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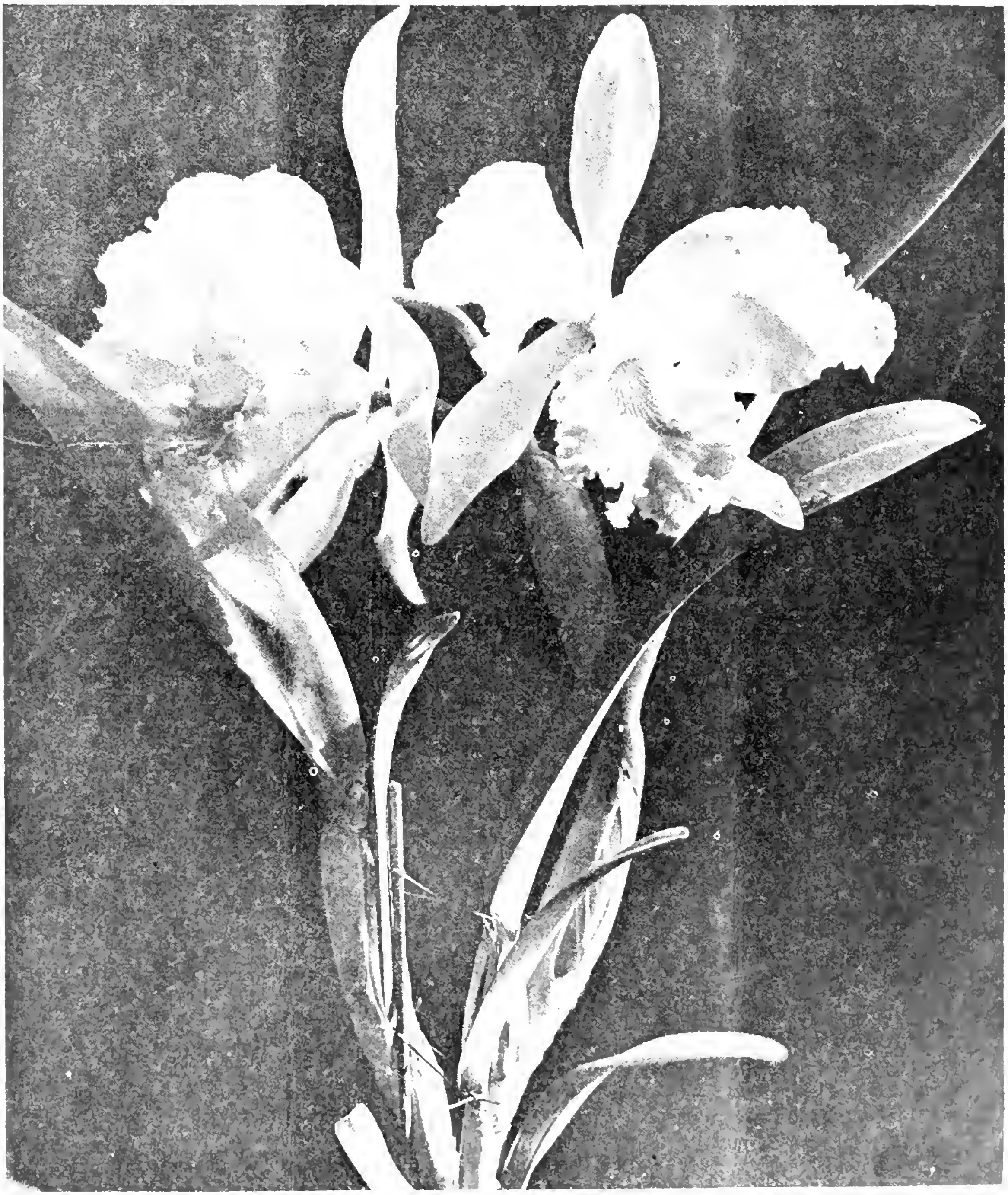
EVOLUTION

A JOURNAL OF NATURE



Keystone-Underwood Photo

WHAT MADE THE FLOWERS?

(See Page 3)

EVOLUTION

A Journal of Nature

For popular education in natural science to combat bigotry and superstition and develop the open mind

YOU will note two additions to EVOLUTION's editorial staff. Prof. A. J. Carlson, Head of Physiology Department of Chicago University, joins our Scientific Advisory Board. Dr. Henshaw Ward, author of "Evolution for John Doe" and "Charles Darwin: The Man and his Warfare," becomes one of our Contributing Editors. Readers who know Professor Carlson and Dr. Ward will already appreciate our good fortune in securing their active co-operation.

IN RESUMING publication of Evolution we wish first to express our appreciation for the support of the many friends of science freedom whose contributions have made this possible. We shall strive to prove that their confidence was merited. We hope not only to bring EVOLUTION out regularly, but to make it a still better instrument for arousing a more general interest in natural science, and a more effective champion of science teaching against the forces of organized superstition.

EVEN if the fundamentalists made no fuss at all there would be need and a field for a natural science journal that is "easy to read" and always accurate. More research work is being done now and more exploration parties are in the field than ever before, and EVOLUTION will help to pass their newly-found information along. There is too great a spread between what the scientific world accepts and knows, and what the mass of the people understand. EVOLUTION will help to bridge this gap. We hope also that teachers and scientists, busy with their specialties, will find EVOLUTION useful for its reliable information outside their own fields.

BUT fundamentlism is neither dead nor asleep. Fundamentalist magazines are constantly agitating their readers regarding the "dangers" of evolution, assuring them that "real" scientists are discarding the "theory", and preparing them for the promised campaign to outlaw evolution teaching through popular referendum vote. This influence has tremendous effect at present through teaching in the schools. And in thousands of school administrations, as for instance in Boston, medievalism is in the saddle and prevents the High School biology teachers from dealing with evolution at all.

THE only solution for this problem is general popular education in natural science. When a sufficient number of people have some inkling of what is meant by a scientific approach to a question instead of accepting opinions dogmatically handed down by authority, this situation will change. There is literally no way to measure the far-reaching effect that a general recognition of man's place in nature, as indicated by the fact of evolution, would have upon the endeavors of the human race. It is a matter of surpassing importance.

EVEN in these days of depression the work of popular education must go on. It is needed all the more. So, now that EVOLUTION has started again, we urge every one of our old readers, as well as the hundreds of new ones that start with this issue, to become active supporters of this great work. The most immediate task is to double the present paid circulation of EVOLUTION, so as to make the journal self-sustaining. Please do not keep this copy to yourself, but show it to your friends and secure a little club of new EVOLUTION subscribers. And, if possible, also contribute a check to be used in EVOLUTION's educational campaign.

NEW EVIDENCE FOR EVOLUTION

Perhaps the most impressive evidence for evolution is the fact that so many different lines of evidence from entirely independent fields of investigation all point to the same conclusion. If there was only one chain of evidence, then a "missing link" might be of some importance. But this loses its significance entirely in view of the multiplicity of independent proofs.

In this issue we present evidence from a comparatively new field of research, about which Darwin and Huxley knew practically nothing. And yet everything that is being discovered today supports the view of these old masters, that evolution is a fact. We refer to the evidence from Parasitology in the article by Professor Robert Hegner. In our next issue the article by Professor H. Gideon Wells will bring more new evidence from Biochemistry. Although for some of our readers it may prove rather difficult to master this material, we are sure they will find it eminently worth while. And perhaps it will also prove entertaining to bring this new evidence for evolution to the attention of fundamentalist friends.

SCIENCE CONGRESSES

Three Science gatherings this summer will interest readers of EVOLUTION.

American Association for the Advancement of Science at Syracuse, N. Y., June 20-25. Particulars from Permanent Sec'y A.A.A.S., Smithsonian Institution, Washington, D. C.

International Eugenics Congress at American Museum of Natural History, N.Y.C., August 22-24. Address: Third International Congress of Eugenics, Cold Spring Harbor, N. Y.

International Congress of Genetics at Ithaca, N.Y., August 24-31. Information from C. C. Little, Sec'y, Jackson Memorial Laboratory, Bar Harbor, Maine.

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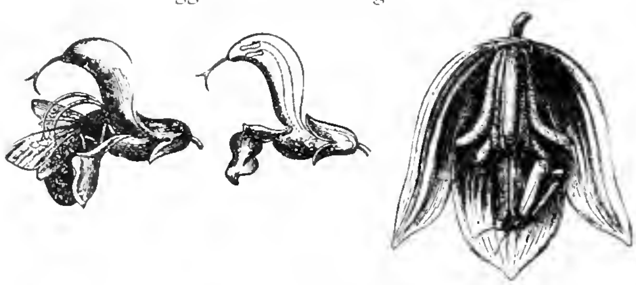
What Made the Flowers?

By HENSHAW WARD

IF ANYONE asks what made the leaves of plants, he is proposing a question that has no answer, for no one can tell how leaves happened to come into existence. But botanists know that "What made the flowers?" is one of the most pregnant queries ever put by a naturalist, and that the answer is the prettiest one in the domain of evolution. *Insects made the flowers.*

Before this answer can be understood, we must know what a flower is. It is an apparatus by which plants make seeds. There is a bewildering variety of flowers, working in various ways; but the most common kind, the kind with which this article deals, consists of two organs. One of these, called a stamen, produces the male element that goes to the making of an embryo. At the top of the stalk of a stamen is a knob in which are fine grains of pollen. These grains correspond to the male element, the sperms, in animals. The second organ, called a pistil, produces the female element that goes to the making of an embryo. At the base of its stalk is an ovary which contains eggs that are waiting to be fertilized.



Botany for Colleges—Ganong: Macmillan

In flower at left, Salvia pratensis, hinged lever arrangement brings stamens down on body of bee. Moth in Yucca flower at right, carries pollen from another flower, tamps it down and lays egg in it.

If you look closely at a typical flower—say a wild rose—you will see at the base of the colored petals a circle of several dozen stamens, each of which is a little stalk that bears aloft its pollen-sac. Within this circle of stamens is a cluster of pistils; each of them is rough and sticky on the upper end of its stalk, and each one terminates below in an egg-sac. The business of every stamen is to convey its pollen to the top of some pistil; the purpose of every pistil is to capture a pollen-grain that will fertilize its egg. Unless the egg is fertilized by pollen, it is barren and cannot produce a seed. This process of fertilizing is called "pollination." And the need of pollination is the origin of all the colored flowers.

If you think of an ear of corn, you can realize what pollination means. On the cob of the young ear were clustered a dozen rows of pistils waiting to be fertilized. From each pistil extended a long, delicate thread, which reached to the end of the cob and stretched out into the air. We call this set of pistils the "silk" of the ear. Two feet above the ear, at the top of the cornstalk, was a cluster of stamens, which we call the "tassel." When mating-time comes for the plant, the pollen-sacs of the tassel open and spill their contents. The microscopical grains float down through the air. When one of them lights on the tip of a thread of silk, it is straightway transformed into a thing of life. It sends out a most slender and delicate tube, so small that it can force a passage down through the core of the silk thread, dissolving, really eating, its way along the whole length until it reaches the egg. There its nucleus combines with the nucleus of the waiting egg. And what then? At that moment the embryo of a new kernel of corn is created. This grows as the weeks pass until it becomes one of the hundreds of juicy kernels that are set on the surface of the cob. If it is not gobbled by hungry animals, but is allowed to grow hard, is kept through the winter, and put under ground next spring, it will sprout and grow into a new cornstalk.

Thus we see that a corn plant is complete within itself: its ovaries are fertilized by its own pollen. If one cornstalk stood all alone in the midst of a large space, it could be self-sufficient with its own pistils and stamens. Yet in an ordinary cornfield, on a windy day when the tassels are ripe, the air is full of pollen, and many silky pistils are fertilized by pollen that is blown from another plant. Such pollination is called "cross-fertilization." Some plants cannot be fertilized by their own pollen; and experiment has shown that most plants are more surely and richly fertilized by the pollen from another plant. The general rule of nature is that most plants require, or are better off with, cross-fertilization. Grasses and trees send out in the spring vast numbers of pollen-grains, which fill the air in uncounted millions. The pine, for example, commits to the breezes a kind of pollen-grain that is wafted by means of air-sacs on either side of it. Perhaps only one in a million finds a pistil. It is a fearfully extravagant method, but it succeeds. It accomplishes the cross-fertilization that plants are in need of.

Plants with conspicuous flowers are not so extravagant. They have found a cleverer way of conveying pollen. They lure and bribe insects to do the carrying. Watch this bee that is buzzing up to a head of clover. She has been attracted by the bright red spot in the landscape, for she knows that it advertises food. She likes the odor, because it certifies to the presence of food. She confidently runs her tongue into the bell of one of the flowerets, and finds, sure enough, a sip of the nectar that she can convert into honey. That is all she thinks of—nectar. But the flower has quite other thoughts. It quickly sticks some pollen-grains on to the bee's head. The bee flies to another flower. As she presses eagerly forward for the next drop of nectar, some of the pollen-grains that she has been transporting are rubbed off and gathered in by the rough, sticky tops of the greedy pistils. The bee has, all unconsciously, accomplished cross-fertilization for the clover.

If botanists knew only of the ways in which insects carry pollen for clover and roses and buttercups and lilies, they would never suppose that they knew the answer to "What made the flowers?" They might guess that these four flowers had developed, through a long course of evolution, such showy and sweet-scented mechanisms as were adjusted to the taste of insects, that the blossoms had been gradually shaped by the success of those plants that varied in such ways as to grow more and more attractive to insects. It might be a likely guess that insects, by avoiding the less pleasant flowers and visiting the more pleasant ones, had actually shaped and colored and given odors to the blossoms that catered to their preferences. But this would be only a guess. Until many naturalists had studied thousands of species of plants for almost a century, they were not well-enough informed to establish a reliable theory of how the insects made the flowers. But sixty years ago they had acquired so much knowledge of the relations of plants to insects that they felt pretty confident of the theory—which Darwin first elaborated. Since then all added knowledge of botany confirms Darwin's theory, and no knowledge has run counter to it. Today every botanist assumes that flowers were developed, in the course of millions of years, by the adaptations that plants made for inviting and employing and rewarding the insects.

In this brief article we can look at only a few examples of those thousands of devices which have been evolved by plants in their efforts to use insects as pollen-carriers.

A series of five facts should be clear in a reader's mind if he is to realize the meaning of the devices. (1) The sweet juice of flowers, the nectar, is the material from which honey is made; and honey is the only food of bees in a state of nature; honey is for them a matter of life and death. They drink the nectar, convert it into honey, and store it in the comb to support life through the winter. (2) Pollen is the source of the "bee bread" on which the young bees are fed. (3) The whole duty of worker bees—to which they devote incessant labor so long as they live—is to bring nectar and pollen to the combs. (4) The whole anatomy of a worker is an apparatus for extracting, carrying and converting the food that is found in flowers. The mechanisms and instincts of a bee are all directed to one end: making successful visits to flowers. (5) All insects that depend on flowers for a living are, like the bees, engaged in the most serious business of their lives when they visit blossoms: if they do not secure food, they die.

And it is equally true of all those flowering plants which depend on insects for pollination that they will die if they do not persuade the insects to visit them. Flowers and insects are engaged every minute of their lives in an unrelenting struggle to exist. If we find them adapted to each other's needs, we can be sure that the adaptation is not a chance and not a joke; it must be a result that has evolved in the course of the long ages of fierce competition to survive.

"One Way Passage" of bee through lady-slipper flower.

Think of a flower whose stamens wither before the pistils are ripe for pollen. It can never fertilize itself. The species would die next year if the blossoms did not succeed in enticing bees to come to them. A bee has been visiting blossoms in which the stamens have skilfully deposited pollen on her head; she comes to these waiting pistils that are surrounded by dead stamens; she rubs off pollen on them; the flowers are fertilized. No botanist can conceive that a flower has had this remarkable adaptation from the beginning of time; it must have evolved at some period in the history of the species. And there is no way to imagine the evolution except to suppose that all flowers which varied toward this arrangement were more likely to have descendants that would continue to vary still further in that direction. We can only imagine that the species was thus transformed by adjusting itself to the tastes of insects.

Look at a flower which does not open until nightfall. It has no gay colors, for they would not be visible; it has the light yellow color that is most prominent in the starlight; it has a strong odor; its nectar is at the bottom of a long tube. It could never have been developed by its need of bees or wasps. Its color, time of opening, odor, position of nectar —all are adjustments to invite a certain kind of night-flying moth. All its structure and habits have evolved as a response to what this moth desires.

There are many plants that have developed ways of fencing out unwelcome ants from the store of nectar—barriers of bristly or tanglefoot hairs. Yet these flowers are so constructed as to admit the long proboscis of the bee. They have been shaped in a complicated and accurate way by the attacks of enemies and the visits of friends.

In some flowers the petals form a cap over the stamens, and this cap is so delicately adjusted that it is thrust aside by the landing of a bee. Instantly the released stamens fly up, strike the bee in the chest, and dust her with pollen, which will fertilize the next flower she visits. Another similar arrangement is a set of stamens that fly up and strike when their base is touched. One of the set of stamens in another flower is provided with a trigger, so set that when the bee's proboscis stretches down for nectar it strikes the trigger and sets all the stamens to vibrating.

When you see an orchid in a florist's window, you are looking at one of the family of plants that have gone furthest in inventing machinery to work tricks on bees. One of them actually provides *a pool of water*, on the brink of which is some food that bees are eager to gnaw—so eager that they often push each other into the water! When their wings are draggled, they can leave the flower only by a tunnel near the overflow spout. In this tunnel the pollen is stuck to their backs, and so will be carried to another flower and fertilize it.

In some of our American swamps there is a delicate little flower called "sundew," because on the surface of its leaves there are drops of sparkling white. These drops are so sticky that they can hold on to the feet of insects; the hairs on the surface of the leaf then fold over one by one and strangle the insect; the plant digests its victim. It has evolved a trap and digestive fluids that enable it to eat meat. Many other plants, of very different kinds, have developed other methods of catching and eating insects. For example, the butterwort—which has to rely on insects for carrying its pollen—captures other insects by snapping leaf-edges over them while their feet are caught in a viscous fluid.

There are African plants that have immense pulpy blossoms a foot in diameter—ugly in shape, unpleasant in color, and smelling like rotten meat when the pistils need pollen. They are disagreeable to human beings, but flies cannot resist the odor. Flies visit flower after flower, carrying the pollen that clever stamens load them with, brushing off the pollen on the eager pistils. The plant is a swindler; for it promises carrion on which flies can lay eggs, but it gives nothing. This curious adjustment of a flower to meet the instincts of flies can only be a product of gradual evolution.

Another rascally flower, in England, plays another kind of confidence game. It coaxes flies to crawl down its throat. They pass quite easily through a ring of hairs that point downward, but they cannot climb out again because those same hairs are now pointed at them and block the way. A fly thus imprisoned must wait until the stamens ripen and dust him with pollen. Then the flower pays its bill with a few drops of nectar; the hairs shrivel up; the fly escapes and soon is down the throat of another flower that captures it and appropriates the pollen it brings. If all flies were teachable and would not venture a second time into the kind of flower that had deceived them, no such trick could have evolved. Flowers have been adjusted to the peculiarities of insects.

Sometimes the relation between flower and insect is romantically useful to each party. An illustration is a yucca called Spanish bayonet that grows throughout the Southwest. It is entirely dependent for fertilization on a small white moth which collects pollen, carries it to the pistil of another plant, and there *tamps it down carefully*. Why is the moth so obliging? Because she is making a place to lay an egg. When the egg hatches, the larva eats some of the seeds, *but not all*.

Such a marvelously exact adjustment of plant to insect seems purposeful. It is hard to believe that the moth has not reasoned out what she is doing. But of course she has not done, she could not conceivably do, anything of the sort. For every such provident action by an insect is known to be a matter of inherited instinct, which is obeyed without any knowledge of what the result is to be. The instinct could only have been developed by a process of evolution, in which the favorable variations of stamens and pistils and egg-laying desire were adjusted to each other. The plant that furnished more enticing pollen would have more descendants; its type would increase in numbers and would tend to produce still more enticing pollen. Likewise the moth that managed the pollen best was more likely to have successful descendants. Each plant or insect that inherited a tendency toward better co-operation was more likely to have offspring, and these descendants were increasingly likely to inherit the traits that made co-operation still nearer perfect.

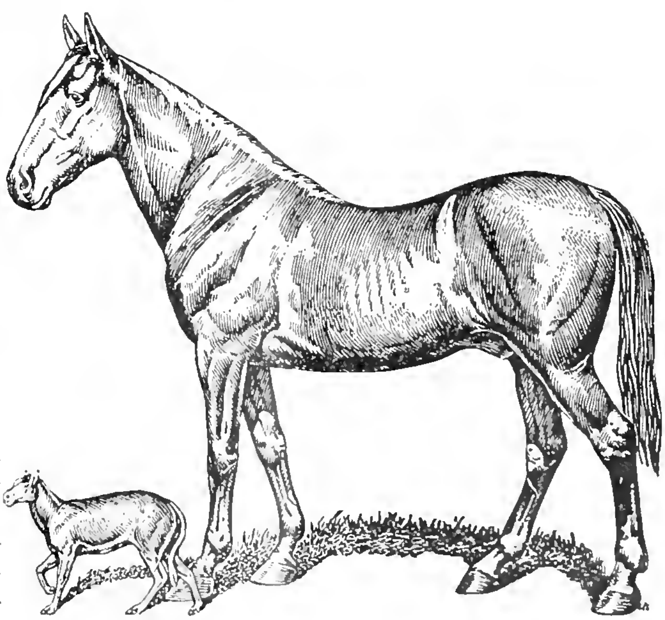
This theory can explain every case of the adaptations of plants to fertilization by insects. No other theory can account for the adaptations. If there were a botanist who rejected the theory because it seemed too miraculous, he would have to do his scholarly work in the dark. All his fellow botanists live in the light of a theory that helps them understand how nature operates. They can see how *insects made the flowers*.

The Tale of the Horse

By ALLAN BROMS

OUTWARDLY we see little likeness between man and the horse, but inwardly they *are* much alike. We see, outwardly, that the horse has four legs and man but two. What we forget, for the moment, is that man's arm was, not long ago in his evolutionary history, just a front leg which has become arm only recently by his uprearing to the erect attitude. But let a horse uprear that way, then look through him to his skeleton, and you will see the resemblance in nearly every part. Proportions have changed, especially in the skull, and the horse has lost some teeth, and leg and arm bones. Otherwise they are strikingly alike. At the American Museum of Natural History you can make this comparison, for they have mounted the skeletons of a man and a rearing horse side by side. The marked likeness shows our remote kinship, while the differences are important in their emphasis of the recent evolutionary changes which made man a man and the horse a horse. But here I will tell only The Tale of the Horse.

The horse is distinctive in having but one toe to each foot and in his unusual teeth. Both are parts of the same story. Already, back in 1870, Thomas Henry Huxley, the great evolutionist, realised what that story must be and foretold that we should find the fossil remains of a series of increasingly horselike creatures that began with a normal five-toed animal having just ordinary mammal teeth. At that time only one fossil of this series had been found, but it was not even recognised as an early horse. Now, however, we have a very complete fossil record, largely dug out of our Western bad-lands, where the arid soil lacks grass roots to



Courtesy American Museum of Natural History

Modern Horse Compared with his early ancestor, Eohippus.

bind it together and the occasional rainstorm torrents cut the loose soil away quickly, exposing the fossil bones.

Dozens of species have been found, most of them side branches on the family tree of the horse. We must stick to a very few along the direct line of descent. Eohippus, meaning the "dawn horse," is the earliest, living during the Eocene Epoch, some fifty million years ago, in our Western states, where the evolution of the horse seems to have occurred. He was somewhat larger than a big cat and had an arched back. However his feet and teeth were not cat-like, but belonged to a browsing, hoofed animal. There were not five toes on a foot, he was too far along in his evolution for that, but he did have four on each front foot and three on each hind foot. His brain was well developed for his time, a sure sign that he was active and swift, to make up for his smallness.

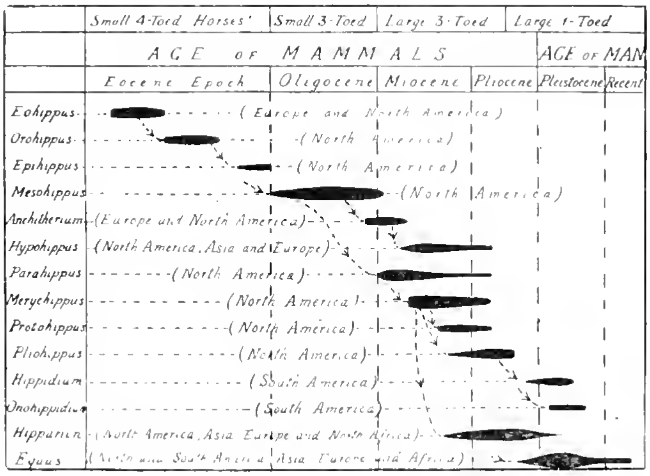
From this beginning, we can now trace the changes that came on progressively up through the geological epochs, which for us means up through the geological strata or layers of the earth crust, for the top layers are of course most recent. There was an increase in size, but only up to a limit consistent with swiftness. Orohippus, the "mountain horse", and Epihippus, the "upon horse", were just a bit larger than Eohippus. By the Oligocene and Miocene Epochs, about twenty million years ago, Mesohippus and Miohippus were already the size of sheep, and though they had three toes on each foot, the two side toes were getting smaller and much of the weight was carried on the middle toe. Hypohippus came a bit later, as large as a pony, its middle toe looking more like a hoof. And so time and change went on until the horses of today have nearly lost their side toes. I say "nearly lost" them, for remnants remain as the two splint bones now entirely buried in the flesh. Now and then some horse of today reverts to his ancestors and is born with extra toes on his feet. Julius Caesar owned such a horse and more are on record.

Courtesy American Museum of Natural History

Evolution of Hind Foot of Horse

Eohippus, Mesohippus, Miohippus, Merichippus, Hipparion, Equus.

You may talk about your old families, but none can ride the high horse on the horse; he has a pedigree that stretches back at least fifty million years. But properly, like other folks with ancestors, he has little reason to take pride, for he had nothing to do with it himself. After all, we are all



Courtesy American Museum of Natural History

Geological and Geographical range of ancestors of horse. Black lines show life span of each genus. Dots. show line of descent.

creatures of conditions, made by our environments which make demands that we must needs meet, or die out. If our variations change us in the right directions, we survive, if not, our careers end. A change of climate made the horse.

When Eohippus made the start, our Western country was low and swampy, just emerged from the sea, for the earth crust here was rising. The climate was moist and the country forest-covered. In these woods, Eohippus hid, alert and quick on the get-away when he was discovered. His coat may have been striped like a zebras to help him hide. His wide, three- and four-toed feet kept him from sinking into the soft ground. He browsed on leaves, which are soft, so his teeth were a browser's teeth, more like those of a tapir than a modern horse.

But not only were the swampy forest lands rising; a mountain range was being uplifted to the West, cutting off the moist winds of the Pacific, causing a dry climate which discouraged the forests. Slowly the woodlands gave way to the grasslands, and the horse found himself out in the open, exposed to many dangers, among them a shortage of leafy food. To survive in this environment, he had to acquire speed for escape and for rapid ranging for his food supply, and had to develop teeth for grinding grasses. The horse perforce became a grazing animal instead of a browser. His teeth disclose that conclusively. Up front they became sharp for cutting. Then came a toothless space, where we place our bridle bits. And way back, where the jaws have a strong leverage, came the grinders. They became strong, fitted for tough, hard food. The grinders have rough surfaces of complex pattern, due to unequal wearing down of the twisty alternating edges of glassy-hard enamel and the soft dentine and cement between. In the early horse, the surface patterns were simple, but as they evolved, the patterns became complex and more horse-like in the modern sense. Also they became longer in root and crown, permitting them, after their original growth to maturity, to move instead of grow outward for many years as their surfaces wore down. Altogether, the teeth became fit for cutting and grinding great quantities of hard and relatively innutritious grasses of the plains, instead of the soft green leaves of the forests. Necessarily the horse, in order to survive, eventually had to become a grazer with the new kind of teeth. But old ways cling and some horses remained browsers in the remnants of forests that lingered for a long time. Nature tried out both experiments, but finally the drying climate rendered a decision in favor of the swift, grazing plains horse that we know.

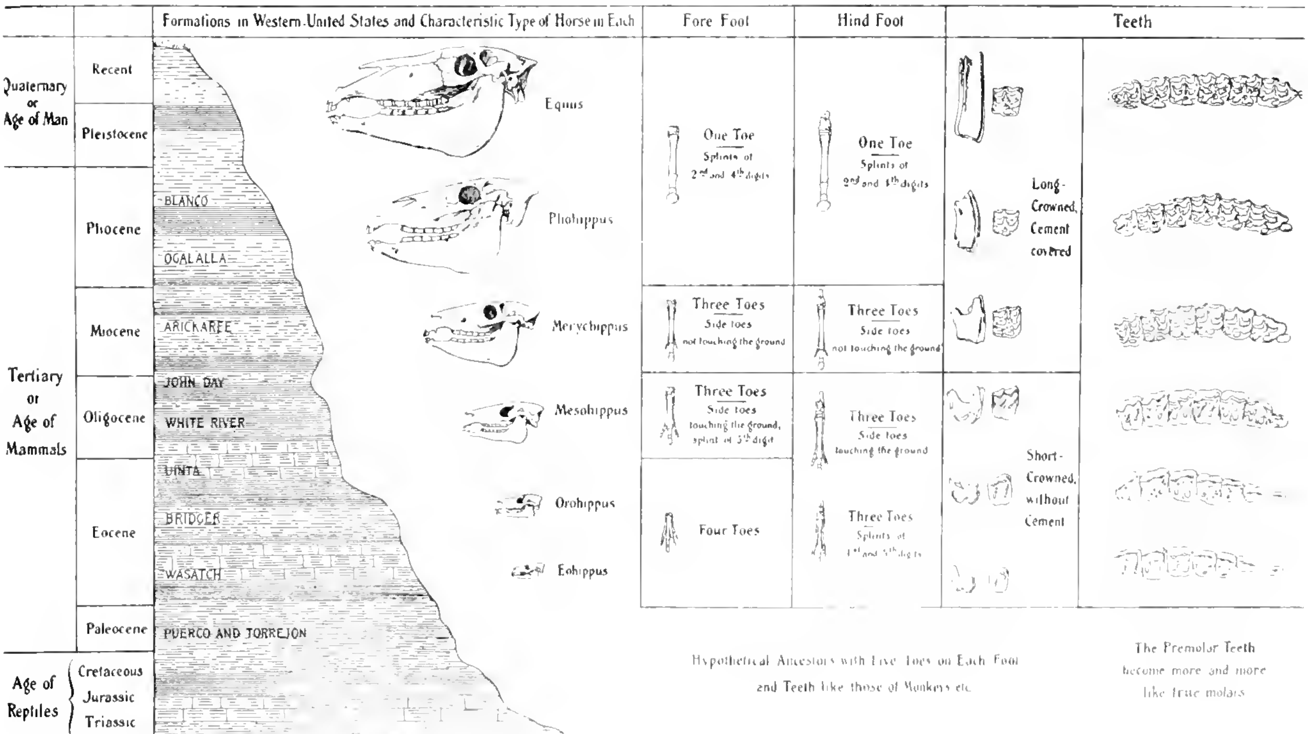
For the horse was gaining swiftness. Increased size helped, but the changes in his leg machinery were also important. Eohippus was really heavyfooted, for he had a lot of bones down in his foot. But evolution slowly got rid of this excess weight, making the horse literally light-footed. If you want to know how foot-weight handicaps, tie weights on your ankles and try to run. Another aid was that even Eohippus walked on his tip toes, for the horse's hock, half way up his leg, is really his heel. On the dry, grassy plains, the ground was hard, and even the narrow hoof of the middle toe would not sink in it. Besides there was less danger of turning the ankle and other joints on rough ground when the wide foot had been gotten rid of. The joints themselves also changed to prevent turning the ankles and similar injuries. With such joints, he need put forth no effort to keep his legs straight sideways, all his muscles can be devoted to moving forward, to give him speed. Mechanically, he is a marvelous adaptation. He is "on his toes," light-footed, without waste muscles, strong and full-lunged to travel fast and far, to escape his enemies, to cover a wide grazing range.

Nature made parallel experiments with several relatives of the horse who were also having a bad time of it in the new hard conditions. Among them was a rhinoceros, small and horse-like, swift on his feet, but somehow not good enough to survive in the severe struggle. Some of the relatives went in for brainless bulk, the heavy-footed Titanotheres for instance, but they starved to death on the widening grasslands, there being just too much bulk to feed. Another relative, the tapir, had specialised too well, found himself unable to adapt himself to the new world, and nearly died out.

In the end, the horse also died out in America where he had evolved, but not before he colonised Asia and Africa with wild species such as the ass and zebra and of course the direct ancestors of our modern horses, whom man has so changed that we hardly know what they looked like. At first, for perhaps fifty thousand years, man just hunted the wild horse for food, and but recently learned that the horse was worth more alive than dead, when he harnessed the horse's strength, placed his burdens on the strong back and finally mounted there himself adding greatly thereby to his own powers and prowess. It can safely be said that, without that humble burdenbearer and mount, man could not have built Western civilization, for his own puny strength was unequal to the tasks he undertook.

Having domesticated the horse, man took him along to every corner of the globe, — repeopling (or should we say "rehorsing") North and South America. He also remade the horse by selection to suit his own purposes: the heavy Percheron draft horse, a mountain of strength, that delicate speed-machine, the race horse, and the tough little Shetland Pony, sure-footed, heavy-coated, fit to survive where going is hard. But now that man has built himself new horses of steel, machines that swim or fly, that eat coal or oil, that can be given any strength and much greater speeds, man is discharging his good servant, Old Dobbin, to a lesser place in the world. For man, as master, remakes his world to meet his own desires. He became master by developing a hand instead of a hoof, but that is another story. However, let us not take too much pride in that, for we are just the lucky favorites of fortunate circumstances that made us into men.

This was a radio talk by Mr. Broms. He speaks over WOR every Saturday at 6:30 P. M. Listen in



Courtesy American Museum of Natural History

Parasitology Shows Kinship of Monkey and Man

By ROBERT HEGNER

Professor of Protozoology in the Johns Hopkins University School of Hygiene and Public Health

THE association of two types of animals in nature is a very common phenomenon. In many cases this association does no harm to either party and may even be mutually beneficial, but occasionally, just as in human society, one member of the association lives at the expense of the other. Such an organism is known as a parasite and the animal it lives on is called the host.

Animal parasites belong principally to three groups in the animal kingdom, protozoa, worms, and insects. Everyone is familiar with worms and insects, but protozoa are invisible to the naked eye and hence are never seen except through a microscope. I shall refer in the following paragraphs only to the protozoa that live in monkeys and man.

Protozoa are the most primitive of all animals. They dry up very quickly and die if they are deprived of water, hence they are to be found only in ponds, streams, lakes, oceans, etc., and in places that are always moist. Vast numbers of protozoa live in both fresh water and salt water. These are called free-living protozoa. Other protozoa, the parasites, live inside of the bodies of animals that live on land, and both inside and outside of animals, such as fish, turtles and whales, that live continuously in the water.

Every species of animal that has been carefully studied has been found to harbor protozoa within its body. In some cases, every individual animal belonging to certain species is parasitized. For example, certain white ants or termites, have their intestines loaded with protozoa that aid in the digestion of their food. This may be considered the normal condition for the white ants. The white ants die if they are deprived of their protozoa, hence every living termite of this type must be a host to large numbers of protozoa.

Among other species of animals, parasitic protozoa may or may not be present. Usually the life of the host does not depend on the protozoa nor do the protozoa injure the host perceptibly. As a matter of fact, most protozoan parasites appear to be harmless, a sort of equilibrium having become established between the protozoa and their hosts which allows the protozoa to live and reproduce successfully but does not inconvenience the host to any extent. A few protozoa are harmful to their hosts and are said to be pathogenic. Among the pathogenic protozoa of man may be mentioned those that are responsible for amoebic dysentery, malaria, kala-azar, and African sleeping sickness. Domesticated animals are injured by such protozoa as those that cause coccidiosis in chickens, Texas fever in cattle, and sarcosporidiosis in sheep.

The protozoan parasites of man have been studied more thoroughly than those of any other animal. They can be separated conveniently into two types: those that live in the digestive tract and are commonly called intestinal protozoa and those that live in the blood and are referred to as blood-inhabiting protozoa. The protozoan parasites of monkeys and many other lower animals have also been carefully studied. The following table presents in orderly fashion the names and location in the body of the protozoa that are known to live in monkeys and man.

Scientific Name	*Type of Protozoon*	*Localization*	*Present in Man*	*Present in Monkey*
Trichomonas buccalis	Flagellate	Mouth	Yes	Yes
Endamoeba gingivalis	Amoeba	Mouth	Yes	Yes
Giardia lamblia	Flagellate	Small intestine	Yes	Yes
Isospora hominis	Coccidium	Small intestine	Yes	No
Endamoeba histolytica	Amoeba	Large intestine	Yes	Yes
Endamoeba coli	Amoeba	Large intestine	Yes	Yes
Endolimax nana	Amoeba	Large intestine	Yes	Yes
Iodamoeba williamsi	Amoeba	Large intestine	Yes	Yes
Dientamoeba fragilis	Amoeba	Large intestine	Yes	Yes
Trichomonis hominis	Flagellate	Large intestine	Yes	Yes
Chilomastix mesnili	Flagellate	Large intestine	Yes	Yes
Embadomonas intestinalis	Flagellate	Large intestine	Yes	Yes
Enteromonas hominis	Flagellate	Large intestine	Yes	Yes
Balantidium coli	Ciliate	Large intestine	Yes	Yes
Troglodytella abrassarti	Ciliate	Large intestine	No	Yes
Troglodytella gorillae	Ciliate	Large intestine	No	Yes
Trypanosoma gambiense	Flagellate	Blood stream	Yes	Yes
Trypanosoma rhodesiense	Flagellate	Blood stream	Yes	Yes
Trypanosoma cruzi	Flagellate	Blood stream	Yes	Yes
Leishmania donovani	Flagellate	Blood and tissue	Yes	No
Leishmania tropica	Flagellate	Blood and tissue	Yes	No
Leishmania brasiliensis	Flagellate	Blood and tissue	Yes	No
Plasmodium vivax	Sporozoon	Blood cells	Yes	Yes
Plasmodium malariae	Sporozoon	Blood cells	Yes	Yes
Plasmodium falciparum	Sporozoon	Blood cells	Yes	Yes
Babesia pitheci	Sporozoon	Blood cells	No	Yes
Sarcocystis (?)	Sporozoon	Muscle tissue	Yes	Yes
Trichamonas vaginalis	Flagellate	Vagina	Yes	Yes

This list is not final since we are still studying these organisms and continually learning more about them. However, on the basis of our present knowledge, we may state that of the twenty-eight species of protozoa listed, all but three have been reported from man and all but four have been found in monkeys.

This condition is very different from that encountered when one compares the protozoa of man with those of any other animal. For example, the protozoa that have been reported from the pig include the following:

1) Eimeria debliecki—Coccidium
2) Endamoeba polecki—Amoeba
3) Iodamoeba suis—Amoeba
4) Trichomonas suis—Flagellate
5) Balantidium coli—Ciliate
6) Trypanosoma brucei—Flagellate
7) Trypanosoma evansi—Flagellate
8) Babesia sp.—Sporozoon
9) Sarcocystis sp.—Sporozoon

Only one of these is known with certainty to occur in man, namely *Balantidium coli*, in spite of the fact that man and pig are very closely associated and must often be inoculated with each other's parasites. A similar condition is met with when the protozoan parasites of man are compared with those of dogs, cats, rats, mice, horses, cattle, and other animals closely associated with man. Protozoa that live in man are practically unknown among wild animals.

The significance of this situation is made clear when the parasites of nearly related animals are compared. Suffice it to state that the more closely related animals are according to their arrangement in the animal series on the basis of organic evolution, the more nearly similar are their protozoan parasites. We know this to be true. These facts can be stated in another way, namely, the more alike the protozoan parasites of two species of animals are, the more nearly are the two species related. Hence the extraordinary situation as regards the protozoan parasites of man and monkeys noted above can lead to but one conclusion, and that is, that *man is more closely related to monkeys than to any other type of lower animal.* The data obtained from our studies of protozoan parasites thus add very important evidence of the kinship of monkeys and man to that already supplied by anatomy and embryology.

Those who wish further information on this subject are referred to the following books and magazine articles.

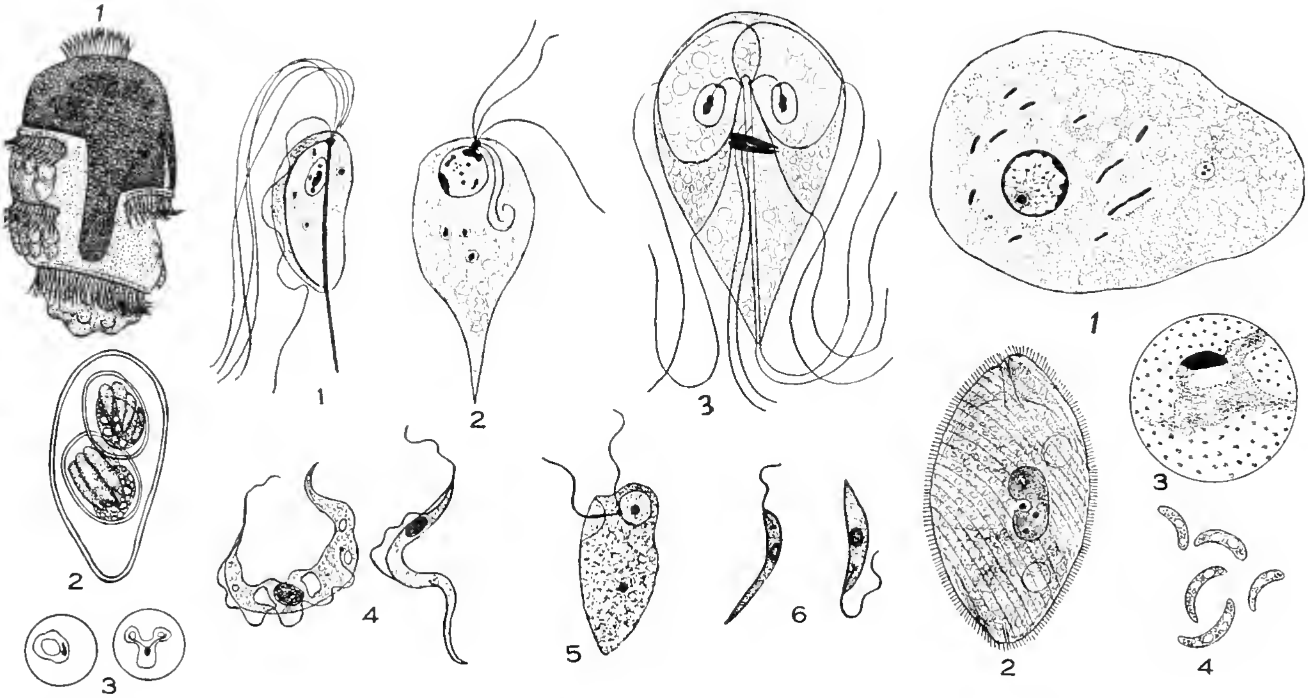
The evolutionary significance of the protozoan parasites of monkeys and man. By Robert Hegner. Quarterly Review of Biology, Vol. III, June 1928, pp. 225-244.

A comparative study of the intestinal protozoa of wild monkeys and man. By Robert Hegner and H. J. Chu. American Journal of Hygiene, Vol. XII. July 1930, pp. 62-108.

Protozoology. A reference book in two volumes by C. M. Wenyon. 1926.

Human Protozoology. By Robert Hegner and W. H. Taliaferro. 1924.

These drawings were all made from specimens that had been fixed on glass slides and stained with hæmatoxylin. They are greatly enlarged.



Protozoan parasites that do not occur in both man and monkeys.
—1. Troglodytella, a ciliate that lives in the large intestine of monkeys but not of man.
—2. Isospora hominis, a coccidium from the small intestine of man, but not yet reported from monkeys.
—3. Babesia parasites like those found in the red blood corpuscles of monkeys but not in man.

EXPLANATION OF FIGURES

Flagellates that occur in both man and monkeys.
—1. Trichomonas, similar to species that occur in the mouth, large intestine and vagina. It is not known for certain whether these flagellates are harmful or not.
—2. Chilomastix, an inhabitant of the large intestine. Its pathogenicity is doubtful.
—3. Giardia, a flagellate that lives in the small intestine and probably sometimes gives rise to "flagellate diarrhea".
—4. Trypanosome flagellates that cause African sleeping sickness.
—5. Embadomonas, a harmless inhabitant of the large intestine.
—6. Leishmania, a flagellate causing kala-azar and oriental sore.

Protozoan parasites that occur both in man and monkeys.
—1. Endamaeba coli, an amoeba from the large intestine.
—2. Balantidium coli, a ciliate that lives in the large intestine where it brings about a type of dysentery.
—3. A malarial parasite within a red blood corpuscle.
—4. Spores of sarcosporidia obtained from muscle tissue.

The Story of the Grand Canyon

By HUGH F. MUNRO

JOHN Burroughs tells us that the West is full of Geology. So is the East for that matter, but in the West we see Mother Nature in her youth, unclothed, raw, angular. In the East she has taken on a mature rotundity and clothed herself with a becoming mantle of green. In the eastern landscape life predominates while the West is stark and bare, less modified by the softening influences of plant and animal life. The West is the paradise of the geologist, for in it the great earth book has been stripped of its covers and its pages lie open for all who care to read and take the trouble to understand its story. More pages of the earth's history are exposed in the Grand Canyon of Arizona than in any other part of the world, yet half of the chapters are missing.

To the tourist the Grand Canyon is merely a great gash in the earth's surface about a mile and a quarter deep, from ten to twelve miles wide and over two hundred miles long. The south rim at El Tovaris is 6866 ft. above sea level, the north rim 1000 ft. higher. Resisting the temptation to dwell on the sublimity of the awe-inspiring spectacle which is felt as well as seen we turn at once to the study of its history.

Aided by rain, frost, wind and chemical action, the Colorado river with its tributaries has been at work for ages cutting away the rock and carrying the debris toward the sea. In the absence of the retarding effect of vegetation, rain cuts its own channels which become deeper year after year, a process that can be seen on any uncovered country road. In the West it is not unusual to cross the dry bed of a river that after a few hours of rain will become a turbid torrent flowing swiftly in narrow channels and carrying a heavy load of scouring material. The rivers all over this region cut out and flow in gorges with almost perpendicular walls.

Descending into the Canyon by the Bright Angel trail, even the most casual observer can see in the varied colors of the rock layers that the Canyon has a history, and little reflection is needed to show that the beginning of that history must be at the bottom where the Colorado river is busy with the continuation of it. At the river level we are standing on the very cellar floor of the earth, so far as the geologist has been able to read the story, the Archeozoic.

No recognizable fossils have been found in the Archeozoic rocks, although there is indirect evidence that life already existed. Where the strata have remained undisturbed, between Grand View and the mouth of the little Colorado river, the Proterozoic rocks have a thickness of 12,000 ft. Within that range, which perhaps covers a greater length of time than all of the subsequent formations put together, the first fossils appear in the form of Algae and primitive invertebrates. Ascending, the upper layers of the Paleozoic are reached, with fossil forms appearing successively as primitive invertebrates, higher invertebrates and fishes. In depth this covers over 4000 ft. and brings us to the Permian which is the highest of the Paleozoic rocks. Here Dr. Chas. W. Gilmore, curator of vertebrate paleontology of the United States National Museum, has collected

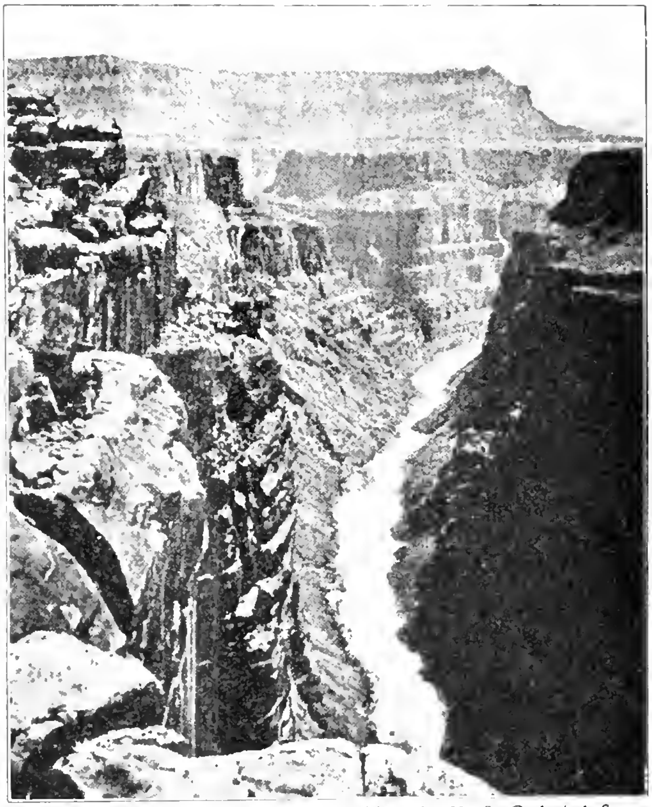
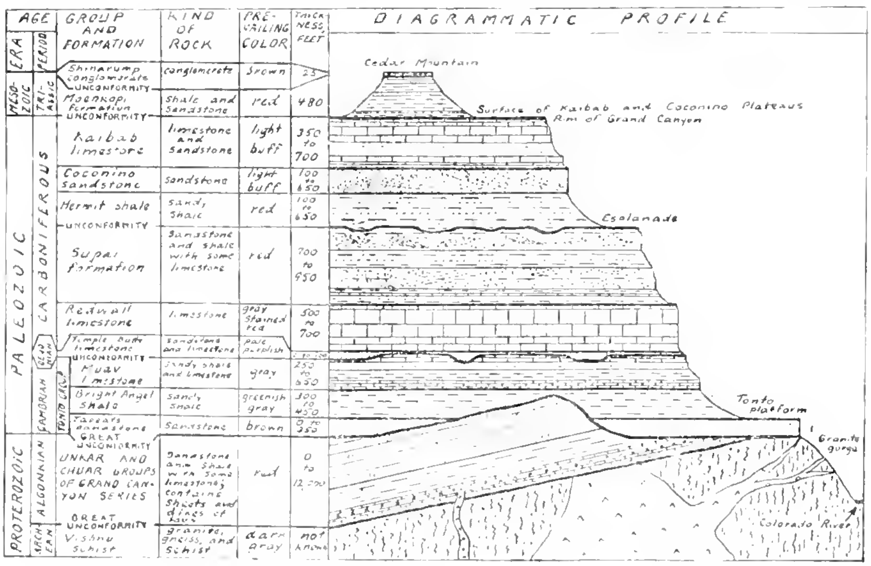


Photo by U. S. Geological Survey

Grand Canyon of Colorado River in Arizona.



Columnar Section, showing position and structural relations of Grand Canyon rocks.

and forwarded to the museum several tons of slabs collected along the Hermit Trail, all showing fossils and foot prints, most of them by large amphibians now extinct.

There are no modern mammals nor flowering plants represented in the canyon walls as the rim is composed of rocks belonging to the Triassic period which antedated the development of such forms. Over a mile of rock is there, but the remaining mile of later deposits is nowhere represented in the Canyon walls. To find it we must travel north to the high plateau in Northern Utah and ascend a gigantic stair whose steps are made of the Jurassic, Cretaceous, and Eocene, to a point one mile higher than the Canyon rim.

Beginnig with the lowest stratified rock in the Canyon, there is layer after layer of limestone, sandstone or shale, with occasional intrusions of lava, gneiss and schist. All of this represents the deposits in water of the debris of earlier rocks, the first of which (Cambrian) is placed by Barrell at 550 to 700 millions of years ago. Assuming that the Canyon area was at one time made up of rocks separating the entire geological series, there must now be enough time allowed for the denudition of one mile of rock until the Triassic is reached. Then the story of the Grand Canyon itself really begins. Add the time that it took the Colorado river to scour out the present chasm a mile and a quarter deep, with the process still going on, for it is deeper today than it was yesterday. Years in Geology mean as little as miles in Astronomy and both may be subject to error. This much however is certain, the story of the Grand Canyon must be read in terms of hundreds of millons of years, emphasizing once more the fact that the earth's history can only be read by the eye of the scientist and interpreted by his type of mind. The hasteless, restless factors of geological change have been writing all through the ages a flat contradiction of all accounts of miraculous creations.

Biochemistry Supports Evolution

By H. GIDEON WELLS
Professor of Pathology, University of Chicago

IN 1859, when Darwin put the subject of evolution on the front page of the daily papers and on all the pages of the religious journals, biologic science was mostly a matter of morphology and classification, as befits a young science. Physiology had not become sufficiently developed as a distinct field of science for the establishment of a Physiological Society of London until 1875, four years after Darwin's second great contribution, The Descent of Man, had been published.

Necessarily the considerations of evolution in its early years were based on the evidence then available, which was almost exclusively structural, and because of this sort of environment in infancy its subsequent career has largely depended on morphological contributions and considerations. But in 1926 Leathes in his presidential address to the Section on Physiology of the British Medical Association pointed out that "natural selection applies to the survival of chemical forms of living matter as it does to complex living organisms. . . . Function alone gives permanence to structure." Therefore it is essential that function, with all that it involves, receive full consideration in working out the course of the evolution of the living world of today.

Origin of Living Matter

Biologic function certainly depends more on chemical properties than on anatomic organization. Formless enzymes may function actively, whereas the most elaborate anatomic structures in our museum jars function not at all, because their enzymes are dead. The evolution of life presumably had first to be the evolution of proteins, carbohydrates and fats, which then somehow constituted the living, probably at first formless, matter, and these were the important first steps in evolution. All the later strange divergencies into such elaborate creatures as cabbages and kings are of minor import.

Therefore one turns to chemistry to see if it can offer a solution of the problem of the origin of life. Such explanations of the origin of life on the earth as that it is the result of the transportation of spores by meteors or star dust, even if true, are no solution, since they merely push back the origin of life to some other part of the universe. One may suspect that the origin of life was the sequel of the formation of inorganic colloids, which served as the antecedents of the formation of organic colloids.

The evidence of geology clearly shows that life in some form appeared promptly when conditions of temperature made it possible, since the oldest sedimentary rocks show that already there were living forms that had much to do with the formation of these early strata of the world's crust. Under the influence of light, formaldehyde polymerizes to produce substances which reduce copper solutions as do the carbohydrates. It is further possible for this formaldehyde in the presence of nitrates or nitrites to produce substances that can build up to form amino acids, and hence the fundamental steps in the evolution of carbohydrates or proteins are possible in the absence of living precursors,—only carbon dioxide, water, nitrites and sunlight are necessary.

If, as Moore suggested, life began by the development of formless colloidal complexes, capable of accelerating synthesis under the influence of light rays, there still remains an unexplained wide gap between such hypothetical chemically active colloidal masses and the simplest microscopically visible living forms, the bacteria. Possibly, the invisible, filtrable viruses represent an intermediate stage antecedent to the bacteria, but there is no knowledge as to how much real structure viruses have, or how many sorts there may be which can not be recognized, because only those that produce disease make themselves known.

Presumably, the next stage in the evolution of life lies in those bacteria which can grow on inorganic mediums and synthesize their proteins, fats and carbohydrates from carbon dioxide and inorganic nitrogen, sulphur and phosphorus compounds.

The step from such synthesizing bacteria to the algae with chlorophyll was probably the next important phase in the

Excerpts from article in Archives of Pathology, May 1930.

The Amateur Scientist

A MONTHLY FEATURE *by* ALLAN BROMS

THE SPRING SAP

IN REFERRING to the Spring Sap, I do not mean either the spring poet nor the young man whose fancies fondly turn at this time of year. I refer to something far more prosaic, the sap which the warmth of spring turns loose within the plants. Once it begins to flow, the leaves bud and the flowers bloom,—but I must be careful lest I wax poetic myself. Like the blood within the animal, the plant sap is the bearer of the stuffs of life. I put "stuffs" in the plural because there really are several, mineral salts, nitrates and so on, soaked up with water from the earth through the roots and borne aloft into the green leaf tissues where the real food factory is. There the green stuff, the chlorophyll, absorbs the sunlight and employs its energy to tear apart the carbon-dioxide taken from the air, releasing the oxygen and then combining the carbon with water to form sugars and starches which store the sunlight energy whose calories we may later consume by eating these carbohydrates. Once manufactured, these foodstuffs are transported down into the plant stem by means of the circulating sap, as you can find out for yourself by tapping a sugar maple tree or sucking a stalk of sugar cane. Finally those sugars and starches may go into storage, as in any starchy potato or plump sugar beet.

Why the sap circulates is a bit of a mystery. To call the force, which lifts it through the tubes of the plant stem, osmosis or capillarity just adds big words to the confusion. But we have an idea how the trick is done. Those tubes have fluted walls, little ridges inside running vertically along their length, with little troughs between. The sap does not fill the center of the tube at all, but flows up those very narrow troughs, each bit of the watery sap adhering to the ridges alongside, thus supporting itself just as the water wetting the side of a glass tumbler supports itself by sticking to the glass surface. In other words, the sap lifts itself by wetting the sides of the narrow troughs of the plant tubes. Up in the leaves, as we have just discovered, the water of the sap is used in making sugars and starches or is wasted by evaporation from the leaf surface. That would dry out the upper plant tubes except that the nearby sap, by flowing in to wet the tube surfaces, replaces the lost water.

But how does that get the sugar and starch products of the leaf factories to move downwards against the upward current of the sap? It does seem impossible, but you can work that out too by means of an experiment. Put some water into a long pan and let it quiet down so it is perfectly still. Then carefully put in some sugar or salt at one end, disturbing the water as little as possible. Of course the sugar or salt dissolves, but does it also move through the water to the other end? Touch your finger gently to the water at the other end and take a taste, at first it has no sweet or salty taste. But wait a while, then try again, you will find both ends of the pan of water equally sweet or salty. The sugar or salt has not only dissolved, but also diffused itself throughout the liquid. The same thing happens to the sugars and starches in the leaf sap, they diffuse throughout all the sap in the plant, doing so faster than the flow of the sap the other way. At least that is one guess as to what happens, though we are not too sure.

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actual creation of life as one now knows it, for only with the coming of chlorophyll to utilize the sun's energy did life on a large scale become possible.

Evolution of Proteins

Since the colloids characteristic of life have as their basic element the proteins, one of the most important of the first steps in evolution was the evolution of the amino acids that make ou the proteins. Only about a score of the great number of theoretically possible amino acids have been utilized to form all the proteins that make up the living world.

Presumably, vastly more than these few sorts of amino acids have occurred in nature, yet for some reason they have been discarded as unsuitable or unnecessary for the sorts of proteins that are required to make a living organism. Nor are all the few known amino acids of proteins necessary for each and every protein, for no protein yet analyzed has been found to contain all of them, and many proteins seem to contain relatively few. It is perhaps significant that the proteins most concerned with cell multiplication and heredity, the nucleoproteins of the germcells, seem to have the smallest number of amino acids, as if these amino acids were the essential ones to keep life going and reproducing, while the rest represent merely those responsible for the differentiation and the functions less essential than reproduction.

It is most significant, furthermore, that much the same amino acids are found in all living cells, whether simple bacteria and yeasts, or the more complex plants and animals.

In view of the general principle that the individual in its development tends to recapitulate the development of the species, one might hope to find the various steps of the evolution of the protein in the substances produced when bacteria or yeasts synthesize their own proteins from the simple mixtures of salts that they are able to utilize in reproducing themselves in vast numbers. But unfortunately this is not the case. The reproduction is completed so rapidly that one can not catch the different stages.

Chemical Steps in Evolution

One can not hope, therefore, to learn through chemical analysis of growing cells the steps by which the proteins as they exist now were developed. Even chemical study of that beautiful material for the investigation of the evolution of the individual, the developing eggs of hens, has not yet thrown any light on the problems of evolution, although there is room for much more profitable study in this field. Undoubtedly, closer biochemic study of developing eggs would give evidence as to the evolution of chemical structures. The vitally important nucleic acids, which form so large a part of the hatching chick, are almost entirely new-formed from other components during incubation. Can one not learn the chemical evolution of keratin, as well as one knows the morphologic evolution of bird's feathers from fish scales? If one could follow the transformations that produce hemoglobin in the egg, one would probably learn how it came into existence in the Cambrian. Needham, who is one of the few biochemists attacking the problem of the evolutionary significance of the changes in the developing egg, brought out an interesting bit of evidence of the well known relationship of birds and coldblooded forms by showing that the developing chick and dog-fish embryos alike have to synthesize 90 percent of the scyllitol that they produce. There is, furthermore, the suggestive discussion of the "Paleochemistry of Body Fluids and Tissues" by Macallum, suggesting that the inorganic constituents of one's body portray the composition of the pre-Cambrian seas from which one's ancestors arose.

BOOKS

UP FROM THE APE. By Ernest A. Hooton. New York, The Macmillan Company, $5. 626 pages.

After having passed the greater part of his career as an anthropologist in turning out technical papers of interest only to specialists, Professor Hooton of Harvard decided it would be "more than amusing to write something which could be read." That the subject-matter of the work thus offered to the lay public can be made interesting was evidenced by his experience as a lecturer to classes most of whom had had no previous instruction in the subject—though he admits that some of these students "endured the lectures in obvious boredom," a fate which will not befall his readers.

Although "Up from the Ape" is free from technical jargon and arrays of figures, and "does not presuppose on the part of the reader any knowledge of geology, biology, anatomy, or anthropology," it is a serious scientific work, even if not "clothed in sackcloth and ashes" and not expounded "in accents of lugubrious pomposity," the author by no means deporting himself "as if he were in church." Professor Hooton calls a spade a spade; and if his subject matter requires a drawing, setting forth what are nowadays euphemistically called "the facts of life," the drawing is there—58 of them in all and 28 full-page plates. In the production of these drawings, Mr. Elmer Rising deserves high praise; and the photographs of primates, most of them due to the skill of Mr. Newton H. Hartman of the Philadelphia Zoological Garden, rise quite to the realm of "art photography."

In view of the fact that one of America's greatest mathematical philosophers has recently declared that Man "is not an animal," many readers will understand why Professor Hooton's Part I is devoted to an easy-reading discussion of how animal relationships are recognized by the scientist, why Man is a mammal, and why he is a Primate, concluded by an interesting explanation of "How Blood Tells." The prejudices and preconceptions of the average man having thereby been disposed of as utterly unsound, merely by a statement of irrefutable facts, the author devotes his second section to the tracing of evolutionary steps—"The Primate Life Cycle"—the origin of the backbone, teeth, limbs, lungs, ears and hair; the arboreal pre-primate stage; erect posture; and so on, in brief and rapid but comprehensive survey. The third section deals with the Primate's individual life cycle—pre-natal development, childhood, adolescence, "Getting Married," "Having a Baby" "Bringing up a Family," etc.

Having defined and described Man as a Primate and as a civilized (or nearly civilized) human being Dr. Hooton devotes the rest of the volume to our fossil ancestors, and to contemporary races (what they are, how they developed, and their evolutionary meaning). Very interesting are his speculations upon racial origins, race-mixture, and the cultural achievements and mental capacities of the various races of mankind.

Finally, the question is raised and answered. "Why Has Man Evolved?" This is, of course, equivalent to asking: Why has anything, plant or animal evolved? Professor Hooton offers no dogmatic answer to this question of questions. He shows, however, that evolution in general and human evolution in particular must have come about in one of four specified ways, none of which is beyond intelligent debate: no one of the four theories that can be advanced on the basis of present-day lack of full knowledge of all factors inolved is fully satisfactory.

Professor Hooton concludes that the pursuit of natural causes leads either to the deification of Nature, or to the recognition of the supernatural, or to "a simple admission of ignorance, bewilderment, and awe." Admission of our present ignorance as to the *causes* of evolution does not, however, imply any suggestion that new light on the complex problems involved may not be the reward of persistent diligence in the search for truth—for real and indubitable answers to man's supreme question. Meanwhile, we need always to bear it in mind that (to quote the concluding sentence of this truly useful book): "Theories of origin and causation are often transient and evanescent; life itself can never fail to interest and evoke the inquiry of human minds."

The bibliography comprehends the more important follow-up works that the layman would find of most assistance to further study. The index is unusually excellent.

MAYNARD SHIPLEY.

THE KEY TO EVOLUTION. By Maynard Shipley. Haldeman-Julius Publications. Girard Kans, $2.

What impresses me most after reading Shipley's KEY TO EVOLUTION is not something specifically said, but the way in which all the many-sided research into astronomy geology and biology lead inevitably to the evolutionist conclusion. Nothing but reading such an account as this, which draws facts and quotes results from so many sources that one marvels how one man can read and acquaint himself with them all, only such a reading can possibly give any notion of the many men who are investigating, what a multitude of fields they probe into, and how every fact without exception, adds to the evidence for and helps to clarify the story of evolution. Nowhere else that we know have the whole results of modern research been brought together as they have here. Yet the entire story has been kept sufficiently popular, despite the fact that perhaps half of the book consists of quotations from the specialists. Between good selection of quotations and just enough explanatory text by the author, the account remains one for the layman.

Though published in "four double volumes" and in paper covers it really is just a fair sized book, the so-called volumes being eight sections on How Life Began; How Plants Arose; The Origin of Animals; The Origin of Backboned Animals; From Amphibian to Man; Man, Cousin to the Apes; Embryology and Evolution; and, Causes of Evolution, a very sufficient summary of the contents. One would have to think long and hard to find any phase of the entire subject that has not been treated, briefly perhaps, yet quite sufficiently for so small a compass. In fact one wonders how he ever managed to get so much matter into less than three hundred pages and still keep it clear for the non-specialist.

ALLAN BROMS.

Book Chat

By CARROLL LANE FENTON

"ALL I know," Will Rogers used to write, "is just what I read in the papers." The statement is one which no scientist would make—could make—for if his knowledge were limited to what appears in the newspapers, he'd be a hopelessly ignorant person. But if Rogers only had said "books," few scientists could have taken exception.

My own life, outside the laboratory, seems to be an endless round of reading. I read for the facts I must use in writing—and then, when I do laboriously arrive at some conclusion or theory that seems to be new, I'm very apt to come upon a book in which someone already has published it.

It's somewhat comforting, then, to recall that even great scientists have found themselves in the same situation, and have made their contributions by developing ideas put forth by others. One of the most original naturalists in America was Edward Drinker Cope—yet when we read COPE: MASTER NATURALIST, by Henry Fairfield Osborn (Princeton University Press, $5.00), we find that the essential evolutionary ideas of this unquestioned genius were published by a Frenchman forty years before Cope's birth.

Of course, that does not spoil the story of Cope's life, which Professor Osborn and his aides have reconstructed from an almost unbelievable number of letters. It is a life which contradicts all of our traditional opinions of a scientist's existence. Cope was ever in a hurry, and ever in trouble. He warred with the powers in paleontology; he published a magazine that was always near bankruptcy; he spent his own fortune collecting fossils, and eventually sold them for what he could get. At a time when evolution was none too respected by scientists, he gave public lectures in the manner of Huxley. Old and worn, he died at the age of fifty-seven, one of the heroic figures in American science. His biography would be a "book of the year" in a country which cared for intellectual heroes.

To read this book with full profit, one should know something of geologic history. For several years I have tried to find a book which surveys the processes and the past of the earth in language that one might read for pleasure. My search has not been very successful, though I've found two volumes which seem better than others.

One is THE EARTH IN THE PAST, by B. Webster Smith (Frederick Warne,

Fundamentalist Follies

In this Monthly Feature EDWIN TENNY BREWSTER *will refute all fundamentalist objections to evolution.*

NO TRANSITIONAL FORMS?

"WHERE are the transitional forms between the various classes or orders? There are none. . . . there are no relics which even by an artificial arrangement can be made to show a transition between the different classes, or even between the various orders . . ."

Thus in THE DEFENDER (Sept. 1931, pp. 11, 14) George McCready Price, Professor of Geology and Philosophy, in Emmanuel Missionary College. The context shows that "class" and "order" are used strictly in the technical sense: Fishes, Amphibia, Reptiles, Birds, and Mammals are the five classes of Vertebrates each of these being subdivided into various orders. Letting, then, the orders go, and confining ourselves to the classes, what our Professor of Fundamentalist geology and philosophy says is that there are no "transitional forms', present-day or fossil, between Birds and Reptiles, Fishes and Amphibia, Amphibia and Reptiles, Reptiles and Mammals.

Well, aren't there! Reptiles are a class. So are birds. And there is *Archaeopteryx*, from the middle of the Age of Reptiles, just about where one would expect it on evolutionary grounds, figured and described in the textbooks for three generations.

Archaeopteryx has wings and feathers. Therefore, by definition, it is a bird. But is has a reptilian skeleton, with three great claws at the angle of its wing where a modern bird has only a rudimentary thumb; it has a lizard's tail as long as its body—as all birds have in the egg; it has teeth—of reptilian type. Its skull if found alone, would have been considered that of a reptile. How much nearer could anybody get to "a transition between the different classes," reptiles and birds?

Besides, there are the toothed birds from the American Cretaceous, later in time than *Archaeopteryx* and therefore more birdlike, already known to three generations of mankind. These have proper bird's wings without claws and the usual keel on the breastbone where the great flying muscles attach. But they have half a hundred shoe-peg teeth like the reptiles and the fishes, and vertebrated tails long enough to wag. Moreover, their vertebrae are concave on both ends, like all fishes, many extinct reptiles but no modern birds.

How is this for a transition between two classes?

To link reptiles and mammals, there are the mammal-like reptiles, many different sorts, from the end of the Permian and Triassic, just where they should appear in the evolutionary series. The more primitive kinds are certainly reptiles, reptiles in every bone and joint. But they have the general build of a dog, standing well off the ground on four strong legs. Some of them have a mammal's teeth, not the numerous conical peg-teeth of all other reptiles that have teeth at all. The more advanced forms are so like mammals that it is merely a verbal quibble whether they shall be considered mammals or reptiles.

But one need not to go back to any "relics" for "transitional forms" between two classes. The class Amphibia itself is just such a link between reptiles and fish.

Fish breathe by gills only—barring, of course, the lung-fishes which have lungs besides. So, too, does the Mexican salamander axolotl which never develops lungs at all. But the same species farther north is like most other salamanders and newts. It starts life as a fish, with gills only. Later, it acquires lungs and loses its gills, just as the frogs and toads do. So, in general, an amphibian starts life as a fish and ends it as a reptile. But various amphibians, our common mud-puppy among them, starting as fishes, develop lungs without losing their gills, and for the rest of their lives are both fishes and reptiles breathing whatever they can get. But certain toads, and various of the tailed amphibians besides, have put the gill-bearing fish stage back into the egg, and hatch as air-breathers only.

So we have in the amphibia absolutely all stages between fish and reptile. Most amphibia, in a single brief lifetime, run through them all.

So much for breathing organs. Lungs suggest hearts. Great play has been made by certain Fundamentalists over two, three, and four-chambered hearts. Two, three and four being discrete integers there can't be any evolution from any to the next!

But let us see! Fishes have in their hearts two chambers only—except, as usual, the lung-fishes which have three. The amphibia, as tadpoles, have a two-chambered heart, being essentially fishes. As adults they change to three chambers which is characteristic for reptiles which the adult amphibian essentially is.

But while the amphibian heart is, when adult, frankly three-chambered, lizards, snakes, and turtles among the reptiles have the ventricle partly divided by a septum. This septum is variously developed in different reptiles. In the crocodile it is virtually complete, so that the crocodile has the four-chambered heart of mammals and birds, except for a small aperture through which no blood circulates. Thus the transition is complete from two chambers to three and from three to four, precisely as it should be on evolutionary grounds.

So with all other organs. In general, conditions are simplest in the fishes; but some fishes foreshadow what the amphibians are to exhibit. Various amphibia, either in their adult state or as they pass from pollywog to adult, exhibit all transitions from fish to reptile. Reptiles, present-day and fossil together, bridge virtually all the gaps between themselves and the birds. By way of the theromorphs, they tie themselves in all sorts of ways to the lowest mammals—the egg-laying mammals of Australia.

The fishes, in short, are ancestors to the amphibia. The amphibia, in their turn are ancestors to the reptiles. But the reptiles have two offspring, the mammals and the birds, neither of which is ancestor to the other, though Fundamentalists are wont to attribute this opinion to the scientific world.

Evidently, then, Fundamentalist natural history is not at all the kind one sees in actual fossils or observes for himself in the local frog-pond.

$4.50) an English book with remarkable illustrations. Those which are photographs are very fine: those made from drawings are astoundingly poor, where they involve restorations of fossil animals. As a survey of geologic history, however, the book does quite well, even though some of its theories are rather old-fashioned. Unless one reads a textbook he can do no better.

But what textbook? There are several good ones in the field of geology, yet not many that are convenient and readable. Fortunately, one of the best has appeared in a new edition—ELEMENTS OF GEOLOGY, by William J. Miller (D. Van Nostrand, $3.00). I like it because, in less than 500 pages, it presents the essentials of geology, with direct reference to regions in North America. Now that we have become a nation of nomads, we travel each summer through much of the country that Dr. Miller describes, so that his text may serve almost as a guide book. As one glances through the abundant illustrations, he will find many that show familiar scenes, accompanied by text which tells what the scenes signify—and thereby makes our own visits to them worth while.

But this is not quite what I started out to say. Most of us don't read when we are on vacation; nor can we hope to visit all of the places mentioned in any good textbook of geology. The value of such a book lies partly in explaining things unseen, and partly in assembling its information where we may get it quickly, when ever we want it. This requires careful selection and organization, plus a good index, which textbooks unhappily do not always possess. That ELEMENTS OF GEOLOGY meets these requirements is the best evidence I can offer that it is a suitable introduction to a science in which "popular" (which means pleasantly readable) books are very few, and of none too high calibre. Yet this remark may not be quite fair—for unless one demands his intellectual food very, very soft and sweet, he'll find Dr Miller pleasant reading.

How They Argued

Compiled by Pauline H. Pederer

1600 YEARS AGO

Lactantius wrote an essay on the *Heretical Doctrine of the Globular Form of the Earth.* He said: "Is it possible that men can be so absurd as to believe that there are crops and trees on the other side of the earth that hang downward, and that men have their feet higher than their heads? If you ask them how they defend these monstrosities?—how things do not fall away from the earth on that side?—they reply that the nature of things is such, that heavy bodies tend toward the centre like the spokes of a wheel, while light bodies, as clouds, smoke, fire, tend from the centre to the heavens on all sides. Now I am really at a loss what to say of those who, when they have once gone wrong, steadily persevere in their folly, and defend one absurd opinion by another." *Draper: History of Intellectual Development of Europe.*

500 YEARS AGO

"There arose a grievous quarrel among the brethren over the number of teeth in the mouth of a horse. For thirteen days the disputation raged without ceasing. All the ancient books and chronicles were fetched out, and wonderful and ponderous erudition, such as was never before heard of in this region, was made manifest. At the beginning of the fourteenth day, a youthful friar asked his learned superiors to look in the open mouth of a horse for answer to their questionings. At this, their dignity being grievously hurt, they waxed exceedingly wroth; and, joining in a mighty uproar, they flew upon him and smote him hip and thigh, and cast him out forthwith. For, said they, surely Satan hath tempted this bold neophyte to declare unholy and unheard-of ways of finding truth contrary to all the teaching of the fathers. After many days more of grievous strife they as one man, declaring the problem to be an everlasting mystery because of a grievous dearth of historical and theological evidence thereof, so ordered the same writ down." *Quoted in Science Progress, Credited to Francis Bacon.*

100 YEARS AGO

"There was circulated in New England a paper which put forth the following objections to the introduction of gas lighting:

A theological objection: Artificial illumination is an attempt to interfere with the divine plan of the world, which had pre-ordained that the night should be dark.

'A medical objection: Emanations of illuminating gas are injurious. Lighted streets will incline people to remain out of doors, thus leading to more ailments through colds.

'A moral objection: The fear of darkness will vanish and depravity increase.

'Police objection: Horses will be frightened and thieves emboldened.'" *Article in Connecticut Newspaper, 1926.*

TWO YEARS AGO

"An effort should be made this winter in every state, to secure by legislative enactment, a law prohibiting the teaching of the brute origin of man in tax-supported schools and colleges, since the false 'science' of evolution is the chief support of infidelity and atheism.

"I shall be glad to send free a copy of my 'Evolution Disproved' by 50 convincing scientific arguments, to all members of committees considering such bills — — —.

'Will you kindly insert this notice for the sake of the truth and the protection of youth?" *Rev. W. A. Williams, Camden, N. J.*

LAST YEAR

The Tennessee House of Representatives gave approval to the statute prohibiting the teaching of the theory of evolution in schools wholly or partly supported by state funds, by rejecting a bill to repeal the law. Only 14 voted for repeal, while 58 voted to sustain the anti-evolution law.

Question Box

Answers by Allen Broms, unless otherwise credited. Send your questions.

SCIENTIFIC JAWBREAKERS

Q. Why do scientists use those big Greek and Latin words? Why not understandable English ones? Are they trying to mystify? —F. R. M.

A. Depend upon it, the scientists are trying to clarify, not mystify, though sometimes their jawbreaker words seem to belie that statement. Usually the trouble is, however, that we are not familiar with the things they talk about. If we knew about them, the words naming them would not seem hard at all. Witness the words Hippopotamus, Rhinoceros, Elephant, Boa Constrictor, etc., all of them big and Greek, yet giving us not a single worry because we know about the things they mean. Just to prove that, consider the easy, two-syllable word "hallux." Now really you should know what that means, you certainly have had it in your mouth often enough, at least as a youngster, for the word just means what you call "big toe." Then why does not the scientist just say "big toe"? For several reasons; for one thing, the big toe among some animals is not really the big one, so the name often would not apply. In the second place, a German scientist would have to translate "big" and "toe" into his language, and a Frenchman into his, and so on, while they do not have to translate hallux at all, that being common to all the languages, or should we say it is a word of a common international scientific language which all scientists understand. A third, and very good, reason is that we would soon run out of distinctive English descriptive names, we would just have to use the same words over and over again, and name our plants and animals by describing them in detail, which, of course, would not do at all. The scientist's jawbreakers do look formidable, but only until you get acquainted with the things he means. That requires studying his sciences, without which his words mean very little anyway.

Funnymentals

Thus the wife of a missionary, laboring with "undraped denizens of the woods," somewhere south of Suez:

"The natives were greatly amused when my husband told them that there were a few white men who thought that men were the descendants of monkeys. Some of the savages lay down on their backs and giggled with laughter at the idea." Quoted; *Christian Faith and Life,* August, 1931, p. 435.

"Evolution is not only anti-Scriptural, anti-Christian, and anti-Spiritual, but is contrary to the best conception of science in fact as well as in reason. How some scientists, who pride themselves on the rigid conformation of their theories to the tests of experiment and observation, can even think evolution is a shrewd theory marks them as devoid of real scientific skill. It is the most unscientific theory held by thinking men today. There is not a properly applied principle of science which will justify such a position. Every basal law of science has to be set aside to permit it." From a sermon by the hero of "Our Serial—The Clamping of the Shackles", *Christian Faith and Life,* August, 1931, p. 446.

"Believers in evolution are one-third beast, one third devil, and one-third university professor". Rev. Dixon, sermon in Calvary Baptist Church, New York City.

"The U. S. Government maintains a department for Pest Control and Eradication. We do not know which our prominent Universities need the most,—the de-lousing machines that were used in the army, or the rat catchers that patrol the sewers of the great cities in time of peace." Editorial in Christian Fundamentalist, April, 1932.

SEND US FUNNYMENTALS

if you run across remarks of fundamentalists that you consider worthy of publication in this column. But be sure to *quote accurately* and give *exact authority.*

MORE BONERS FROM EXAMS

The Rhinoceros has three feet therefore an odd number of toes.

Peristalsis is a syncopated movement, necessary in digestion.

The first man pertained to Erectus Philantrocreepus.

Puberty is the period that intervenes between adolescence and adultery.

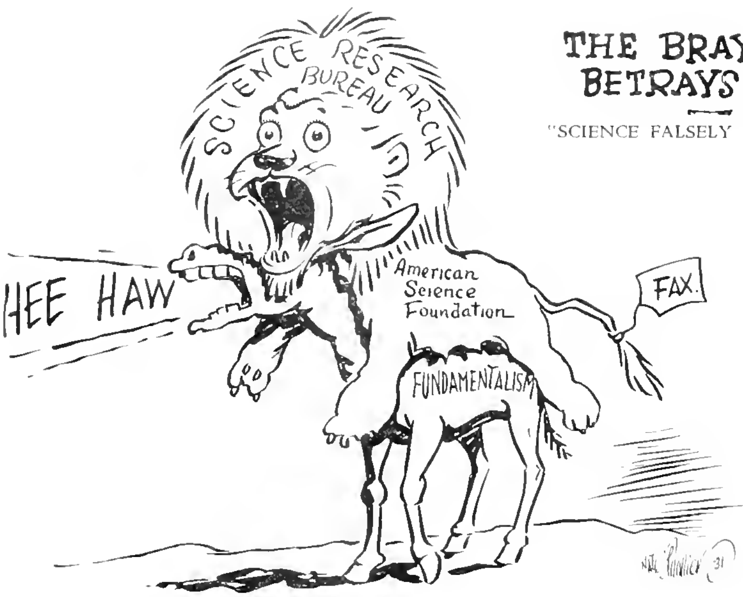
The Protozoa move by extending a pseudonym and moving the rest of the body into it.

A peneplane is a land form which has reached the lowest depth of degradation while trying to remain on the level.

The gall bladder is a secretive gland.

*

Readers are invited to report "Boners".



THE BRAY BETRAYS HIM.

"SCIENCE FALSELY SO-CALLED."

THE BRAY BETRAYS HIM

The current issue of the Christian Fundamentalist carries a full page announcement of The Research Science Bureau, Inc. as "one of the most unique Corporations in America." 'Unique' is right. For lo and behold, it is "to conduct research in all physical sciences, for the defense of the Bible." Its membership is limited to "persons of good moral character", who "believe the Bible" and come across with five bucks.

One of our readers in North Carolina writes us that Rev. Harry Rimmer, while exhorting converts to join this "scientific" society, specified as qualification for admission to its learned ranks that you "must not believe in evolution".

Fundamentalist bigotry, trying to camouflage under the mantle of a scientific sounding name. But "The Bray Betrays Him".

A NEW SHOW IS PROMISED

At the suggestion of a Dr. J. G. Huisinga, who is "a little weary of the American Association for the Advancement of Science, in that it is too hospitable to atheism", the editor of the Christian Fundamentalist proposes the organization of an "Association of men of science in all its branches, having as chief qualification for entrance, Christian Faith". He promises to "report progress in our next issue".

We'll keep one eye peeled, brother. What an entertaining season this promises to be.

QUOTH THE MONKEY

"Evolution", quoth the monkey,
Maketh all mankind our kin;
Theres no doubt at all about it:—
Tails you lose and heads we win."

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