Life Before Man

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The Emergence of Man

Life Before Man

by the Editors
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THE EMERGENCE OF MAN

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The Cover: Tyrannosaurus rex, or king of the tyrant reptiles, which ruled the earth some 75 million years ago, peers from a ferny thicket. The scene has been re-created by superimposing a painting of the giant predator on a photograph of a type of forest known to have existed in the Age of Dinosaurs. The same technique has been used on pages 148-149.

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Introduction

A man is a man, and a woman a woman, but both are also primates, mammals, vertebrates, chordates and metazoans. Those are not merely words invented by professors to beguile the public. They are a way of saying that man, whatever additional he may be, is an animal. He has something in common with all animals. The microbes in the ditch, the ants on the lawn, are relatives of man, and his development cannot be fully understood without reference to them. How he rose from a rare, not especially impressive animal to his present status of dominance is the subject of The Emergence of Man, the series of books of which this book is a part.

The story is a tortured, twisting one. It must account for the strange fact that man, and not the lordly dinosaurs that ruled when man's furry ancestors first scurried about, survived to command the earth. And before the tale ends with modern man—living on a planet that he has already modified, not always for the better, and has the power to destroy—it must trace the origins of ideals and rituals, prayer and cannibalism, tools and war, gods and empire, trade and farming, and all the facets of life that make man human. But it begins with his biological background, treated in this volume.

The concept of human evolution is as old as Charles Darwin's *On the Origin of Species,* which was published in 1859—even older in a timid way. But today knowledge about the mechanisms of evolution is accumulating at an unprecedented and ever-increasing rate. Part of the new understanding comes from new scientific techniques. With an electron microscope, for instance, a virus so small that its existence had to be indirectly inferred is made to show up as clearly as the windows of a building across the street. Each such new view reveals more clearly how man came to arise from the simplest forms of life in the primeval waters.

Great advances have also been made in dating methods. Until well into the present century most figures given for the age of fossils or the remains of ancient man were hardly better than guesses. But recently estimates have been replaced by accurate measurements. One method, which uses the radioactive decay of carbon, provides a reliable time scale nearly 40,000 years into the past for objects containing carbon, such as campfire charcoal. For dates ranging into millions of years, a method known as potassium-argon dating is being increasingly used as a guide to the age of rocks and many objects, such as bones, that may be embedded in them.

One of the most fruitful of the new ways to learn about human antecedents is to observe—as this book does—living animals that resemble man's direct ancestors. Among these distant cousins of man are tree shrews: primitive animals not very different from the earliest mammals. Another is the coelacanth, a rare fish descended from ancestors that had inside their fleshy fins bone connections uncannily like the bones of human arms and legs. On limbs much like these the first vertebrates crawled up on the land.

Today even animals distant from man can reveal insights into his past. In particular, much about ancient behavior is deduced from studies of modern animal behavior. Man is a social animal, for example. He was not, however, the first to find strength in numbers. Several types of insects did so many million years ago, and the result was the wonderful world of the social insects—ants, bees, wasps and termites—whose "civilized" colonies can be found in every inhabitable part of the earth. Though the insects provided none of man's heritage, their group living offers illuminating parallels to his own societies.

Similar parallels can be found in the tightly structured group living of such animals as wolves and baboons. But none of these low-level societies of mammals, interesting as they are, show signs of progressing to a higher level. This feat, which literally changed the face of the earth, was accomplished by smallish, erect-walking primates who were the direct ancestors of man. Their hunting groups, which at first were presumably as simple as wolf packs, gradually became more tightly organized. Their descendants developed speech for quick and accurate communication. They learned how to use fire and fashion weapons of wood, stone or bone. They built shelters to protect themselves from inclement weather and acquired clothing that enabled them to live comfortably in cold climates.

From this point onward, the history of man is largely that of his technical advances and social achievements. Perhaps the greatest achievement was the almost simultaneous development of agriculture and animal husbandry. When the first farmers had acquired domesticated plants and animals, they turned unproductive land into cultivated fields and pastures. Human population increased enormously and pushed into areas inhabited thinly by wandering hunters. Villages appeared, grew bigger, acquired walls for protection and temples for local gods. Then came cities; then empires. In not much more than 1.3 million years—a short time on the evolutionary scale—from the appearance of the first creature that could be called human, man had changed from a scarce and wandering hunter to undisputed lord of his planet.

—The Editors

Chapter One: The Paragon of Animals

After 3.5 billion years, Homo sapiens sapiens, thinking man, emerges before the energy-giving sun to become the dominant species.

The house lights have dimmed. The stage is a black void. The rustling of programs and the murmur of gossip subsides. Silence. Gradually a figure appears; ghostly, transparent at first, then more and more substantial, solid, radiant at last, shining out of the darkness. It is man—the hero of this story.

Shakespeare glorifies him as only Shakespeare could: "What a piece of work is man! How noble in reason! how infinite in faculty! in form, in moving how express and admirable! in action how like an angel! in apprehension how like a god! the beauty of the world! the paragon of animals!" Yet in his very next words the poet could not resist asking the question that all of us, at one time or another, have asked ourselves, "And yet, to me, what is this quintessence of dust?"

The question is as old as man and has been answered in nearly as many ways as there have been men to pose it. In the technical jargon of biological classification, modern man is *Homo sapiens sapiens* —a Latin label that means only "intelligent man." More informatively he has been called a political animal, a tool-using animal, a social animal, a creature that is aware of itself—and these are but a few of the aphorisms with which men through the ages have sought to nail down what it is to be human. Men are all these things, of course—and more. From a purely materialistic point of view, for instance, a man—any man—represents the most complex assemblage of molecules ever to appear on earth, possibly in the universe. In this respect an individual man differs from other organisms only in degree. But collective man—that is, man organized in social groups—represents a quantum leap beyond all other organisms. For the moment, at least, he is in command of the spaceship Earth, perhaps in danger of wrecking it even before liftoff, but equally able to steer for the stars.

To understand how man came to seize the controls is to answer Shakespeare's question. The story is complex, full of surprising twists, and strangely long, beginning at the moment when life first appeared on earth more than 3.4 billion years before man himself existed. This last third of the 20th Century is an especially good moment to trace the story, for this era is seeing a new phase in the study of man. In the past the most meaningful descriptions of the human state were made by prophets, artists, philosophers and poets. Theirs were personal views, colored by personal, subjective biases. We do not lack for such descriptions today, but at the same time we are gaining another perspective upon man, an objective view seen through the lens of modern science. The lens does not present a fixed image; instead, it builds an expanding mosaic of exquisite details, less poetic, perhaps, but no less awe-inspiring than Shakespeare's description.

New fossil evidence of man's ancestors, for example, is turning up at an unprecedented rate in regions such as eastern Africa, allowing us to trace the steps by which humans arose from less-than-human forebears. In 1859, when Charles Darwin propounded the landmark theory that underlies our present understanding of man's evolution, scientists knew of exactly two fossils that were relevant to the search for man's origins: one of an extinct ape, another of the early type of Homo sapiens called Neanderthal man. Hardly more than a century after Darwin's book appeared, expeditions in the Lake Rudolf area of East Africa unearthed more than 150 near-human bones in a single five-year period. One of these bones, the so-called Lothagam jaw, is 5.5 million years old, a date that pushes the record of man's certain ancestry more than a million years further back than any previous find.

The paleontologists' hunt for fossils has been aided by knowledge and insights drawn from other sciences. Atomic physicists, studying the rates of radioactive decay in various natural substances, have given paleontologists new and more accurate methods for pinpointing the stages in the evolution of life. Scientists can now determine the age of volcanic rocks by measuring the transformation of radioactive potassium into argon gas within the rock; the amount of argon found indicates how much time has passed since the rock formed and its potassium started to change. In a similar way, somewhat younger materials that once were alive, such as wood and bone, can be dated by measuring the transmutation of a radioactive form of carbon to another substance.

Equally valuable have been the contributions of modern biochemistry. Not until 1966 did biochemists finally decipher the genetic code—the complex structure and functions of a substance called DNA, which is present in virtually all living organisms. Through DNA, instructions for the building of new cells and new organisms are formulated and passed along. And having cracked DNA's code, scientists can begin at last to understand two contrasting mechanisms of evolution: mutation, in which minute variations in DNA instructions may originate new species of animals and plants; and genetic invariance, the precisely accurate duplication of DNA instructions without variation, generation after generation, that enables members of existing species to reproduce themselves essentially unchanged.

At the very frontiers of modern biochemistry, DNA is yielding new secrets to researchers. One of the most exciting of them is the process by which, over millions of years, mutations gradually create subtle differences in the structures of proteins, the basic building materials of all living things. Some scientists believe these differences accumulate at a steady rate and thus can be used to measure the evolutionary separation between man and other species. In the blood substance called hemoglobin, for example, the proteins of a horse exhibit no fewer than 42 differences from those of a man; clearly, the ancestors of man and horse parted company as distinct species a long, long time ago. By contrast, the hemoglobin proteins of man and monkey exhibit only 12 differences, while those of man and chimpanzee have none at all. Obviously, man is close to the apes, less close to monkeys, still less close to horses. But scientists already knew that.

What is exciting in the new knowledge is the possibility of working out a sort of protein clock that would indicate the time at which all existing species of animals first emerged. Though the protein clock is still tentative and experimental, it offers the hope of a dating method supplementary to the older techniques that depend on fossils, radioactivity or the differences between layers of rock.

Other clues to the past are coming from studies of a very different kind involving a host of living animals. The science of animal behavior is a relatively new discipline, but it is a flourishing one, and its basic materials are peculiarly accessible to the layman. Consider, for example, Jane van Lawick-Goodall's description of the greeting rituals among chimpanzees on a reservation near Lake Tanganyika, in Africa: "When two chimpanzees greet each other after a separation, their behavior often looks amazingly like that shown by two humans in the same context. Chimpanzees may bow or crouch to the ground, hold hands, kiss, embrace, touch, or pat each other on almost any part of the body. . . . A male may chuck a female or an infant under the chin. Humans, in many cultures, show one or more of these gestures."

Observations like Jane van Lawick-Goodall's help explain the basis for some human behavior, particularly in social actions, and also suggest how ancestral man may have acted, and why. Studies further from the human family tree are no less significant. Even insects tell something of how life can be organized. And wolves, like man, have evolved complicated life styles based on the cooperative hunting of game and the sharing of the kill. As individuals wolves shed little light on humans, but their hunting strategies, their hierarchical social structure, their divisions of labor and their territorial jealousies help explain similar patterns in early man.

From studies like these, a new view of man and of man's ancestry has been emerging. It places man in perspective in a vast span of millennia amid a vast crowd of creatures, and it shows something of why he is, as Shakespeare said, the "paragon among animals." But before we turn to distant places and distant times, before we bring on stage the cast of millions, let us look at the finished product, the hero of the epic, isolated on a dark stage. For the moment our concern must be more limited than Shakespeare's. We cannot completely answer "What is man?" until we can answer a simpler question: "What makes man different from other creatures?"

His mind, to be sure. But what our new knowledge makes ever clearer is that the mind is not enough. Without a remarkable combination of organic hardware that supports and abets it, the mind would be useless. Man dominates the animal kingdom not only because he is blessed with a big brain but because of a special combination of physical characteristics that is often taken for granted. Beside the sleek grace of a jungle cat, the streamlined strength of an 1,800-pound tuna or the regal bearing of a horse, what is man's puny body? The answer to that rhetorical question, as a careful examination of man's physical adaptations will illustrate, is: everything.

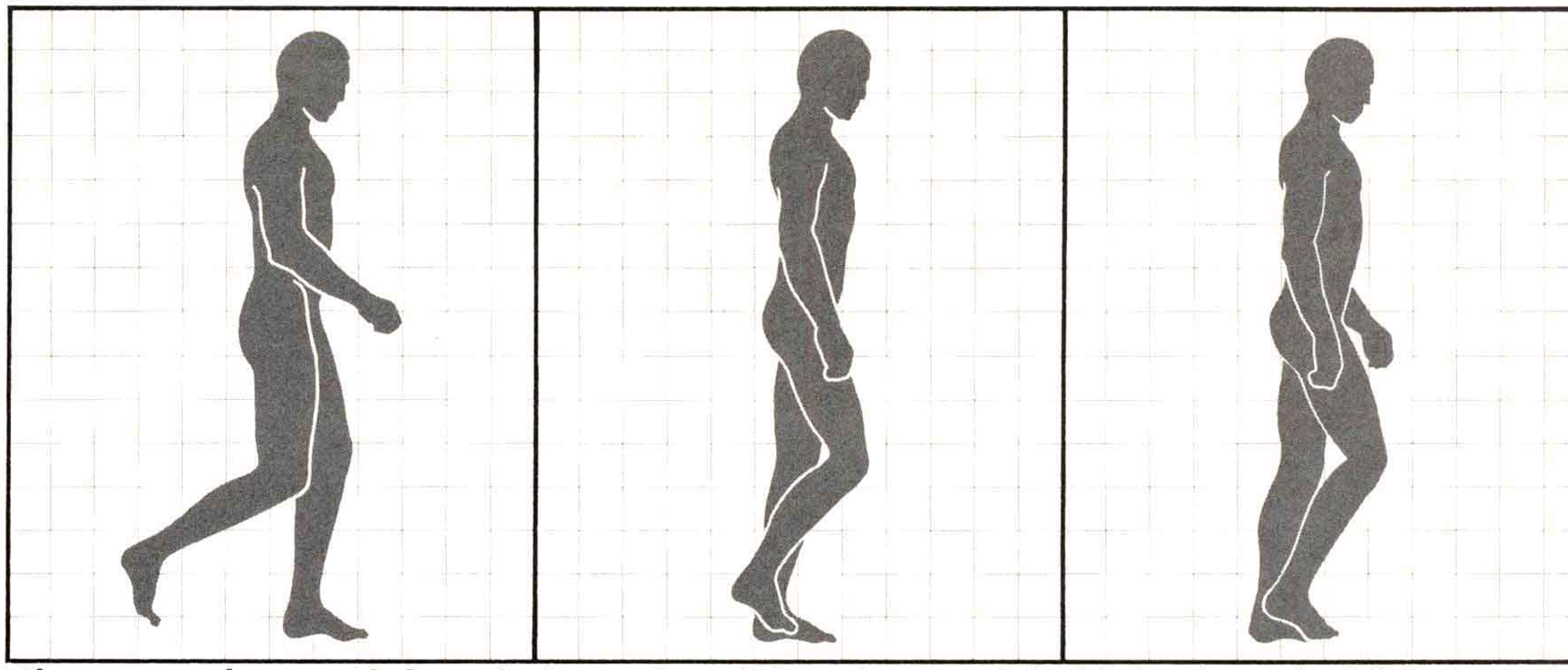
Among the physical traits that together separate all men on the one hand from all other animals on the other, there are three of overwhelming significance: a skeleton built for walking upright; eyes capable of sharp, three-dimensional vision in color; and hands that provide both a powerful grip and nimble manipulations. Controlling and making use of this equipment is the brain—a physical organ itself, but one that introduces the capacity for rational thought and, with the body, makes possible that other most human of all man's distinctive abilities, speech.

These attributes, uniquely combined in man, interact with one another. It is impossible to say that one led to the next, or that one is necessarily more important than the others. They developed together, each reinforcing the others and making possible improvements in them. Nevertheless, one attribute stands out simply because it is so conspicuous: upright walking. It is a remarkably effective method of locomotion, and no animal can use it as man does.

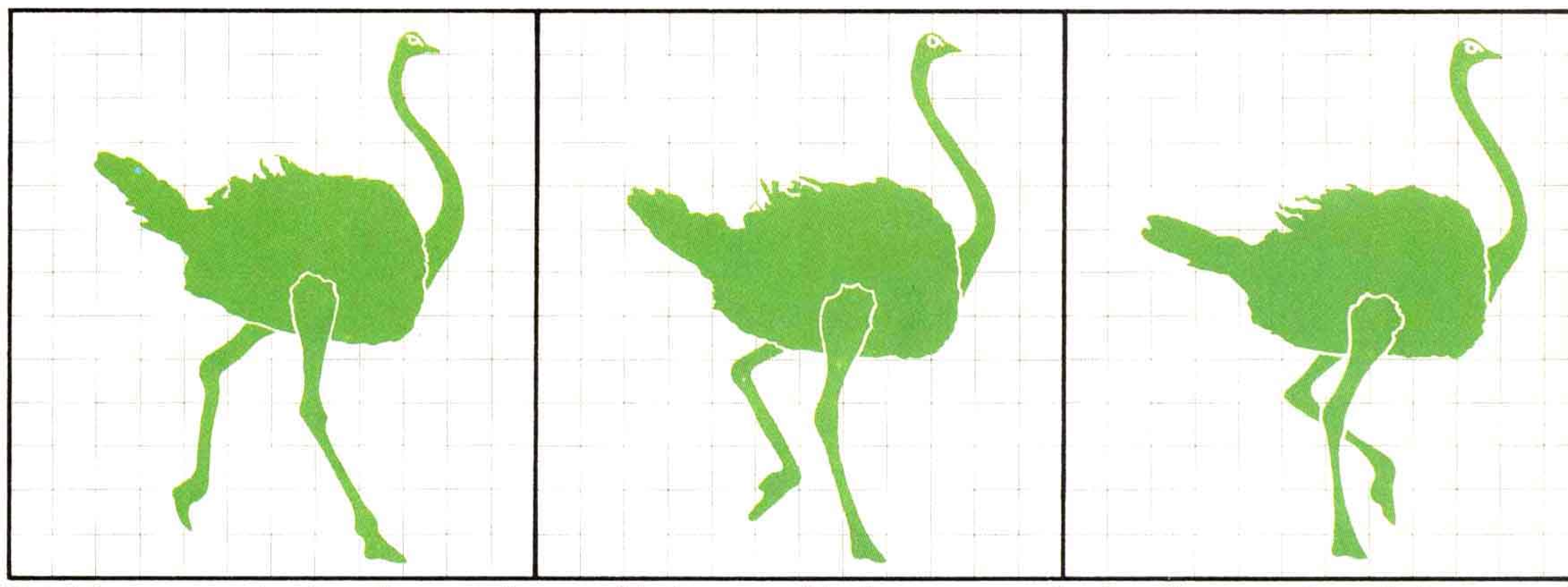
Man versus Runners, Jumpers, Walkers

The four animals at right are all equipped for effective locomotion over the level land they normally inhabit. Yet each moves in a quite different way. The long-legged ostrich can run at a speed of 50 miles an hour; the kangaroo can hop in 40-foot bounds; the pig's rocking gait, which he shares with other quadrupedal mammals, covers long distances with little effort.

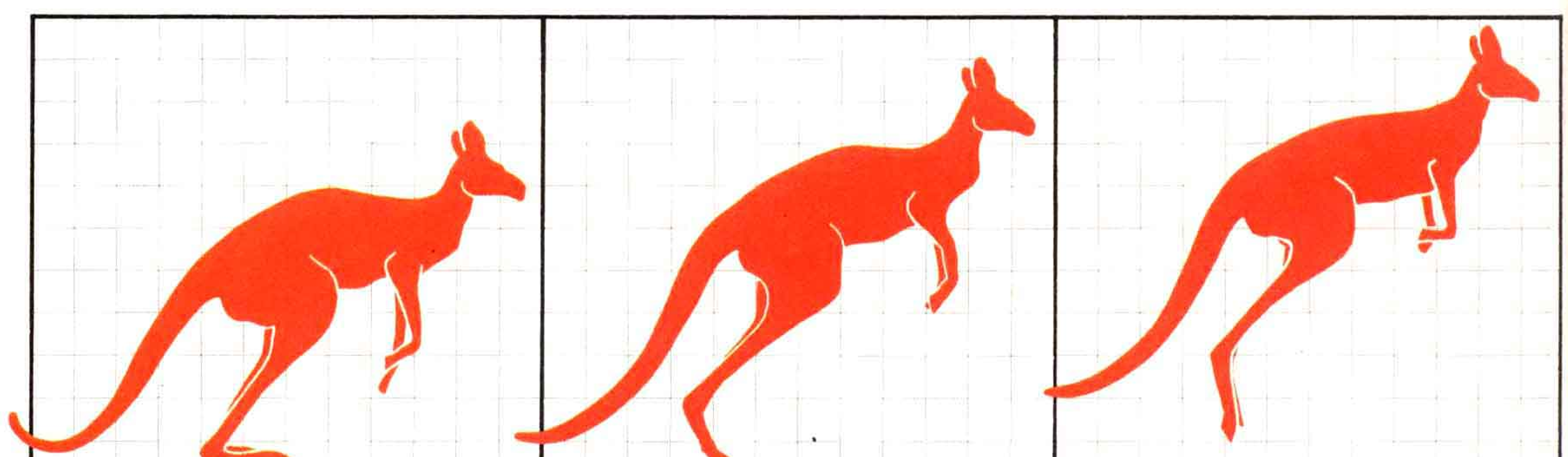
Man, upright on two legs, cannot match the specialized gaits of ostrich, kangaroo and pig. But his unique anatomy enables him to make use of all three advantageously: He can run at 15 miles an hour for several minutes and can attain a maximum speed of more than 20 miles an hour over short distances; he can broad-jump 29 feet and walk 50 miles or more in a day—to say nothing of swimming rivers and climbing mountains. In addition, his upright movement frees his hands for tasks that give locomotion another dimension of usefulness.



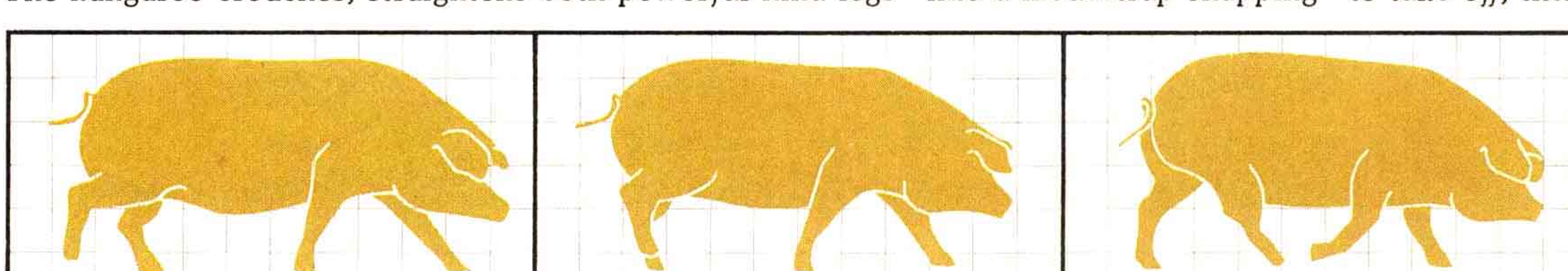
When a man takes a stride his right foot pushes off from the toe and the left foot bears the full body weight



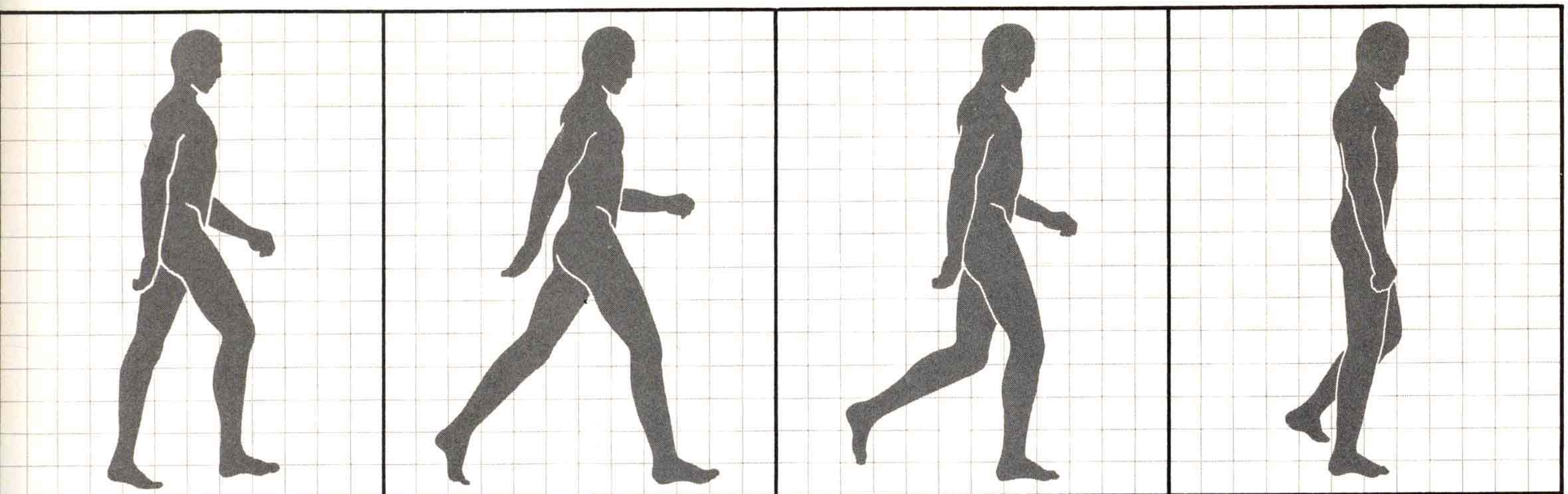
Ostriches step out using alternate legs and balance on big feet, as men do, but they stand on their toes, and



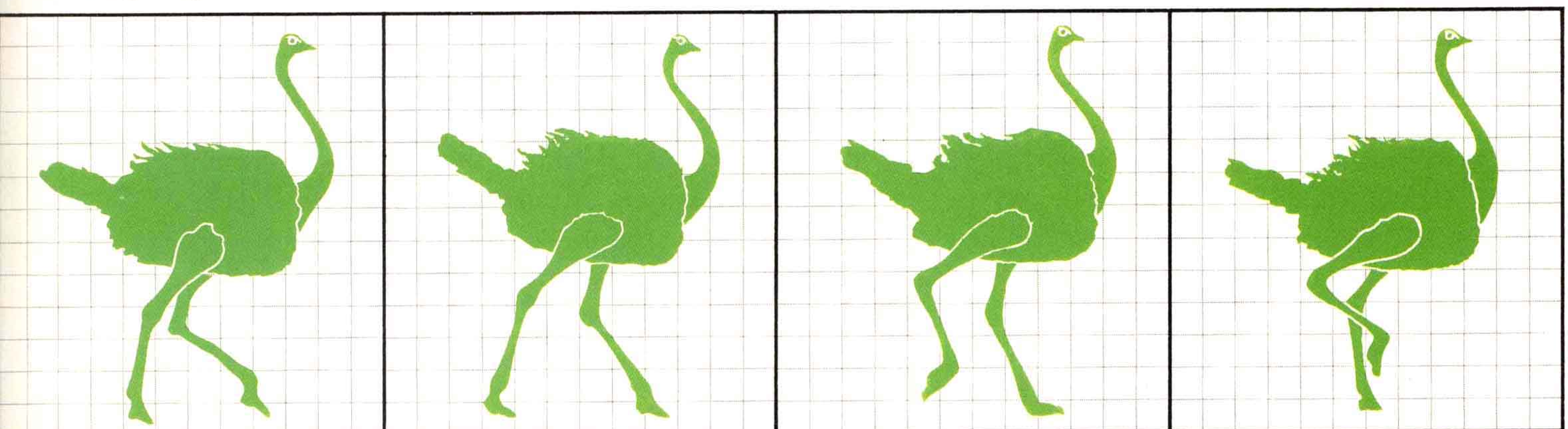
The kangaroo crouches, straightens both powerful hind legs—like a mousetrap snapping—to take off, then



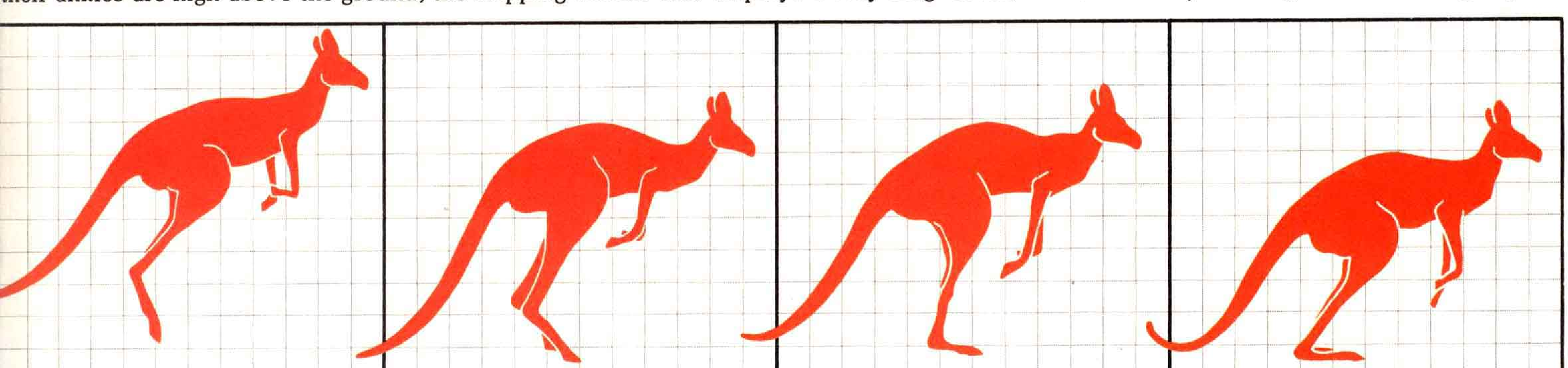
Lifting one leg at a time when walking—right hind foot, right fore foot, left hind foot, left fore foot—the pig



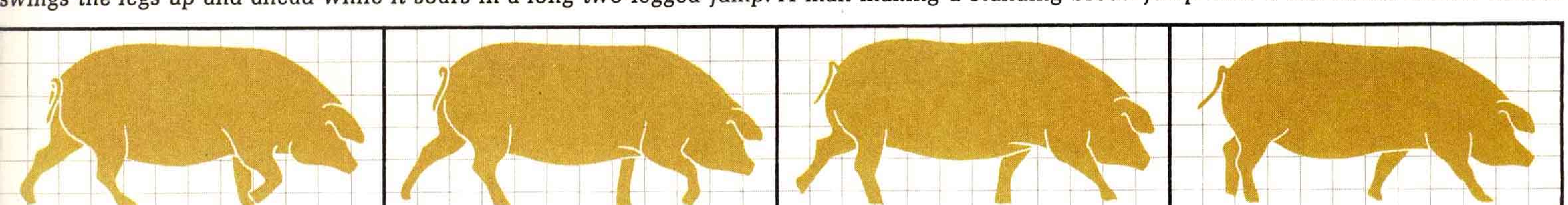
while the right leg moves ahead to land on the heel; then the left foot thrusts off. In order to run fast, he stays on his toes, like an ostrich.



their ankles are high above the ground; the stepping motion thus employs a very long "lever," which makes for a long stride—and high speed.



swings the legs up and ahead while it soars in a long two-legged jump. A man making a standing broad jump uses a somewhat similar action.



rocks from side to side to avoid falling, keeping its body weight over the tripod defined by three legs while the fourth is commencing a step.

Let us begin, then, with the act of walking. For all its apparent simplicity, it is an adaptation as specialized as flying is to a bat or swimming to a seal. True, man is not the only animal able to stand on its hind legs alone; birds, bears and a number of man's primate cousins are bipedal on occasion. But with the exception of a few flightless birds, such as the ostrich, man is the only animal that depends exclusively on two legs for locomotion—whether crossing a room or crossing a continent, moving at high speeds or aimlessly strolling, with arms burdened or swinging free. Using his two legs, a man has the endurance to outrun a deer. He can carry heavier loads, pound for pound of body weight, than a donkey—the French-Canadian *voyageurs* who transported Indian trade goods through the North Woods routinely backpacked 180 pounds of bales over nine-mile portages, and a legendary hero among them named La Bonga is said to have portaged 450 pounds. No terrain is totally impassable to a man; he can reach an eagle's aerie or a pearl oyster's bed. Only a man, the British scientist J. B. S. Haldane noted, can swim a mile, walk 20 miles and then climb a tree. When compared with the versatile and powerful scheme of human locomotion, even the regal movement of a horse turns out to be limited indeed.

Like horses, men have a variety of gaits; they amble, stride, jog and sprint. Among them all, though, the simple stride is at once the most useful and the most peculiarly human way of getting from one place to another. Developed on the African savanna, where man's early ancestors often covered many miles in the course of a day's hunting, the stride has taken man to every corner of the earth. It is no minor accomplishment. When compared with the way four-legged animals get about, human walking turns out to be a surprisingly complex feat of acrobatics. "Without split-second timing," says John Napier, a British authority on primates, "man would fall flat on his face; in fact with each step he takes, he teeters on the edge of catastrophe." Human walking is actually a balancing act in which the muscles of the feet, legs, hips and back are alternately contracted and relaxed according to synchronized orders from the brain and spinal cord.

It is all uniquely human, this "heel-and-toe-and-away-we-go" cycle, and to those who can see it with fresh eyes, it is strangely beautiful. Uniquely human, because no other creature on earth can do it. And beautiful in its sheer efficiency, in its superb adaptation of bone and muscle, brain and nerve, to the tricky problem of moving about on two legs rather than four. The adaptation was achieved at considerable cost. Back trouble, for one thing, is common among men, and comes partly from upright posture.

But why is it so important to man that he stand erect and walk on two legs? Part of the answer has to do with man's head, another with his hands. The advantages for the head are often overlooked, yet simply raising the head high above the ground has had crucial results. The head is where the eyes are, and the taller a man stands the more he sees. A dog running through tall grass is forced to leap into the air time and again to find his bearings, but even on a smooth surface, where no obstacles obstruct vision, the advantage of height is enormous. Eyes that are two feet above ground level can detect objects two miles away; eyes five feet above the ground can see a mile farther.

The advantage of height is especially important because vision is by far the most directly useful of man's five major senses.

Scientists estimate that some 90 per cent of all the information stored in the brain arrived there through the agency of the eyes. Not surprisingly, man's eyes are attuned precisely to his needs. For general seeing they are unsurpassed by any in the world. A hawk may see more sharply but cannot move its eyes easily and generally moves its head to follow its prey. A dragonfly can follow faster movement than a man but cannot focus a sharp image. A horse can see almost completely behind its head but has difficulty seeing objects straight ahead at close range. Most important, among higher animals only man and his nearest primate relatives have the special combination of full stereoscopic and color vision. Man's eyes, placed at the front of his head rather than the sides, can focus together on an object so that it is perceived as a single three-dimensional image in the brain. Within this image his color vision enables him to pick out details by hue as well as by form and brightness.

Taken together, color and depth perception bring man enormous advantages over most other animals, the majority of which are color-blind and have a relatively poor capacity to judge visual distances or focus in fine detail upon particular objects. What a hunting dog sees when it looks out over an open field is little more than what a black-and-white movie might show and his distance focus is limited. If there is a rabbit in the field, the dog is unlikely to spot it unless it moves—one reason why rabbits and similar prey freeze to conceal themselves from their enemies. A human hunter, on the other hand, can scan a scene from his feet to the horizon in a few seconds by focusing sharply and selectively upon a succession of different images. And he sees more images than any dog does because his eyes are raised at least three feet higher above the ground.

But if man stands up partly in order to see, and stays up partly because he sees so well, the freedom that his posture gives to his arms has proved even more decisive. Chimpanzees, among man's closest competitors in upright posture and bipedal movement, have never really mastered the art of walking on their hind legs, and they lack man's free use of the arms. For a brief while they can get about in their forest homes with a bunch of bananas or an infant in their arms, but they must always be ready to assist their balance with the help of a knuckle on the ground. On the other hand, man, who learned very early how to walk in open country, has thrown caution to the winds. Babies may crawl on all fours; old people may rely on canes; but most men go about with never a thought of support from anything but two legs: their hands are free to grab and use things.

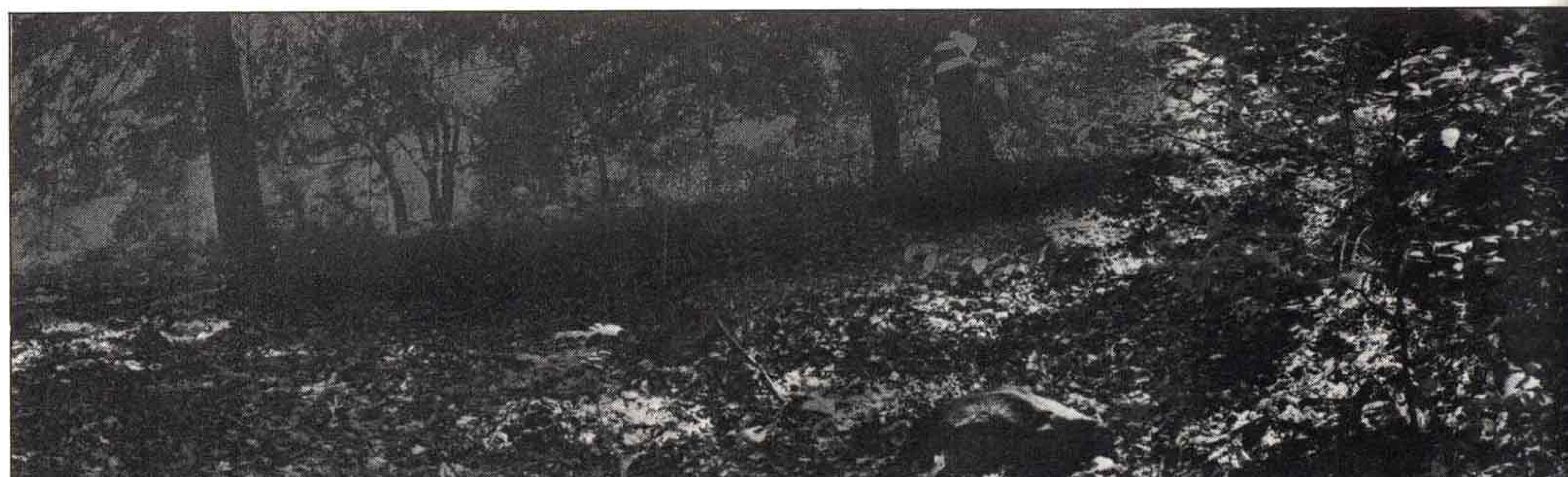
The hand that is not needed for support can take on more responsible and more creative tasks, and it has become the instrument by which man has prospered. With 25 joints and 58 distinctly different motions, it represents one of the most advanced mechanisms ever produced by nature. Imagine a single tool that can meet the demands of so many different tasks: to grip a stick, to play a concerto, to wring out a towel, to hold a pencil, to gesture and —something we tend to forget—to feel. For, in addition to the ability to perform tasks, the hand is our prime organ of touch. In the dark or around corners, it substitutes for sight. In a way, the hand has an advantage over the eye, because it is a sensory and a manipulative organ combined into one. It can

Four Views of the World

The photographs at right show how differently a man, a dog, a horse and a bee see the same sunlit grove. (The horizontal visual field of each has been assembled by lining up photographs specially made to represent animal vision).

Man sees the smallest part of the grove—but in that section he sees the most. The human visual system distinguishes among some 10 million gradations of color; it also can adjust to the 10-billion-fold range between the dimmest thing it can discern and the brightest object it can see without pain; it focuses to see sharply either the nearest ferns or the most distant tree. And man's vision has one more quality the pictures here cannot show: the sense of depth provided through his broad, stereoscopic field of view.

A spring scene appears to man's 180° vision in full color, the green



The dog's color-blind eyes perceive a broader and in one way sharper field—nearby leaves are

A horse's wide-set eyes cover everything in a 360° view that is interrupted only by a narrow area directly behind the head. Though the horse does

A honeybee sees a fuzzy pattern made by the thousands of lens-tipped cones of its compound eyes. Its vision spans a circle—minus parts blocked