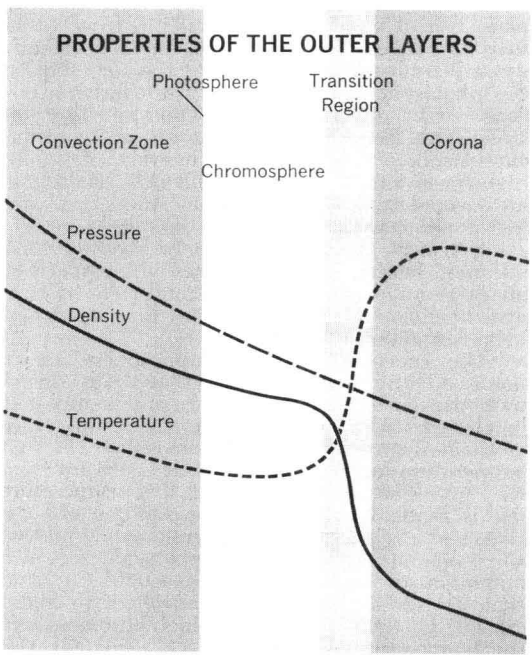
Spicules—rapid jets of gas—shoot up from the chromosphere into the corona, each lasting about 5 minutes.

Prominences. Solar prominences extend into the region of the corona. They appear to be similar in many respects to the chromosphere. That is, their spectra show emission lines of the same neutral and ionized atoms as do chromosphere spectra. However, different kinds of prominences show marked differences in the relative intensities of their spectral lines, a fact that indicates differences in temperature and density.

Knots of material in a prominence move predominantly downward, usually along gently curved trajectories that follow the lines of force in localized magnetic fields. Even though the matter in prominences is seen through telescopes to move downward, however, this does not mean that it is falling freely under the force of gravity. Instead, the magnetic forces that are present tend to balance the force of gravity and keep the downward velocity constant. And some kinds of prominences, such as eruptives, surges, and sprays, show a predominantly outward motion.

Prominences generally move at speeds of about 100 miles (160 km) per second. The fastest such motion ever observed was a surge that moved outward at 830 miles (1,330 km) per second. Since the velocity for escape from the sun is 380 miles (610 km) per second, this means that the material in the surge and similar fast-moving prominences escapes the sun's gravitational pull.

THE TRANSITION REGION of the sun's outer layers corresponds to the region in the photograph above in which brighter and darker gases merge. Gas pressure drops slowly from the convection zone to the corona, but temperature and density change sharply.



Corona. The corona is the tenuous outermost part of the solar atmosphere. In a total solar eclipse the corona shines with the brightness of the full moon, and may be seen extending out to several times the diameter of the sun. In fact, it extends beyond the orbit of Jupiter, thus encompassing the earth. At these distances it is very tenuous and is known as the *solar wind*, the effects of which are discussed below under *The Sun and the Earth*.

It has been mentioned that an unknown coronal line was discovered at the eclipse of 1869, and that this was followed by the discovery of other emission lines on the coronal spectrum. When astronomers failed to identify these lines with any known set of laboratory spectra, they were prompted to invent a new element, "coronium." It was not until 1940 that the Swedish physicist Bengt Edlen identified several of the lines with familiar terrestrial atoms—atoms subjected, however, to extremely "abnormal" conditions in terms of the earth's environment. Thus the "green" line discovered in 1869 was identified with iron atoms having 13 of their normal 26 electrons removed. Other lines were identified as iron atoms missing 9 to 14 electrons, and still others were identified with similarly stripped atoms of nickel, calcium, and argon. Such high stages of ionization, it was determined, require temperatures of about 1,800,000° F (1,000,000° C), and this was verified by other data.

It is these high temperatures that cause the corona to expand continually outward, forming the solar wind that sweeps past the earth into the far limits of the solar system. The high temperatures also produce intense amounts of X-rays and far ultraviolet photons, and give rise to intense noise-like signals at radio wavelengths. It is believed that the chromosphere and corona are heated by shock waves generated in the sun's subphotospheric convection zone.

SOLAR ACTIVITY

Sunspots are the most familiar example of solar activity, but the emphasis they are given as a measure of such activity arises primarily from the ease with which they are observed. Frequently a wide variety of complex phenomena, requiring refined observational techniques, are found in association with sunspots. These phenomena are referred to collectively as *solar activity*, and those regions that show a marked degree of activity are called *active regions*.