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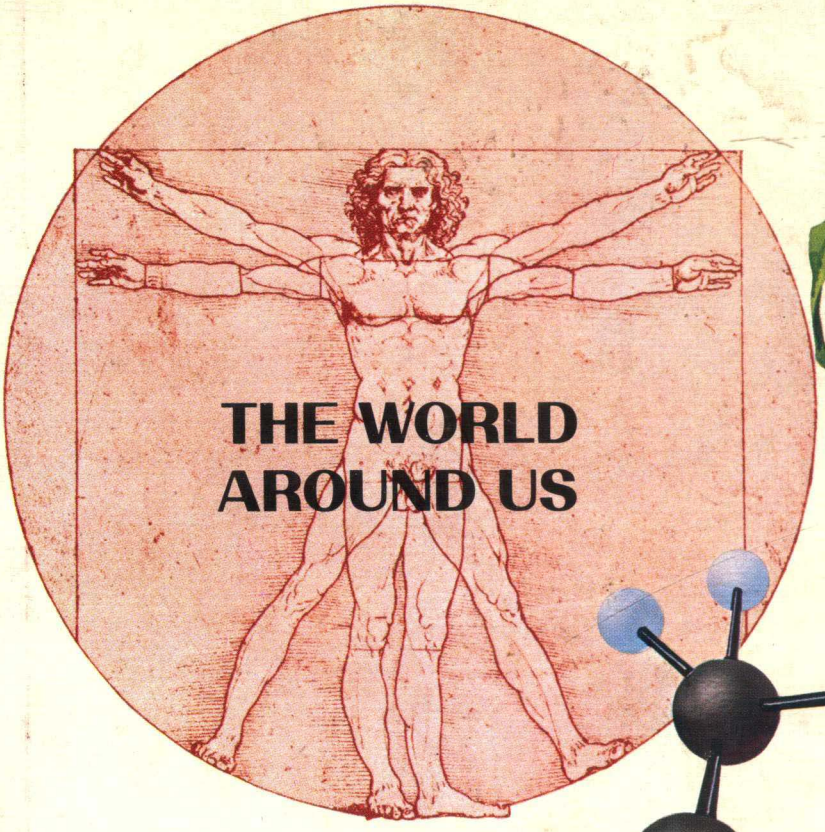

THE WORLD AROUND US

Science and Technology Illustrated

The World Around Us

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The World Around Us

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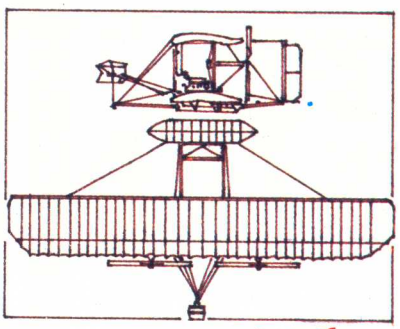
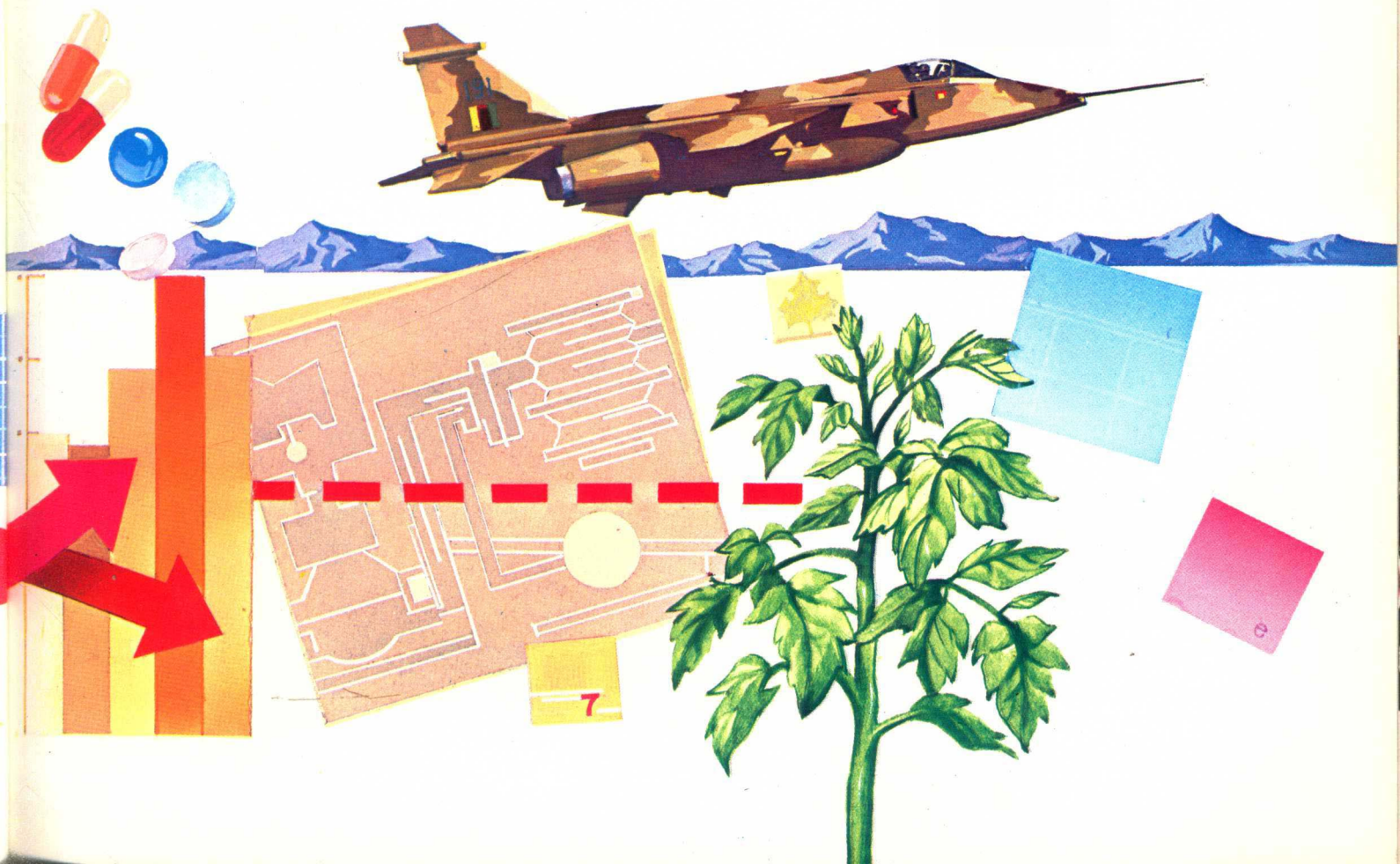




Steering, Automobile

Two tons of steel hurtling down the road at 80 feet (24 m) a second have a powerful tendency to continue moving in the same direction. To devise a suitable steering system to turn such a mass in a vehicle whose direction you control is not at all easy. It is not enough to set the body on four wheels and fashion some way of moving the front two to the right or left. This would enable you to control the movements of your vehicle at low speeds, but steering would be difficult and inefficient, and the car would have a tendency to wander. The tires would wear out rapidly, because they would scrape and slip against the road when turning. At high speeds, your vehicle would be dangerous, tending to skid on corners, and the shocks and bumps sustained by the car and transmitted through the steering wheel could knock your teeth out.

Much more is involved in steering a car than simple swiveling wheels; a car should be built to be precisely maneuvered, not merely aimed. The steering system converts the rotary motion of the steering wheel into the right-and-left motion of the front two wheels. Alignment refers to the various tilts and angles given the wheels to ensure safe handling, easy steering, and good wear on the car and tires.

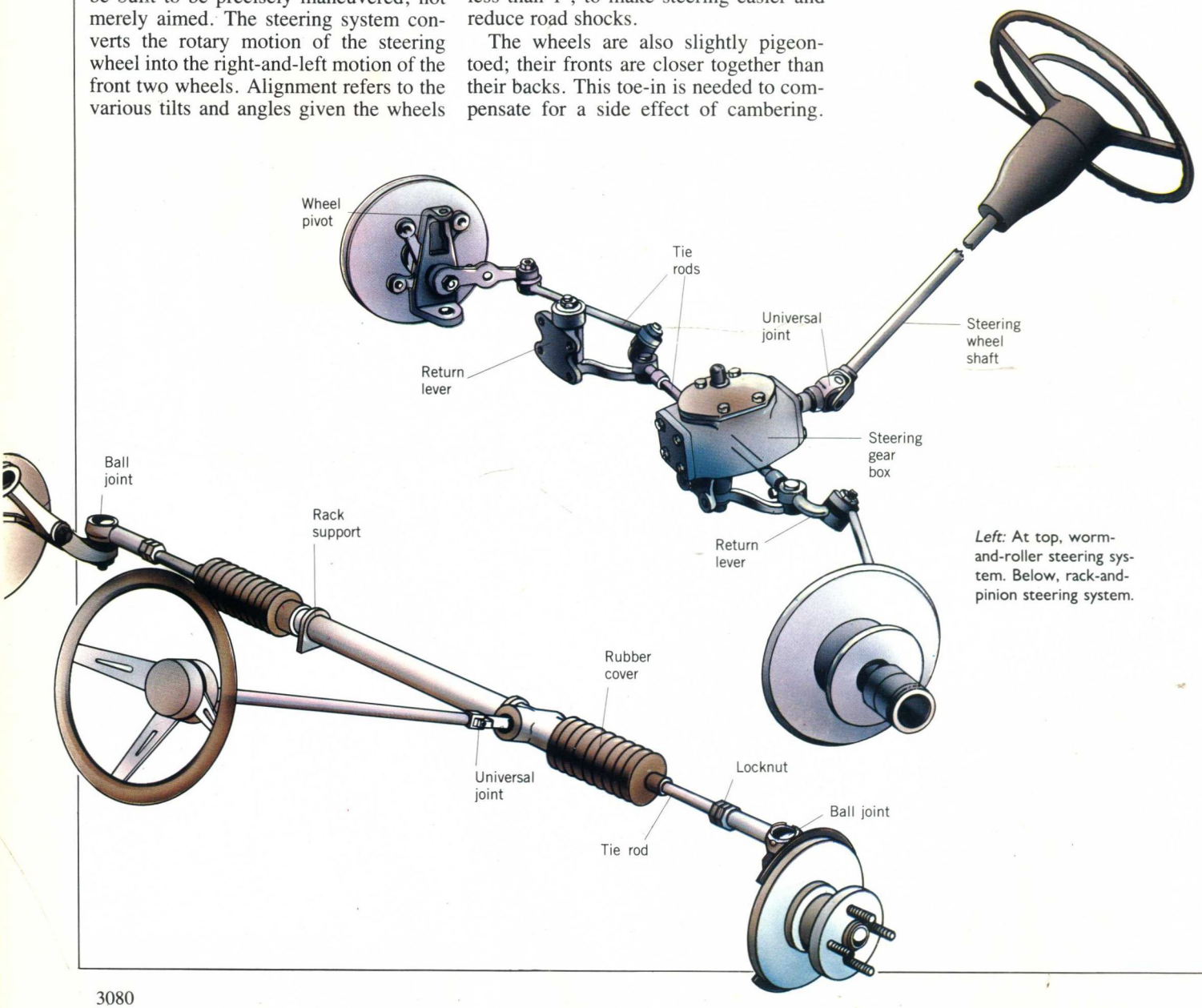
Wheel Joints

The contact between the wheels and the frame is called the wheel joint. On older cars, this joint is like a door hinge, with a huge pin—a kingpin—running through the hinge parts. On more modern cars, this joint is a steering knuckle, formed by a ball and socket that can swivel back and forth and up and down. Depending on how the wheels are hung from this joint, they may be tilted in one of several directions to improve their grip on the road as well as steering efficiency.

The front wheels, for instance, are not hung straight up and down, but are usually tucked in a little at the bottom. This is called positive camber; if they were closer at the tops, it would be called negative camber. Front wheels are given a small amount of positive camber, usually less than 1°, to make steering easier and reduce road shocks.

The wheels are also slightly pigeon-toed; their fronts are closer together than their backs. This toe-in is needed to compensate for a side effect of cambering. When a wheel is cambered, it contacts the ground at an angle and has a slight tendency to roll out away from the car when in motion. Tilting the front wheels inward as little as one-eighth to one-quarter of an inch (3-6 mm) eliminates this effect and makes steering easier.

Finally, the axis of the wheel joint itself may be tilted. It would seem natural that a wheel hinge should be absolutely vertical, like a door hinge. In fact the wheel hinge is often tilted slightly toward the rear of the car. This is called positive caster; in negative caster, this relation is reversed. The tiny swivel wheels on the legs of shopping carts are called casters, and they are actually examples of positive caster, for the swivel axis—the leg of the cart—is ahead of the wheel. Any push forward on the cart makes the wheels return to a straight-ahead position and pre-



Left: At top, worm-and-roller steering system. Below, rack-and-pinion steering system.

vents the cart from swerving. Positive caster has a similar effect on your car, helping the wheels line up straight after turns and keeping them that way during those brief moments of inattention all drivers have.

Gearbox and Linkage

With all these tilts, it is not surprising that the system of angles involved in alignment is often referred to as the steering geometry. The steering system itself has two basic parts: the steering gearbox, which converts the rotary motion of the steering wheel into the side-to-side motion, and the steering linkage, which carries this motion to the front wheels through the tie rods.

When a car turns a corner, the inner wheels travel a shorter distance than the outer ones, in the same way that a dancer on the inside of a swinging chorus line travels a shorter route than one nearer the end. The differential compensates for this on the drive wheels. Up in front, the steering linkage must do the compensating, which it does by turning the inner wheel a little more sharply on corners. The tie rods do not go directly from the gearbox to the wheel; they are connected to the steering arms, which angle outward from the tie rods before hooking onto the wheel joint. The arms slope outward at somewhat more than 90° from the tie rods, gripping the wheel joint at the end of each "hand." This is known as parallelogram linkage, for if a shaft were to run between the two wheel hubs, the steering linkage would be in the shape of a parallelogram. This way, any motion of the tie rods to one side or the other causes the inner wheel to pull inward a bit more sharply than the outer one.

The tie rods are moved back and forth by a short, stubby shaft called the pitman arm, which protrudes from the steering gearbox. The steering gearbox converts the round-and-round motion of the wheel into the side-to-side motion of the pitman arm and the attached tie rods.

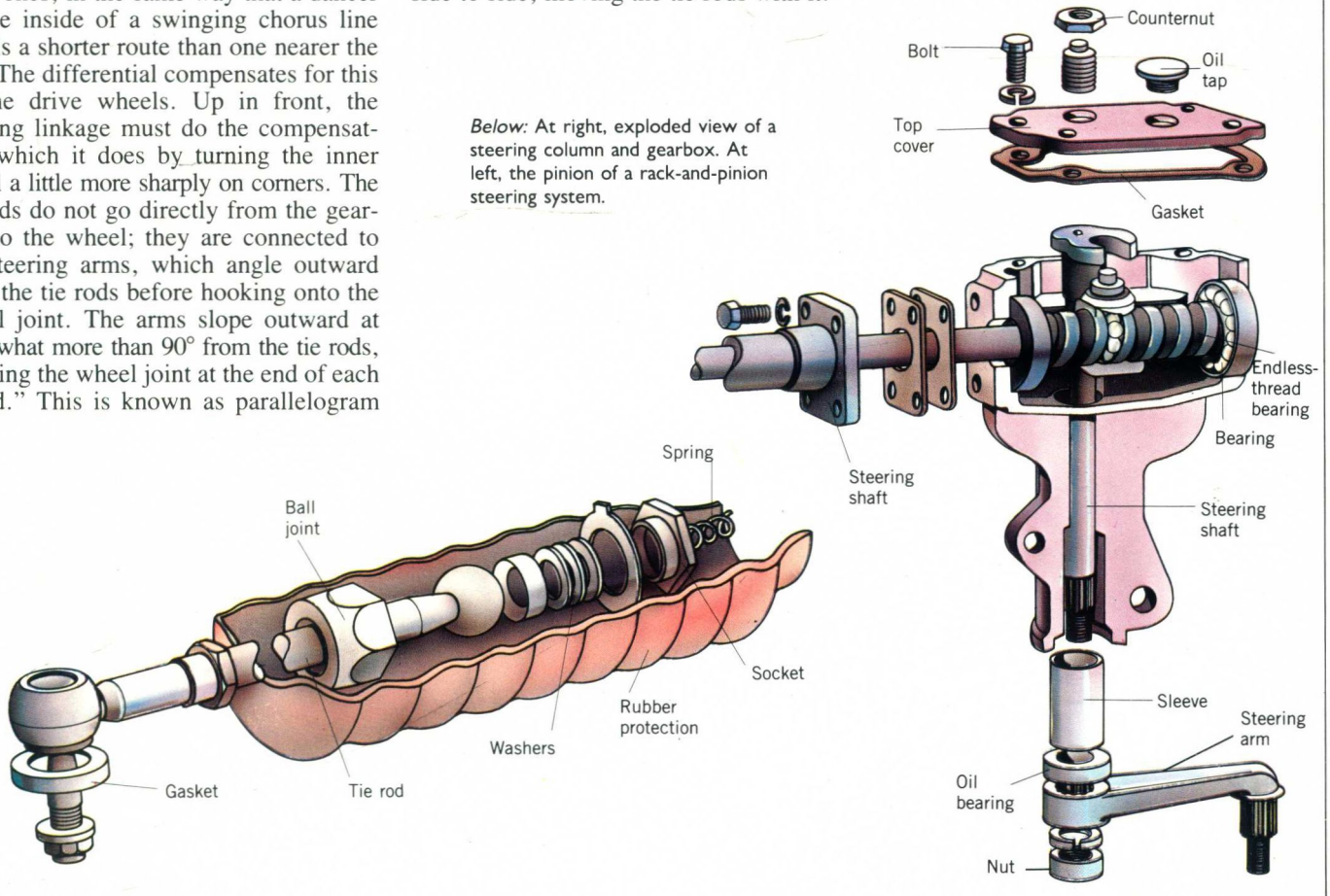
Most cars made in the United States have a form of worm and roller gear in the steering gearbox, while quite a few cars made in Europe and Japan use a rack and pinion. A gear is a wheel with ridges cut into it for transforming motion from one part of a machine to another. A worm gear is shaped like a screw whose ridges, or "teeth," spiral around a central shaft. The worm is found at the very end of the shaft turned by the steering wheel. When the wheel turns from side to side, the worm pushes the roller back and forth. The roller (some systems use cams or nuts) is mounted on a wheel, and the pitman arm is attached to the same shaft as this wheel. When this wheel turns, its shaft carries the short, stubby pitman arm from side to side, moving the tie rods with it.

A pinion is a small gear wheel. In a rack and pinion system, the pinion, which is at the end of the steering shaft, meshes with a rack—a straight rod with teeth cut into it. When the pinion is turned right or left, the rack moves laterally, pulling and pushing the rods with it.

Power Steering

Heavier cars can require a certain amount of force to turn the wheels. In power steering, the driver gets some assistance. When the driver turns the wheel, a valve opens, admitting oil at high pressure to one side or the other of a piston. (A piston is a circular mass of metal on the end of a rod, which moves back and forth inside a hollow chamber called a cylinder.) The power steering fluid is kept under pressure by a pump run by the fan belt. The oil pushes the piston in one direction or the other, and the piston rod then pulls or pushes the tie rods.

The steering system is made so that it can still be turned by hand if this power system fails. Another safety feature on many cars is integral in the steering system. Collapsible steering columns retract like telescopes in the event of a collision, so that the driver isn't skewered as he is thrown upon it.



Below: At right, exploded view of a steering column and gearbox. At left, the pinion of a rack-and-pinion steering system.

Power steering can reduce much of the effort needed to turn a car, as well as many of the shocks of the road. However, it is important that the steering system offer some resistance and feed some of the shocks and strains back to the steering wheel. An experienced driver can sense from the steering wheel when to turn more sharply to compensate for gusts of wind or bumpy corners, whether the wheels are slipping, and even whether a tire is misaligned or improperly inflated.

Stegosaurus

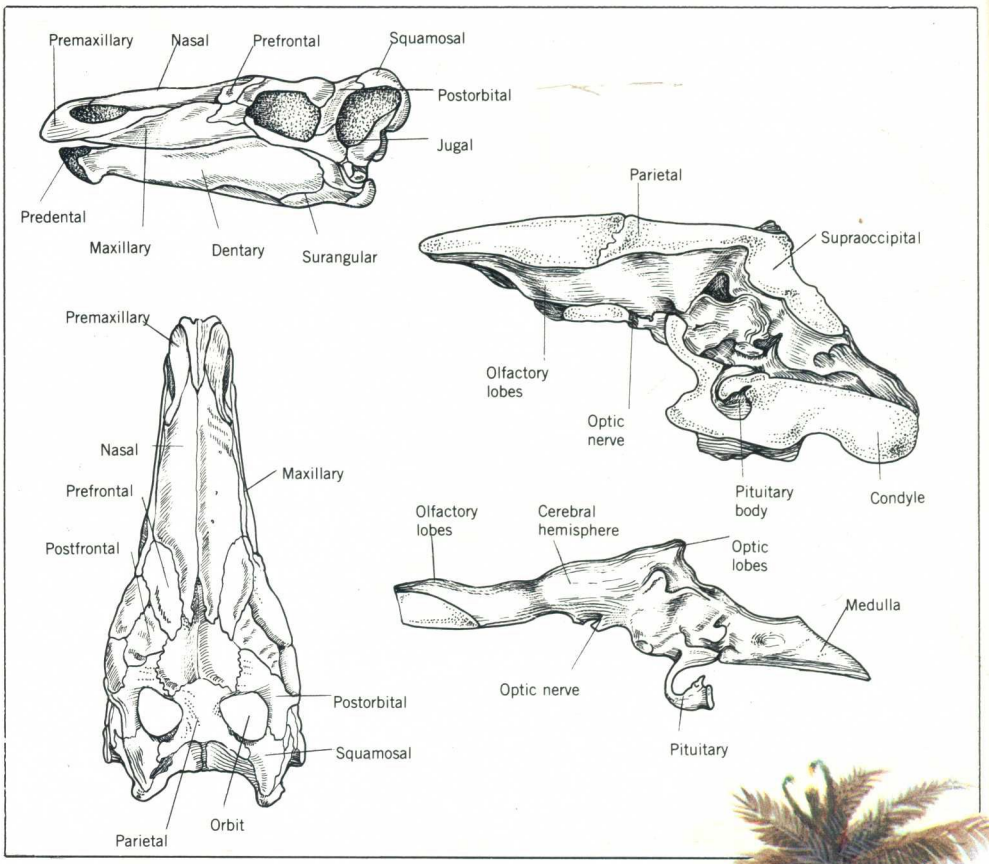
About 170 million years ago, during the upper Jurassic age, the Earth harbored the strangest creatures ever to walk on its surface. These were dinosaurs of the genus *Stegosaurus,* 20-foot-long (6-m) armored creatures, each with a tiny head and a double row of huge, upright, triangular plates in its back. *Stegosaurus* shared much of its habitat with the other groups of armored dinosaurs, the ankylosaurs and ceratopsians, as well as with the great swamp-dwelling *Brontosaurus* and the predatory *Megalosaurus*.

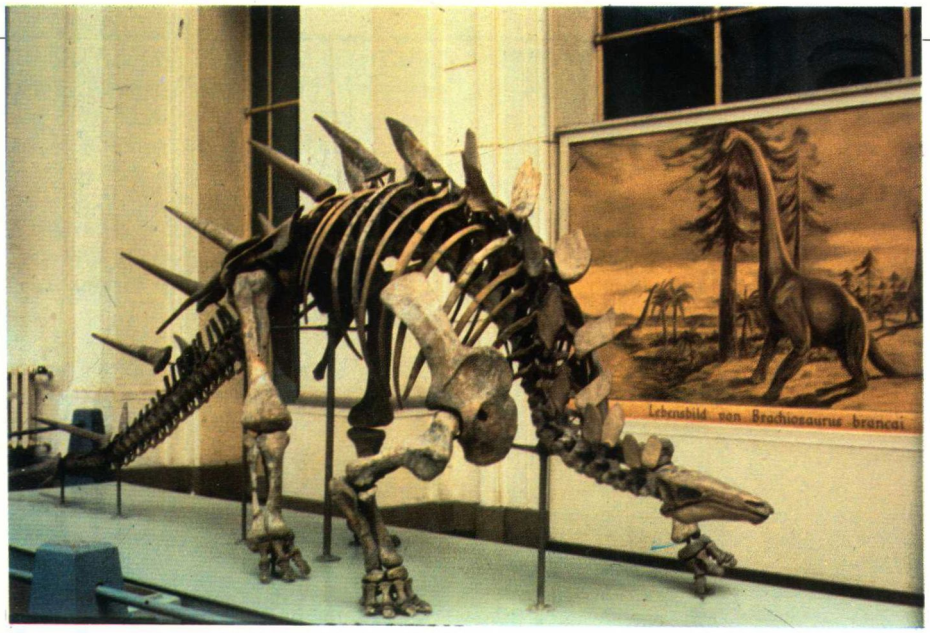
Defense or Comfort

The most curious feature of a stegosaur was the double row of bony plates it carried on its dorsal (back) surface. The lar-

Below: Drawing shows a group of dinosaurs, including 2 brontosaurs (one with only head visible), a diplodocus (in the water), and the stegosaur, with its crest of bony plates.

Right: Stegosaurus skulls and sections of the brain cavity.

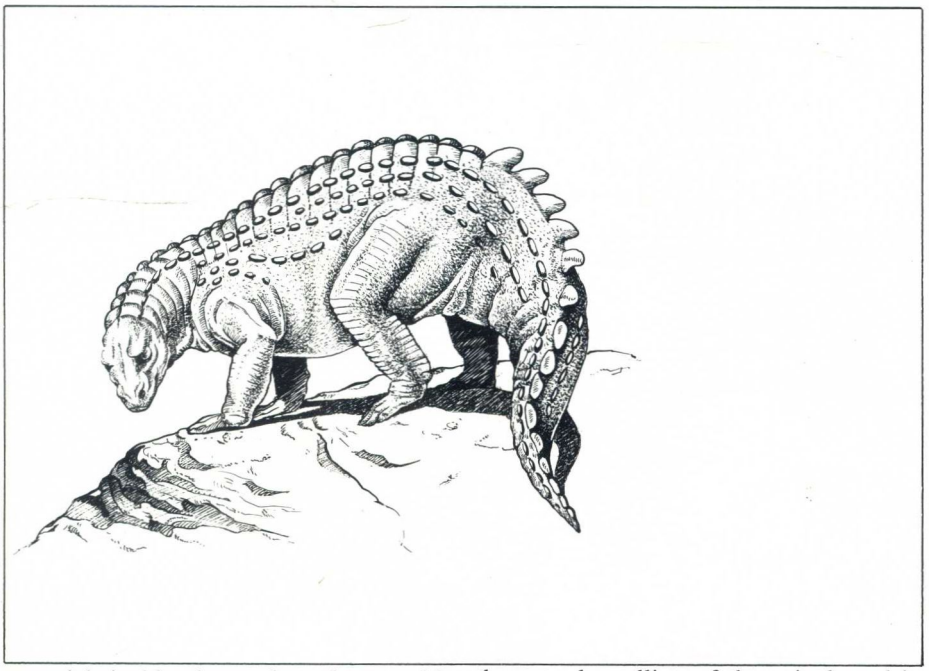




England. It had dermal plates similar to those of its better-known relative, *Stegosaurus,* but the exact placement of these plates is unknown. The East African *Kentrosaurus,* which lived during upper Jurassic times, resembled *Stegosaurus,* except that the plates were restricted to the forepart of the body. On its hips and down the tail were pairs of large spikes. Fossils of *Stegosaurus* have been found in both North America and Europe.

The bipedal ancestry of these beasts is apparent from their leg structure. The hind legs are much longer than the forelegs, causing the hips to stick up at an ungainly angle, while the back slopes steeply down to the tiny head. The brain of a stegosaur is so small that it is exceeded in size by

Above: Complete *Stegosaurus* skeleton.
Right: Drawing of *Scelidosaurus,* a near relative of *Stegosaurus.*



gest of these plates were found above the hips; they diminished in size toward the head and tail. The usual reconstruction of a stegosaur represents these plates as vertically oriented down the creature's midline, with the two rows of plates alternately placed. In this arrangement, the plates seem useless for defense, as the animal's flank would be entirely open to attack, which could only be thwarted by the four large—about 3 feet (1 m) long—spikes at the tip of the heavy tail. It is also possible that the plates actually lay on the creature's skin, where they would provide greater defense, but this is not a commonly accepted view.

However, the conventional vision of the plates as a means of defense has been challenged by the suggestion of an entirely different possible function—as temperature-regulating devices. The plates were rich in blood vessels and so could easily exchange body heat with the environment, thereby absorbing the Sun's rays when the animal was cool and quickly dissipating heat when the body temperature increased too much. If stegosaurs had any degree of physiological control over blood flow between the body and the plates, they could have had a very effective heat-control system.

Evolution and Anatomy

Placed by scientists in the dinosaur order *Ornithischia,* stegosaurs evolved from an early group of bipedal (standing on two feet) ornithischians and reverted to the quadrupedal (four-footed) posture found in early reptiles. The earliest stegosaur discovered was a 12-foot-long (3.5-m) member of the genus *Scelidosaurus,* which existed during the lower Jurassic period in

the neural swelling of the spinal cord in the hip region, and this has given rise to the fallacy of the "two-brained" dinosaur. Actually, this portion of the spinal cord is enlarged in order to enable it to coordinate the nerve system in the massive posterior portion of the stegosaur's body.

The tiny head contained teeth only in the hindmost portion of the jaw, the front of the jaw being toothless. Stegosaurs and their cousins probably lived on some type of soft-tissued, ground-covering plants. Certainly, this nearly 2-ton dinosaur was not built to get up off the ground to browse on tall vegetation.

The awkward-looking stegosaurs were among the first of the Ornithischia to become extinct. Even so, the group lasted until the early Cretaceous age (about 125 million years ago), and so existed for nearly 50 million years.

Steppe and Tundra

Some of the largest, most open landscapes on Earth are those seen on steppes, which are vast, often treeless plains sparsely overgrown with short grasses. The tundra, treeless land of the Arctic, can be monotonous and dreary. The tundra is mostly devoid of human habitation. Only the polar regions, the highest mountains, and a few remote deserts are less inhabited than the tundra.

In general, the steppes are vast areas of land, usually plains or gently rolling land in semiarid areas, where mostly short grasses grow. Prairies, which closely resemble steppes, are in wetter areas, where the primary vegetation is tall grass. To be called a steppe, the area must be in a relatively dry region with cold winters.

Some authorities state that only the short grass regions of Russia are steppes, but others include the prairie region in North America from about the 100th meridian west to the Rockies, enclosing the area from mid-Texas to the North Saskatchewan River in Canada. The Russian steppes stretch in a band eastward from Rumania, through Volgograd, and thence more or less along the 50th parallel to the 80th meridian. They continue once more, from about the 92nd meridian east to the Mongolia-Manchuria border. There is another small area of steppe country near Mukden (Shenyang), in China. Some of the pampas of South America are also steppes.

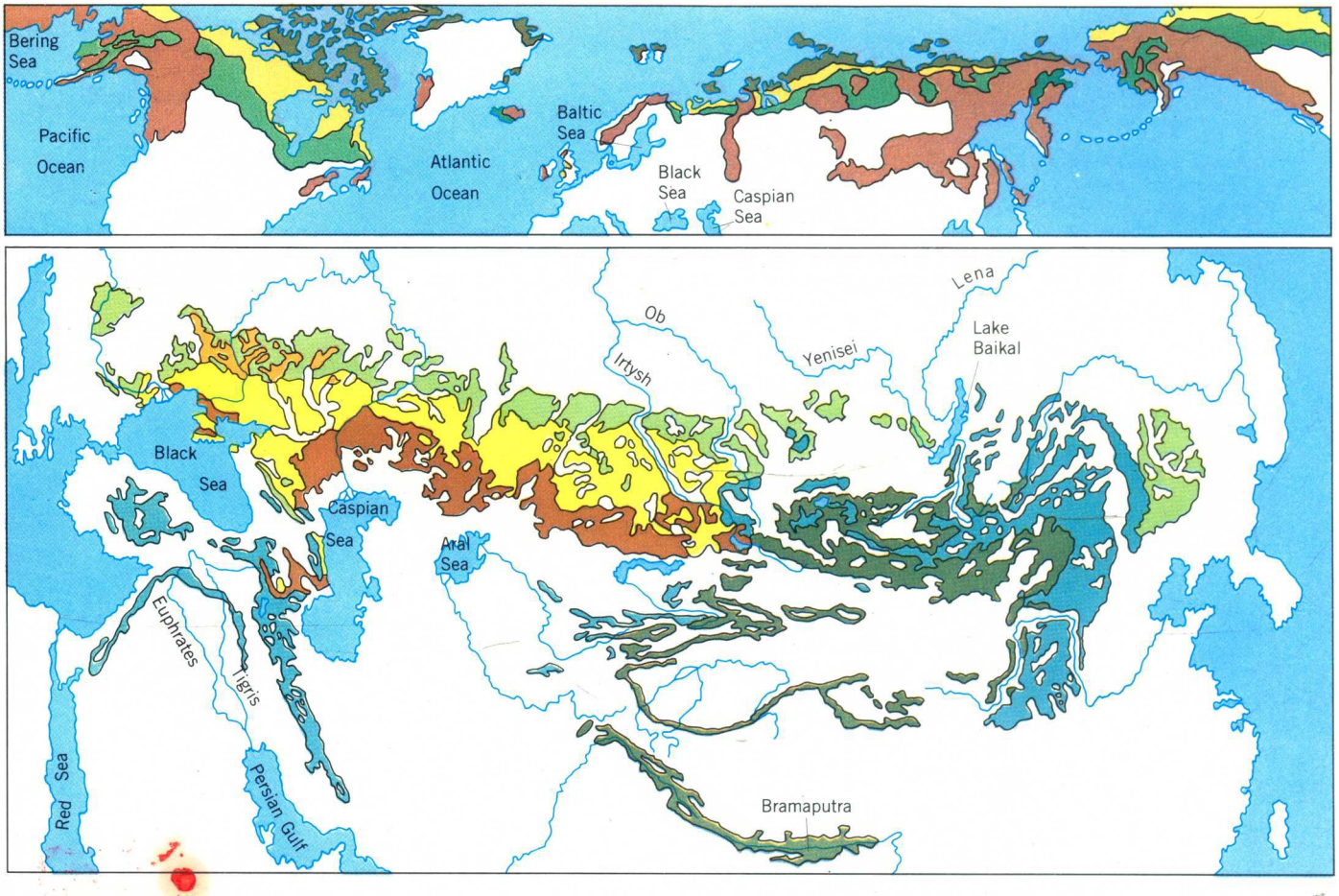
Plants and Animals of the Steppes

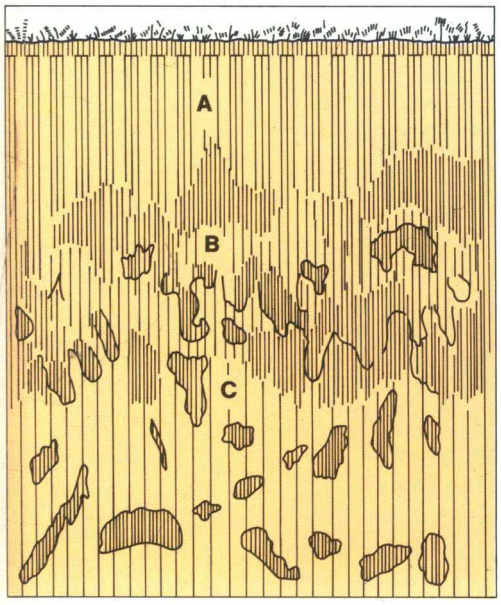
The most characteristic plants are various grasses. Most common on the Russian steppes is silvery feather grass. Growing on these steppes are many bulbous plants, such as iris, tulip, grape hyacinth, and crocus. Sunflowers, pasqueflowers, anemones, and sage are also seen. In Asia, the steppe country usually fades off into wooded steppes to the north. To the south of the steppes, much of the land progressively becomes more and more desertlike.

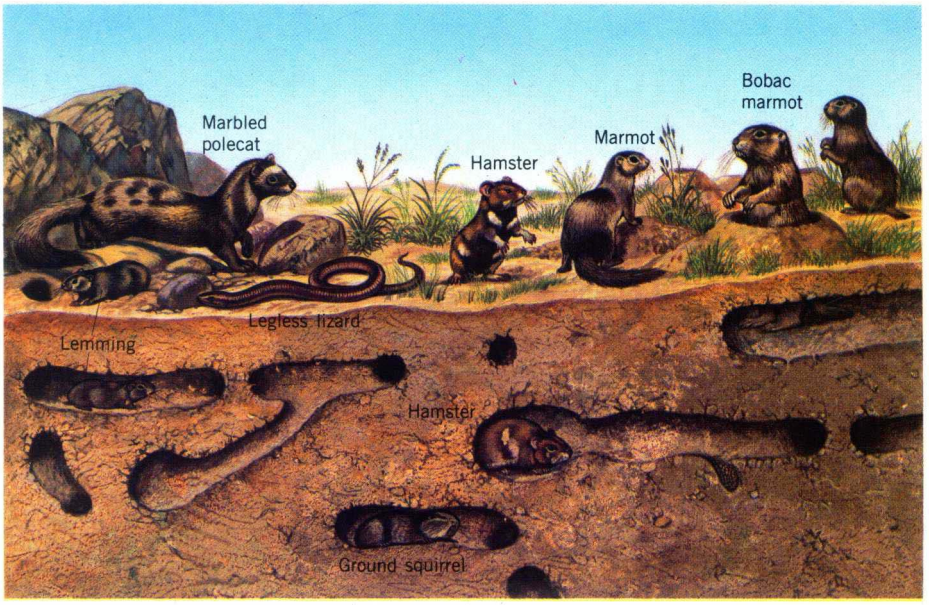
Before the steppes became used for nomadic herding, the land was populated by wild horses and wild cattle; there are still foxes and wolves. At one time, the steppes were the homeland of nomads and later of the famous Cossack horsemen. Today, the larger, drier regions are used for grazing, and a few of the wetter regions are used for growing wheat.

The North American short-grass prairies resemble the Russian steppes to some degree. The American grasses are mostly blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*). Clumps of sage dot parts of the short-grass prairies, and sunflowers are common. As the short-grass prairies merge with drier regions to the south and west, yuccas and prickly-pear cactus appear. To the east lie the tall grass plains, which are much lusher. To the north of the Canadian short-grass plains lies the tundra.

Before the arrival of Europeans, the animals of the region were antelope, bison, prairie dogs, wolves, and coyotes. The wolves are gone, but some of the others, especially coyotes, still roam the short-grass prairies in numbers. Many types of ducks migrate through the region. The most typical birds are ravens, meadow-







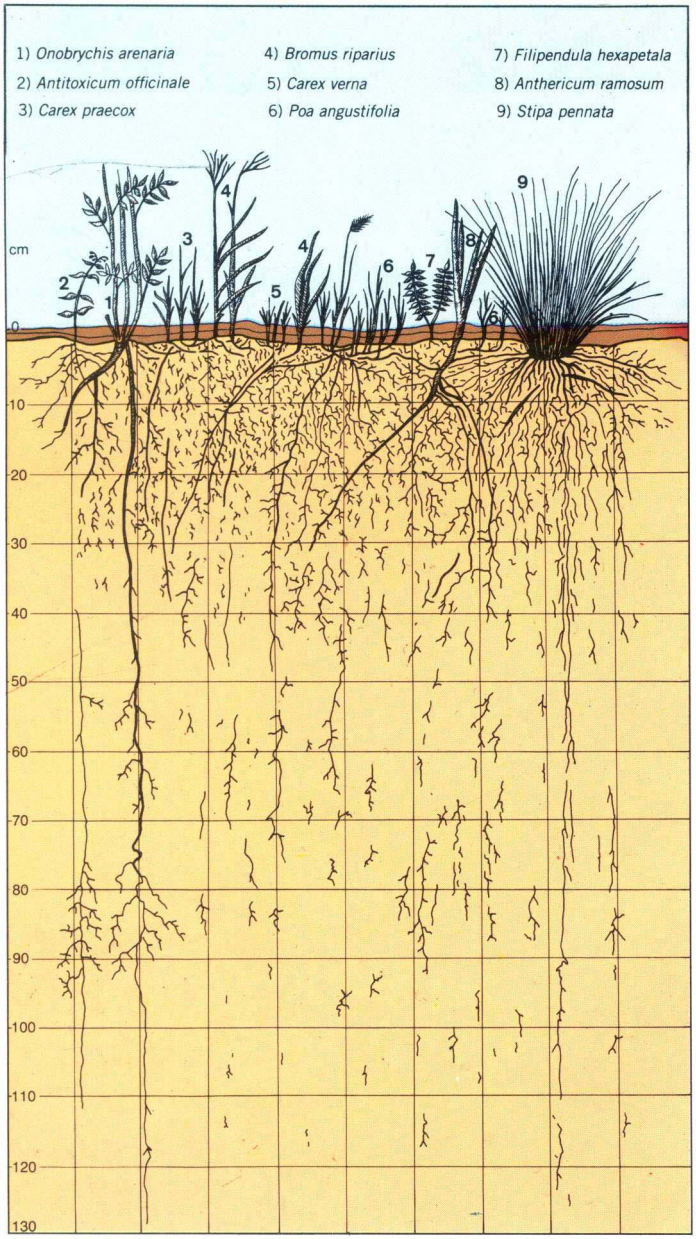
larks, horned larks, magpies, and sage grouse. Today, the short-grass prairies of North America are used mostly for grazing cattle. In the larger, predominantly dry regions, sheep are sometimes raised. In the smaller, wetter areas, wheat is sometimes grown. Most of the land is rolling, even hilly. Some areas lie between mountain ranges. Unlike the steppes of Russia and the high-grass country, the region is rarely flat or monotonous. In part due to overgrazing, much of the short-grass prairie is crisscrossed by deep gullies.

The Tundra Defined

The vast, treeless plains of the north are called tundra. They are found along the northern coastal areas of Alaska, Canada, and Russia and on most of the Arctic islands. A few very small places in the Antarctic regions could also be called tundra. The tundra is treeless, since a few feet below the soil, the earth and water in it are frozen solid—too solid, in fact, for tree roots to penetrate. Even so, in a few isolated places, where local conditions allow the earth below to be ice-free, there may be small, scattered groves of trees, usually willow or rhododendron. Some rhododendron, though dwarfed and less than 3 feet (0.9 m) high, have been found to be at least 400 years old.

Though lacking trees, the tundra is covered with flowering plants and grasses. To the south, in almost all cases, there are dense forests called taiga or boreal forests, consisting mostly of spruce and firs. In some places, as in Greenland and some arctic islands, the tundra ends where it meets glaciers.

Tundra lands are also found in mountainous regions above the timberline. Such tundras are almost identical to arctic tun-



Far left: Map shows distribution of different kinds of steppe and tundra lands around the world.

Above: At left, cross section of the upper layers of the *chernozem,* the black soil of the Russian steppe. The levels shown are: (A) 3-5 feet (1-1.5 m) of humus from decomposing plant matter; (B) patches of humus left by plant roots in decomposition; (C) black, muddy soil with patches of materials left by tunneling rodents. At right, representatives of animal populations especially adapted to steppe conditions. Burrowing rodents are the typical mammals of the steppe.

Left: Root distribution of different steppe plants. Rooting is shallow, mostly in the upper 8 inches (20 cm) of soil.

Above: Raising of horses on the Mongolian steppes. Irregular rainfall and low soil fertility make herding the principal economic activity.

Left: Experimental cultivation of *stipa,* a grass of the Russian steppes.

Right: At top, typical tundra flora of fungus and lichens; below, reindeer herding, the only significant agricultural activity possible on the tundra.

dra in plant life and sometimes animal life as well. The largest mountain tundra in the world is in Tibet.

The tundra landscape varies from very flat to rolling, hilly, and, in a few places, abutting against mountains. In some areas, there are many lakes that were formed when glaciers gouged out the land during the ice ages. In summer, there are also numerous ponds formed by meltwater from the permanent ice below. The soil of the tundra is often black and "mucky." This is because it is waterlogged. The summer temperatures never get high enough for the land to dry out.

The winter weather often alternates between windy, cold, gray days and still, icy days with a blue sky. Spring is almost exactly like winter, but storms, when they do arrive, are less severe and last a shorter length of time. Summers are cool. The average temperature never gets above 50°F. (10°C.). Brief periods of subfreez-

ing temperatures occur all summer long. Fall is windy and stormy. Oddly, the tundra, in spite of being so wet, has a rather dry, almost desertlike climate, for it is a region of little precipitation.

Plants and Animals of the Tundra

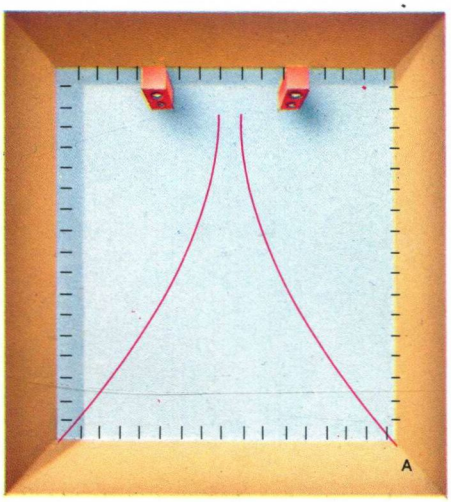
During much of the summer, the Sun stays above the horizon for long periods during the day and even remains there all night. Though the temperature rarely gets up to 60°F. (16°C.) at any time, it is often warm enough for a profusion of flowers to appear. Heather, dwarf willows, mosses, various berries such as crowberries and cloudberries, arctic poppies, blue bells, purple saxifrage, and many other plants grow in areas of the tundra.

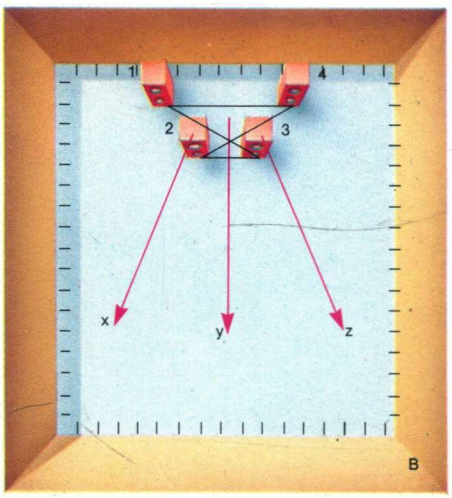
As the ice melts and ponds become ice-free and the temperatures climb higher, huge swarms of mosquitoes rise into the air, making life miserable for people and animals alike. Gnats often form visible clouds over the land. These insects, however, have their place in the balance of nature, for flocks of birds that arrive from the south and nest in the tundra eat countless millions of the insects. During the summer, the land is quite lively. Mammals that are seen include an occasional polar bear, but only near the sea, and herds of caribou; some wolves, foxes, and musk ox roam a few scattered areas. In the winter, the birds are gone, and the insects are dead. The caribou migrate southward. But many animals stay on, such as the hares, wolves, and foxes.

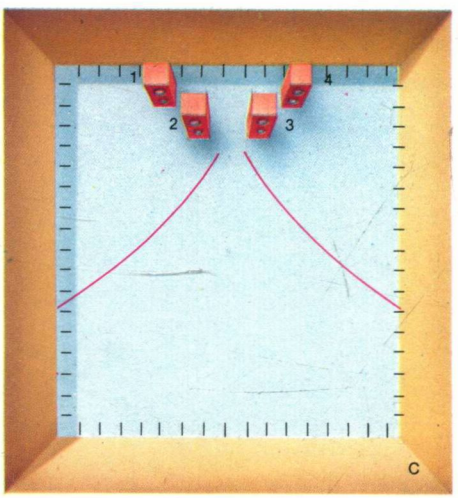
Stereo

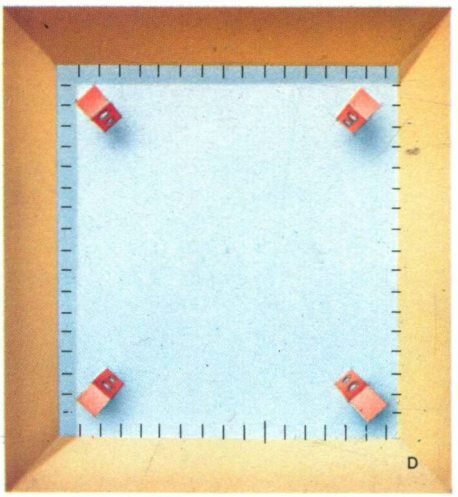
Whether they are called record players, hi-fi's, gramophones, stereos, or phonographs, stereos have firmly altered the habits of hundreds of millions of people and turned the music world upside down. Until Thomas Alva Edison invented the first practical phonograph in 1877, people could only listen to a symmphony if they were actually in the presence of the musicians playing it. This meant that only the very rich could have any but the simplest kinds of music in their home, and that operas, symphonies, and popular music were almost never heard outside a concert hall. Now, more than 100 years after Edison's invention, it is frequently complained that there is too much music in people's homes, and nobody can think straight with all that blasting rock 'n' roll.

The word "stereo" is something of a misnomer, because it really refers only to stereophonic sound reproduction systems, that is, sound systems with two independent speakers, each handling a different part of the music. If the two (or more) speakers are arranged in the right position, listeners receive almost the same sound that they would get at the concert hall. Monaural record players, on the other hand, have only one sound track.









Above: Positioning of speakers for maximum sound fidelity. (A) Two speakers, aligned side by side. (B) Four speakers in paired configuration. The balanced zone from speakers 1 and 3 is X; for 2 and 3, Y; for 3 and 4, Z. (C) Balanced zones for 4 phased speakers. (D) Quadraphonic positioning.

Stereo or mono, all record players consist of three parts: a turntable, an amplifier, and one or more speakers. All three play an essential role in the process of producing sound from a record. Each side of a record is almost completely covered with a single narrow groove that runs in a tightly packed spiral from the edge around to the center. Less than .00125 inch (.032 mm) deep and about .0025 inch (.064 mm) wide, record grooves have slanting walls whose angle from the vertical varies to correspond precisely to the music.

Turntables

There are two parts to a turntable: a drive, which is a motor that smoothly spins the record around at a precise speed, and a tone arm, which holds the mechanism for playing the record. The tone arm is usually a steel tube attached by a pivot at one end to the rest of the turntable, with the other end tipped by a stylus, or needle, which is generally a tiny chip of diamond. As the record turns, the stylus rides in its groove. Because the walls rapidly change their inclination, the needle vibrates rapidly from side to side in the groove, wiggling in a way dictated by the sound grooved onto the record.

The needle is connected to a cartridge. The cartridge is a type of transducer, a device that converts one kind of signal (in this case, the motion of the diamond) into another (pulses of electricity). In most turntables, the top end of the needle has a little permanent magnet, which wiggles with the motion of the stylus. The magnet is set next to two coils of wire within the cartridge at the head of the tone arm. When a magnet moves back and forth near a coil of wire, it sets up an electric voltage in the coil that fluctuates with the motion of the magnet. In this way, the vibration of the needle is transduced into pulses of electricity that are fed into the amplifier. Stereos have two coils to create two electric voltages whereas mono tone arms have only one, but both cartridges feed electricity into the amplifier.

Amplifiers

In most large stereo systems, the "amp," as it is often called, has a box of its own, separate from the turntable. Its face bristles with an array of dials and switches: an on-and-off knob, jacks to plug in headphones, a volume dial, and controls for the balance and quality of the sound.

The task of the amplifier is to boost the voltage coming in from the turntable, amplifying it enough to drive the speakers. To do this, the circuits in the amp draw on household electric current to create pulses of electicity that are identical in form to, but much more powerful than, the pulses from the tone arm. In addition, amplifiers clean up the signal from the turntable, correcting for the distortion introduced by the needle's inherently imperfect pickup from the record.

In the past, amplifiers were made with tubes; today, they are full of transistorized circuitry. Transistors are made from elements like germanium and silicon, which have atomic structures that endow them with special electrical properties.