

ANTHROQUEST

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THE CO-EVOLUTION OF THE BRAIN AND FAMILY

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I would like to dedicate this article on the co-evolution of the brain and family to Mary Pechanec, who recently relinquished her position of many years as Executive Director of the L.S.B. Leakey Foundation. As I will note later on, there is a "Dear Mary" element in human evolution that makes it natural to think of her in connection with the present topic.

In 1980 several regional White House conferences dealt with threats to the unity, stability, and health of the family in modern times. It helps to allay pessimistic feelings about the future of the family if one keeps in mind that the family, as a biological institution, has survived 180 million years, having originated with the earliest mammals living in Late Triassic times. This is a duration of time that would allow the election of more than forty million U.S. presidents and the building of the same number of their monumental libraries.

The history of the evolution of the family is the history of the evolution of mammals. Although the historical record is nowhere inscribed, we are beginning to find some relevant hieroglyphs in the brain. The main glyphs are seen in best relief by viewing the progressive evolution of the primate brain that culminates in human beings. In expanding to its great size, the primate forebrain retains the anatomical features and chemistry of three kinds of brains that reflect an ancestral relationship to reptiles, early mammals, and late mammals (Fig. 1). I refer to the amalgamation of these three-brains-in-one as a *triune* brain, a concise term straight from the Greek. This situation suggests that

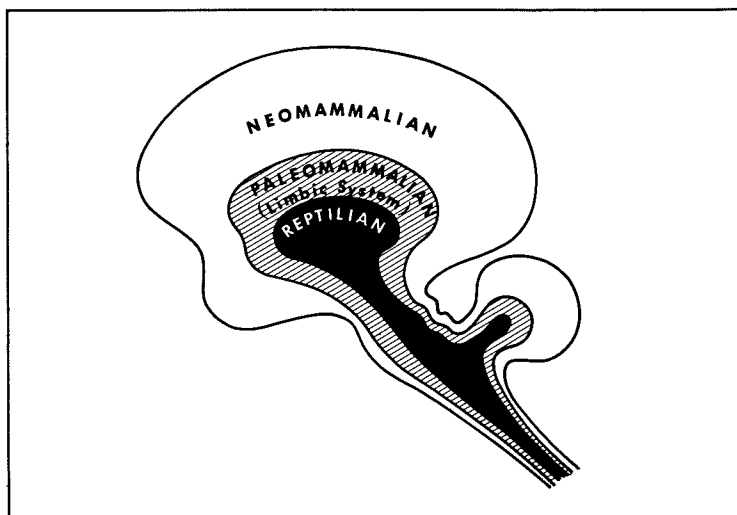
psychencephalic functions depend on the evolutionary link-up of three quite different mentalities. For us as human beings, there is the added complication that the two older cerebral formations do not have the capacity for verbal communication.

The term cold-blooded not only applies to a biological condition of reptiles, but also to seemingly heartless forms of behavior. Take, for example, cannibalism: the young of the giant Komodo lizards (Komodo dragons) must take to the trees for the first year of life in order to avoid being eaten by their parents or other adults. In the evolution from reptiles to mammals three distinctive behavioral innovations were the development of (1) nursing in conjunction with maternal care, (2) audiovocal communication for maintaining maternal-offspring contact, and (3) playful behavior.

How did mammals get to be the way they are? Many of the secrets are still locked up in the Karroo beds of South Africa, where, according to the calculations of Robert Broom, there still lie hidden the remains of more than 800 billion mammal-like reptiles. Otherwise known as therapsids, these animals are of great human interest because they are so close to the roots of our family tree. In Permian times (long before the dinosaurs) the therapsids covered the face of the earth when there was but one giant continent, Pangaea (Alfred Wegener).

The carnivorous therapsids from which we stem had a likeness to dogs and wolves. Apropos of the present topic, it is hoped that

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The triune brain. In its evolution the primate forebrain expands along the lines of three basic formations which anatomically and biochemically reflect an ancestral relationship, respectively, to reptiles, early mammals, and late mammals. The three formations are labeled at the level of the forebrain which may be regarded as the psychencephalon. (from MacLean, 1967)

the L.S.B. leakey foundation

The L.S.B. Leakey Foundation was established in 1968 by a group of eminent scientists and informed lay people who recognized a critical need to strengthen financial support for new multi-disciplined research into human origins, our evolving nature and environmental future. It was named in honor of the man who had become known as "the Darwin of pre-history," Dr. Louis S.B. Leakey.

The Foundation sponsors:

International research programs related to the biological and cultural development of humankind.

Long-term primate research projects which may help us to understand how we evolved as a species.

The training and education of students in these fields.

Conferences, publications of scientific papers, and educational programs designed to disseminate knowledge relevant to our changing view of humanity's place in nature.

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PRESIDENT'S MEMO

To the editor, Liz Brady:

Congratulations on your new title. But don't think no one has noticed that the number of "marching men" has been dwindling. Are you trying to tell your readers something? Some of them will surely have noticed the gradual feminization of one of the hithertofore "men". I'm glad that ERA has won in your publication.

Would our readers like a book report section? Dian Fossey has a "tremendous" book coming out next year entitled *Gorillas in the Mist*, which is being published by Houghton Mifflin. The British rights have been sold for a handsome sum to Hodder and Stoughton. It will contain many color plates of gorillas, seven scientific appendices, and the most complete bibliography on gorillas ever published. *Gorillas* is even being considered for Book of the Month Club. Our "stones and bones" grantee Don Johanson's *Lucy* was a Book of the Month Club selection. (Don is particularly to be admired because, with all his popular fame, he remembers how the Leakey Foundation responded with a critical \$5,000 in response to an urgent cable in the early stages of his Ethiopian research.) *New Interpretations of Ape and Human Ancestry*, to be published by Plenum, is yet another new book in galleys by our grantee in Burma, Dr. Russ Ciochon.

Our readers seem to like your growing emphasis on more signed scientific articles. Of course we would never attempt to emulate our good friends at the National Geographic or the Smithsonian by attempting quality color illustrations. So your decision to put some of our modest funds into special articles is appreciated. But shouldn't we have an index to all our issues? Russ Ciochon cites this publication several times. And what about letters-to-the-editor? If our readers write, we can print some of their thoughts.

Another refreshing new policy is that school and university libraries can receive AnthroQuest at cost. Librarians must be sick and tired of subscription prices which are much higher for libraries than they are for individuals! Your lower price for libraries will help to spread scientific news.

The key to the modest successes of the Leakey Foundation is the contributions of volunteers such as you. Fran Muir and her Associates group, especially Joan Wrede who volunteered to do public relations, made a great success of the visit of H.R.H. The Prince Philip and the scientific presentations at the seminar "Primates and the Tropical Forest".

In addition to the volunteer staff which now contributes so much, we need more volunteers to help us expand our programs in other cities across the United States as well as in Southern California.

Ned Munger

CALENDAR

A symposium is scheduled for May 7, 1983, at the Palace of Fine Arts in San Francisco. The cosponsors are the Leakey Foundation, the California Academy of Sciences and the University of California at Berkeley.

The Leakey Foundation is planning a Caltech lecture series for the spring, with Robert Jastrow, Gerald O'Neill, James Burke and Edward Krupp speaking. The probable title is "Ancient Footprints - Steps in Space". Details will be announced soon.

TRIMATE NEWS

The Trimates - Jane Goodall, Dian Fossey and Biruté Galdikas - have been elected this year to membership as non-resident fellows in the Explorers Club. Their work with primates is world renowned.

NEW FELLOWS

The L.S.B. Leakey Foundation is proud to welcome to its Fellows roster:

Mr. and Mrs. Robert A. Hauslohner, Rosemont, Pennsylvania, Mr. and Mrs. Francis L. Dale, Los Angeles, and Dr. Armand Hammer, Los Angeles.

RECEPTION HELD

A reception for Harold Coolidge was held last June in Atlanta during the Ninth International Primatological Congress. Its purpose was to honor his pioneering contribution regarding *Pan paniscus*, the pygmy chimpanzee, which he had a role in discovering and raising to full species level in its classification. The reception was co-sponsored by the Leakey Foundation and World Wildlife.

PRIMATES AND THE TROPICAL FOREST

Excerpts from presentations given at the seminar cosponsored by the L.S.B. Leakey Foundation and World Wildlife—U.S. at Caltech, September 21, 1982. Other speakers were H.R.H. The Prince Philip, Duke of Edinburgh, Dr. Shirley Strum and Dr. Thomas Lovejoy. Papers from this seminar are expected to be published in book form.

ETHNOBOTANY, CONSERVATION AND THE FUTURE OF THE TROPICAL FOREST

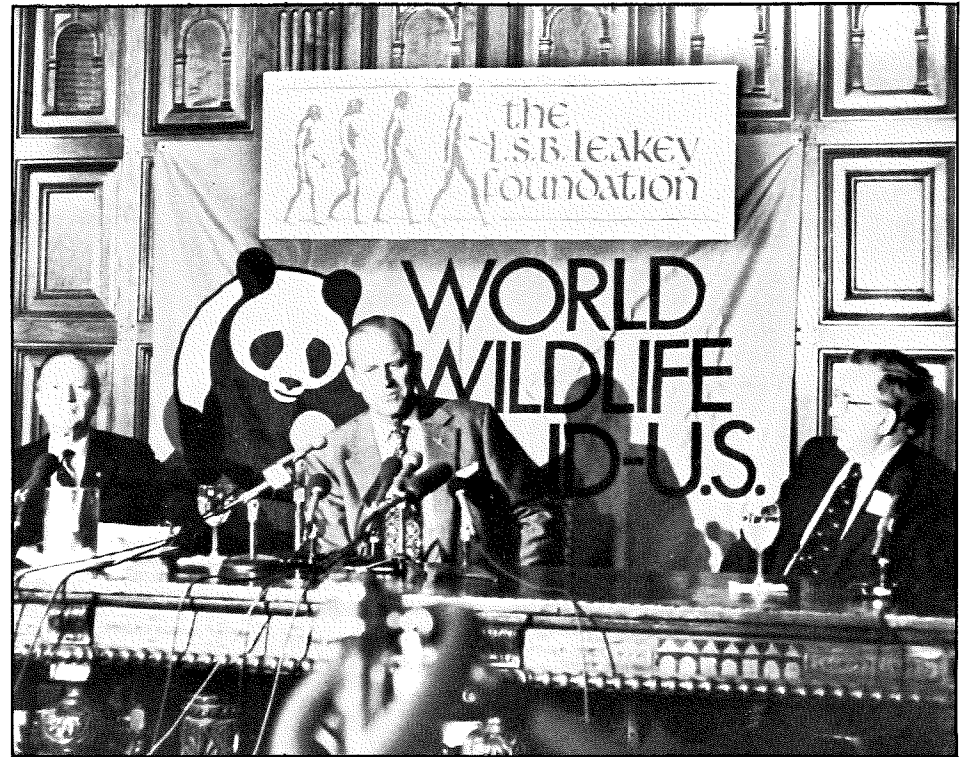
by Mark J. Plotkin
World Wildlife Fund—U.S.
and Harvard
Botanical Museum

The tropical forests of the world are being irreversibly destroyed. Cleared for ranching, cut for fuel, logged for timber, and burned for agriculture, these forests are disappearing far more rapidly than they can regenerate. As population continues to expand in tropical countries, the pressures upon these forests will continue to intensify and countless species of plants face certain extinction. At the same time, we are witnessing the acculturation and extinction of many primitive tribes of forest-dwelling peoples who have, over the course of thousands of years, developed intimate knowledge of these forests and the natural products they contain. The disappearance of both the plants themselves as well as the knowledge of their utilization represents a tremendous scientific and economic loss to mankind.

Resolving the issue of conservation versus destruction of these forests will, in the final analysis, come down to a question of economics. Governments of developing countries have usually viewed tropical forests as valuable resources only in terms of timber and eventual crop or pastureland.

How then to increase production of goods and services from tropical forests while ensuring the conservation of a major proportion of their rich biological diversity? To answer this question, we must turn to the science of ethnobotany.

Ethnobotany, an increasingly important branch of tropical anthropology,



Russel Train of the World Wildlife Fund—U.S., H.R.H. The Prince Philip and Ned Munger, president of the Leakey Foundation.

is the interdisciplinary study of the utilization of the Plant Kingdom by aboriginal peoples. These tribal cultures are an integral part of the tropical forest ecosystem, and they have a profound knowledge of which forest species are useful and how they can best be exploited.

Aboriginal peoples utilize these forests as sources of foods, fibers, medicines, shelter, fats, oils, waxes, tannins, dyes, gums, resins, and poisons. Through ethnobotanical investigation, we can determine which forest species have underexploited economic potential and design financially remunerative alternatives to tropical deforestation.

Tropical forest plant products can make major contributions to medicine, industry, and agriculture.

Plants have traditionally served as man's most important weapon against pathogens. Only relatively recently, however, with the advent of modern technology and synthetic chemistry, have we been able to reduce our almost total dependence on the Plant Kingdom as a source of medicines. Nevertheless, we continue to rely on plants to a much higher degree than is commonly realized. Almost half of all prescriptions dispensed in this country contain substances of natural origin — and over 50% of these medications contain a plant-derived active principle. Annual sales of drugs which contain natural materials are estimated to be over eight billion dollars, and many of these

compounds are extracted from higher plants.

What then is the value of ethnobotany to the search for new biodynamic compounds? Of the 500,000 species in the world's flora, only a fraction have been even superficially investigated by biochemists. Furthermore, biological and phytochemical screening of plants is an expensive and time-consuming process. By studying ethnobotanical data we take an important shortcut, since we can focus our studies on plants which have been experimented with for thousands of years by aboriginal peoples who have discovered which plants have useful properties.

Let us consider the case of the rosy periwinkle, *Catharanthus roseus*. This herbaceous plant, native to Madagascar, is the source of the anti-tumor alkaloids vincalucoblastine and vincristine which have achieved up to 90% remission in treating acute lymphocytic leukemia and 80% remission in treating Hodgkins disease. Overall, 80 alkaloids have been extracted from the periwinkle and six of these have been found to have anti-tumor activity. Yet this plant was first investigated because of its use by local people as an oral hypoglycemic agent. Thus, we can clearly see that investigation of plants used for medicinal purposes by "unsophisticated" peoples can provide us with new biodynamic compounds which may have very important applications in our own society.

It has been noted that 70% of the plants

known to possess some kind of anti-cancer property originate in the lowland tropics; yet only a minute portion of tropical plant species have been screened for their anti-cancer compounds. Furthermore, the plants that have been studied in the lab have been studied for their activity against only a few of the many cancer types that are known to exist.

Developing countries cannot afford to spend millions of dollars to import medicines which they themselves possess the genetic stock to produce. Forest management usually means manipulating the forest ecosystem to maximize production of timber, yet some forests in Germany are currently being managed for production of foxglove (*Digitalis purpurea*). Why not try to manage tropical forests to produce plants that can be the bases of local industries, thus allowing developing countries to achieve "pharmaceutical self-sufficiency"?

Fungal skin rashes are ubiquitous in the tropics. There are a variety of plants which can be used to treat these infirmities which could serve as the bases for local drug industries.

There are three ways in which ethnobotanically important tropical forest species can aid modern agriculture:

1. as new crop species which can be brought under cultivation;
2. as "topping up" material for cultivated species; and
3. as sources of new biodegradable pesticides.

Only a very minute proportion of the world's 500,000 plants have ever been utilized as a food source on a large scale. Of the several thousand of species which are known to be edible, only 150 have ever become important enough to enter into world commerce. Today, fewer than 20 plant species produce 90% of our food — 20 species that stand between us and starvation.

Where can we turn, then, to look for new crop plants and reduce our dependence on such a small number of species? North America north of Mexico has given little to the store of man's economic plants. As pointed out on March 22, 1982, in an editorial which appeared in *The New York Times*, if the American farmer had to rely on purely native species, he would be growing mostly sunflower seeds, pecans, and cranberries. Of our common foodstuffs, corn, rice, bananas, sugar cane, pineapples, sweet potatoes, cocoa, and coconuts all had their origin in tropical regions.

How does ethnobotany help us to decide which species should be brought into cultivation to reduce over-dependence on a few species? It should be noted that few if any of the tropical staples were discovered "de novo" from the forest by European explorers. In almost every case, these plants were being cultivated by indigenous peoples when Europeans arrived. When we want to decide which tropical species might be brought under cultivation, we would do well to consider which are already being exploited as "doorsteps"

— that is, plants already being cultivated by aboriginal or local peoples. This assures us, in most cases, that we are dealing with species that are free from indigestible compounds with relatively high nutritive value and suitable for growing in some sort of agricultural system.

In re "topping up": Wild relatives of commercial species are continuously cross-bred with these species to increase their resistance to insect pests. Global trade in coffee, rubber, and cocoa totals almost \$20 billion a year, and each of these commodities is dependent upon related wild strains for its survival. A number of these wild strains have been found by ethnobotanical study of aboriginal tribes.



Drawings by Daphne Amati

As for pesticides: Many tropical plants have evolved sophisticated chemical defenses to deter predation by herbivores. Many tropical peoples have identified and utilized these plants, often as curares or fish poisons. These compounds may conceivably prove useful as biodegradable pesticides. The World Wildlife Fund—U.S. Conservation and Ethnobotany project has identified over 20 species of Amazonian plants considered poisonous by local Indians which merit further scientific analysis.

During the Arab oil embargo of 1973,

the American business community was faced not only with the loss of a major energy source, but also an extremely important raw material for the manufacture of innumerable synthetic products. Few of us realize how many of our everyday products are made from petroleum and petroleum by-products, such as plastics, fertilizers, lubricants and adhesives. According to USDA estimates, use of petroleum-based chemicals in the U.S. during the mid-70s totaled over 100 billion pounds per year.

By developing local phytochemical industries, we may be able to generate badly-needed employment in tropical countries while reducing our own precarious dependence on fossil fuels.

For example, Nobel prize winner Dr. Melvin Calvin at the University of California, Berkeley, is studying the *Copaifera* tree. Native to South America, this tree produces up to five gallons of diesel-like heavy oil per tree every six months. This oil can reportedly be poured directly into a diesel engine, and one research institute in Brazil has been running a fleet of Toyota trucks on this fuel since 1978.

There is a worldwide shortage of wax, and demand continues to grow. The United States is able to meet some of its own needs by synthesizing wax substitutes from petroleum. Nevertheless, some of the highest quality waxes are of vegetable origin, and their quality is unequalled by the synthetic compounds.

Waxes usually serve to reduce water loss in plants and are therefore most abundant on a number of desert species. An example is the famous carnauba wax, produced by the *Copernicia* palm of the dry and desolate deserts of northeastern Brazil. There is one wax-producing Amazonian species, however, that merits immediate consideration: *Calathea lutea* — cauassu — is a large herb found along Amazonian river banks. The wax produced on the ventral surface of the leaves is comparable to the finest carnauba wax produced by the *Copernicia* palm. Cauassu can be exploited immediately from wild stands and could easily become the basis of a new cottage industry.

By designing programs to rationally exploit these species, we hope to provide an economic incentive for preserving tropical forests which are the home of 90% of the world's primate species. The bottom line, though, is the human primate. *Homo sapiens* is really the key factor in determining the future of the tropical forests. I am speaking not only about aboriginals, but also the so-called "colonists" who are encouraged by their governments to settle in tropical forest regions to relieve the overcrowding in capital cities. These are the people who are born into a hard life and are trying to make a go of it. We must take what we have learned from forest peoples and devise programs to improve management of the complex tropical forest ecosystems. Only then can we truly conserve the tropical forests, and with it their rich primate fauna.

LIVING PRIMATES AS A KEY TO HUMAN EVOLUTION

by John G. Fleagle
Health Sciences Center
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Stony Brook, New York

Living primates, as our closest relatives, can provide many clues to our own evolutionary past. In many respects the lemurs, tarsiers, monkeys and apes who live in the ever decreasing forest of the world are surviving remnants of stages through which we ourselves passed during our evolutionary history. It is equally true, however, that the living species are not just frozen examples of earlier evolutionary periods for they too have evolved from the ancestral forms which gave rise to our own lineage in the geological past. Our knowledge of these real ancestral forms and other extinct species which have left no descendants can come only from the fossil record, a record which, with the support of groups like the Leakey Foundation, is becoming more and more complete every year. If we view primate and human evolution as a large jigsaw puzzle, it is exciting to see the pieces gradually accumulating to provide a more and more complete picture of our past.

These exciting fossils, which provide the most direct, or should I say our hardest, evidence about our evolutionary past, are not found as living animals but as bones and teeth. If we are lucky, skeletons, but more frequently parts, can yield considerable information about the behavior and ecology of their owners. Our understanding about how bones and teeth behaved in the geological past is based on our understanding of the behavior and ecology of living species.

What do we usually want to know about a fossil primate when we find one? First, we usually want to know about the taxonomy. Is it a new species? How many species, or types, of fossil primates are there? Do the variations indicate two species or just males and females?

To answer questions like this we need to compare the diversity of the fossil bones with a range of living species. For example, my colleagues and I have been trying to understand the early evolution of apes that lived 30 million years ago in Egypt. There were many jaws, teeth and bones, some found earlier this century, others in recent years. By comparing the range of variation in teeth and jaws we could show that many of the specimens which had been given separate names probably belonged to the same genus, and that many of the differences used to identify distant types of fossils were of a type more characteristic of

different species. Similar types of comparisons led Don Johanson and Tim White to suggest that all of the fossils from Hadar belonged to a single species of early hominid, *Australopithecus afarensis*.

What about behavior and ecology? We know from studies of living species that a primate's diet is often the most important feature for determining where it lives, how it moves and even what kind of groups it travels in.

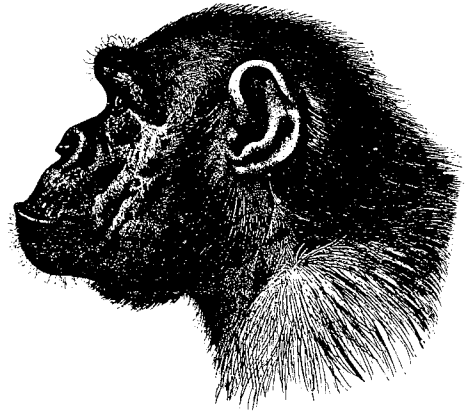
Reconstructing the diets of fossil primates usually involves careful analysis of their teeth — the shape, the size, the thickness and even microscopic scratches that can only be seen with an electron microscope. More recent studies have looked at strontium in bone. Diet leaves its mark on all of these features and by comparing the fossil teeth with those of living species, we can get an idea of the diet of an extinct form. However, these anatomical studies only have value if they can be checked against information from animals living in the wild. If we find that the teeth of a fossil ape more closely resemble those of an orangutan than a gorilla, we can only understand the fossil if we know about the diets of the living apes and see how they use their teeth.

As humans, we are unique among primates in that we walk erect on two legs. Most other primates and our own primate ancestors, being forest animals, used other methods of locomotion. Some leap, some walk on branches or run on the forest floor, and the more spectacular ones swing by their arms. The locomotor habits of a primate leave their marks on bones in proportion and shape, and in more subtle features that can only be examined with x-rays or sophisticated equipment like CAT scanners. However, to understand the way in which bony shapes translate into locomotor behavior we need information on how living primates use their limbs in the forest. Only then can we understand how a 30 million year old ape bone may have been used by its owner.

In the past, anthropologists and psychologists used to think that early hominids, like most groups of monkeys and apes, lived in large, nomadic groups with no real internal structure, the primordial horde. From studies of our primate relationships we now know that such groups really don't exist and probably never have. Primate lives are more orderly than that. All primate groups live in home ranges with well defined boundaries. And, although primates' social groups vary considerably in size, these groups are well structured and relationships between individuals follow identified rules. Can we find out anything about the social life of a fossil primate? Again, the answer is yes, if we have enough comparative information on living primates.

Clearly, living primates provide our most important clues to the evolutionary relationships and the behavior of fossil primates. But I want to emphasize that the information we need to unravel the fossil

record changes with each new discovery. As Stephen Gould has so eloquently argued, evolution is a history of accidents and paleontology is the study of animals you never would have imagined.



The most dramatic example has come in studies of the early apes from the Oligocene and Miocene of Africa and Europe, 30 to about ten million years ago. When these fossil apes were first recovered exactly 50 years ago, we only knew about their teeth and it seemed most reasonable to argue that they were probably intermediate in size between living monkeys and apes of Africa and Asia. Yet as more complete specimens have been found it is clear that the early apes of Africa show greater similarity in their skeleton, at least, with the larger monkeys of South America than with the monkeys and apes of Africa and Asia today. In many respects the New World monkeys, like the howling monkey and the muriqui, have preserved or perhaps independently evolved a way of life that characterized our ape ancestors of 20 million years ago. They are certainly not living fossils, but they are the closest living models to the type of ape which subsequently evolved into the living apes and the human primate.

An equally interesting example arose when one of my colleagues, Richard Kay of Duke University, tried to understand why many fossil apes and hominids, including some *Australopithecus*, have such large molars with thick enamel and flat cusps. When he looked to our closest ape relatives, the chimpanzee and the gorilla, he found that their teeth were very different. The most similar teeth, he found, were in such diverse species as the orangutan of Southeast Asia and the cebus monkey of South America. What these animals seemed to have in common was a dietary preference for hard seeds and nuts, which led him to suspect that this diet might have been important for the earliest hominids.

In closing, I'd like to talk about one particular example that highlights the critical interrelationship between primate

evolution and conservation. Of all the species of living primates, many people feel that the pygmy chimpanzee from Zaire most closely resembles the earliest hominids. When paleoanthropologists have looked closely at the bones of early hominids like Lucy, they find that in features of the knee, the hand and the foot, *Australopithecus afarensis* was more like a pygmy chimpanzee than any other primate. Up until just a few months ago, this knowledge was of very little value because we knew virtually nothing about the behavior of the pygmy chimpanzee. Thanks to the work of my Stony Brook colleague, Randall Susman, and his associates, we are finally learning about the behavior of this rare ape — information that has great importance for our understanding of human evolution. Yet just as our knowledge of this species increases, the forests in which it lives are disappearing. We hope the Zaire government will establish a natural park in the area to protect these apes. It would be most ironic and most tragic if the living primate most similar to early hominids came to resemble our fossil ancestor in one last feature by becoming extinct itself.

ENDANGERED PRIMATES: THE LEMURS OF MADAGASCAR

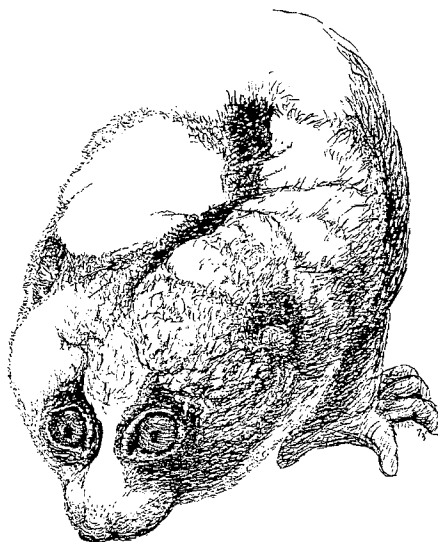
by Alison F. Richard
Yale University

Madagascar is a land of contrasts and its unique evolutionary history makes the conservation of its flora and fauna of particular interest to scientists. Today, what remains of Madagascar's heritage is critically threatened by a wave of destruction that began about two thousand years ago with the arrival of people on the island. Time is surely running out and the need for action is urgent.

Madagascar is without, has always been without, many of the animals with which we are familiar: there are no lions or leopards, no antelope, zebra, elephants, horses or deer, no squirrels, hares or rabbits — the list of what is missing is long. Even so or, more accurately, precisely because so many of the animals that occupy the rest of the world are absent, the fauna of Madagascar is unique and diverse in ways not found elsewhere.

The most striking members of the modern Malagasy fauna are the lemurs. They are primates like ourselves, monkeys

and apes. Today they number 22 species. Three thousand years ago there were at least another 13 species, all of them bigger than those living today. Modern lemurs are forest-living and arboreal, except the ring-tailed lemur (*Lemur catta*) which usually travels on the ground, and ranges through dry shrubby areas as well as forests in the south. In the east, we find the indri, the largest living lemur and the only one without a tail. It lives in small family groups and is famed for its beautiful and eerie dawn chorus. Also in the rain forest live the exotic eastern sifaka (*Propithecus diadema*) and the variegated lemur (*Varicia variegata*), neither of which has been studied in the wild. Another denizen of the



east is the extraordinary aye-aye (*Daubentonia madagascariensis*). With a bat's ears, a fox's tail, a rodent's front teeth and a spindly elongated middle finger like no one else's in the world, aye-ayes play the role of woodpeckers in Madagascar. They search the branches of trees by night for insect larvae and, once found, stir them to a soup which they slurp up with that long finger. Brown lemurs (*Lemur fulvus*) live in many forests all over the island. With long swinging tails and a glorious array of gurgling calls, they spend much of the day lolling about and well deserve Bob Sussman's designation as the "hippies of the forest". If brown lemurs are the hippies, verreaux's sifaka (*Propithecus verreauxi*) are surely the ballet dancers. Like the brown lemurs, they are widely distributed in the forests of the island, surviving as do most lemurs on a diet of leaves, flowers and fruit. They are vertical leapers, like the indri, bounding from tree trunk to tree trunk with matchless grace and, when they occasionally come to the ground, bouncing along in a comical cross between a gallop and a kangaroo hop. Except the aye-aye, all the animals we have talked about so far are active by day. But a walk through the forest at night would reveal another world

of lemurs. These include the mouse lemur (*Microcebus spp.*), one of the smallest primates anywhere, the dwarf lemur (*Cheirogaleus spp.*), the fork-crowned lemur (*Phaner furcifer*), the gentle and sportive lemur (*Haplemur* and *Lepilemur spp.*) and the owl-like woolly lemur (*Avahi laniger*). Several of these species are particularly interesting because they feed heavily on gums, a dietary speciality that is rare among primates of the Old World.

If we were to put the clock back two thousand years, not only would we be able to add to our faunal list lemurs the size of goats, lemurs that have been likened to large baboons, and lemurs that swung through the trees by their arms, but also a pygmy hippopotamus, an aardvark, and a carnivore resembling a short-legged puma. We would also be able to see the Malagasy ratites. Ratites are large, flightless birds, the best known of which today is the ostrich. Two thousand years ago in Madagascar there were between six and a dozen species of these elephant birds. Two giant land tortoises are the final entry on our list "in memoriam".

The reality of the threat to the living lemurs is brought home by a recent evaluation of their conservation status. Hardly a species is safe. Habitat destruction is, I believe, the most critical threat, but it cannot usefully be considered as a single problem, for the habitat is being destroyed by different means in different parts of the island.

Forest destruction for traditional and commercial agriculture, for firewood and timber, forest destruction by grazing and browsing livestock, by burning to promote growth to feed livestock, are the threats. None of them are activities we can easily condemn as a capricious abuse of natural resources. There are no poachers killing lemurs to sell as trophies; the Malagasy government is not trying to sell the island's remaining forest cover to logging companies. In a sense, it might be easier if these were the threats, if the problem were greed. But it is not. The problem in Madagascar is that the destruction is largely wrought by people trying to make a simple living. They cannot reasonably be asked to stop doing this.

In the long run, fundamental changes must be made if the Malagasy themselves are to survive, let alone their wildlife. Bleeding soils on the east coast spell an end not only to the rain forest and its denizens, but also to human economic life and indeed to almost any form of life.

There are ways in which relatively small amounts of money in combination with a lot of hard work can produce and, indeed, thanks to World Wildlife Fund, are producing immediate and positive effects on the conservation status of Madagascar's flora and fauna. These are:

1. Improving the status of the Natural Reserves;
2. Expanding a complementary system of small reserves, such as the reserve at Berenty;



species live in groups of ten or twelve animals that occupy an area little larger than many of our backyards. In much of the world it is absurd to talk seriously about conserving a couple of hundred hectares here, a couple of hundred hectares there. In Madagascar, it may not be absurd. It is certainly worth a try.



ENDANGERED PRIMATES: THE MONKEYS OF BRAZIL'S ATLANTIC FORESTS

by Russell A. Mittermeier
World Wildlife Fund—US

3. Documenting the flora and fauna and

4. Education. The future of Madagascar's wildlife lies ultimately in the hands of the Malagasy themselves. In the long run, the best hope lies in educating people into an awareness of the importance of their natural heritage.

It is easy to sit at a desk in America drawing up lists of imperatives to save Madagascar's soul. In reality, though, is this a futile exercise? On the negative side, there is the poverty of Madagascar. Many times has it been said to me there, don't keep telling us what to do. We know. Give us the resources to do it with. Resources are indeed in short supply, and feeding and clothing people and reducing the national debt receive higher priority than long-term conservation goals. Moreover, many of the conservation measures needed require fundamental changes in the lifestyle of large sectors of the population. A persistence will be required to push them through that it is hard to see being generated when the only obvious reward will be the satisfaction of knowing what has *not* occurred — destruction has been averted.

On the positive side, however, the government of Madagascar is increasingly aware of conservation as an issue, witness their blessing upon the establishment of a World Wildlife Fund—Madagascar in the last few years. More generally, the Malagasy people have a natural love of and affinity for their wildlife; lemurs in particular play a central role in folktales and, in fact, many Malagasy consider the lemurs to be close relatives. Finally, turning from people back to the wildlife itself, the fact that Madagascar is a small, exquisite and fanciful replica of the world in itself provides grounds for optimism. For few animals in Madagascar occupy a range larger than 40 or 50 acres, and some

Wild populations of most nonhuman primates are decreasing all over the world. Several species, such as the golden lion tamarin (*Leontopithecus rosalia*), the cotton-top tamarin (*Saguinus oedipus*), the mountain gorilla (*Gorilla gorilla beringei*), and the lion-tailed macaque (*Macaca silenus*), are already on the verge of extinction; others, like the woolly monkeys (*Lagothrix spp.*), the uakaris (*Cacajao spp.*) and the orangutan (*Pongo pygmaeus*), are disappearing at an alarming rate; and some, like the rhesus monkey (*Macaca mulatta*) and the capuchins (*Cebus spp.*), though still abundant, are declining in many parts of their range. Only a handful of highly adaptable species appear to be holding their own, and these are mainly small, rapidly breeding monkeys from the vast Amazon forests of South America — species like the squirrel monkey (*Saimiri sciureus*), the golden-handed tamarin (*Saguinus midas midas*) and the pygmy marmoset (*Cebuella pygmaea*).

The major reasons for the disappearance of primates vary from area to area, but habitat destruction, and especially destruction of the world's tropical forests — which are the home of more than 90% of all primates — is without a doubt the major threat.

Another reason for the decline of primates is hunting of these animals as a source of food for man. The effects of hunting vary greatly from region to region and from species to species. It is a relatively minor factor in many parts of Asia, where primates are either considered sacred (e.g., in the Hindu religion the monkey god Hanuman occupies a special position) or are considered unclean and not fit for human consumption, as is the case in Islam. However, hunting of primates is a very significant threat in at least three parts of the world: the Amazon region of South America and both West and Central Africa. Primates are a major source of food in

these regions, and thousands are killed every year for the pot.

Primates are also killed for a variety of other purposes. Some are hunted to obtain their skins or other body parts for ornamentation. The most striking example of this is use of black-and-white colobus monkey (*Colobus guereza*) skins to make either cloaks or headdresses for native Africans or coats and rugs for American and European tourists.

Primates are sometimes killed because they are considered agricultural pests. This is particularly the case in Africa and Asia, where monkeys like baboons and macaques can be quite significant crop raiders.

Primates are even at times killed as bait. In remote corners of the Amazon region, larger species like woolly monkeys and spider monkeys (*Ateles spp.*) are shot by cat hunters to bait traps for jaguars and ocelots. The cats are caught alive in these traps, and then either strangled or shot in the head, giving the hunter a skin without shotgun pellet damage.

Live capture of primates, either for export or to serve a local pet market, is another important reason for the decline of primates. For the most part this is a minor factor compared to habitat destruction and food hunting, but for certain endangered species that are in heavy demand it is very serious. Species that have been hurt by the trade include the chimpanzees (*Pan troglodytes*) from Africa and the cotton-top tamarin from Colombia, both of which were important biomedical research models, and the woolly monkeys, which are still very popular pets for local people in Amazonia. Infant primates are usually captured by shooting the mother and then removing the clinging infant after it has fallen to the ground.

In spite of what has been done to date,

primate conservationists have barely begun their task. The problems are overwhelming and, if present trends continue, it is quite possible that a substantial percentage of the world's living primate species will disappear in the very near future. Of the roughly 190 species of primates currently recognized, about 35%, or one out of three, are already considered endangered, vulnerable or rare. Of these, at least 14%, or one in seven, are highly endangered and could be extinct by the turn of the century or even sooner if something isn't done very quickly.

Given the fact that nonhuman primates are the human primate's closest living relatives, this potential loss of diversity is quite frightening.

In recognition of the importance of primates and their close interrelationship with the world's rapidly disappearing tropical forests, World Wildlife Fund will be launching a special *Tropical Forest and Primates* fund-raising campaign in October, 1982. Eleven major program areas are covered in this campaign, and high on the list is the Atlantic forest region of eastern Brazil, which rates as one of the two highest international primate conservation priorities.

The Atlantic forests of eastern Brazil are a unique series of ecosystems quite distinct from the much more extensive Amazonian forests to the north. They once stretched pretty much continuously from the state of Rio Grande do Norte at the nose of South America south as far as Rio Grande do Sul, the southernmost Brazilian state. However, this region was the first part of Brazil to be colonized, and it has developed into the agricultural and industrial center of the country. It also has within its borders two of the three largest cities in all of South America: Sao Paulo, which recently became the largest city in the world, and Rio de Janeiro.

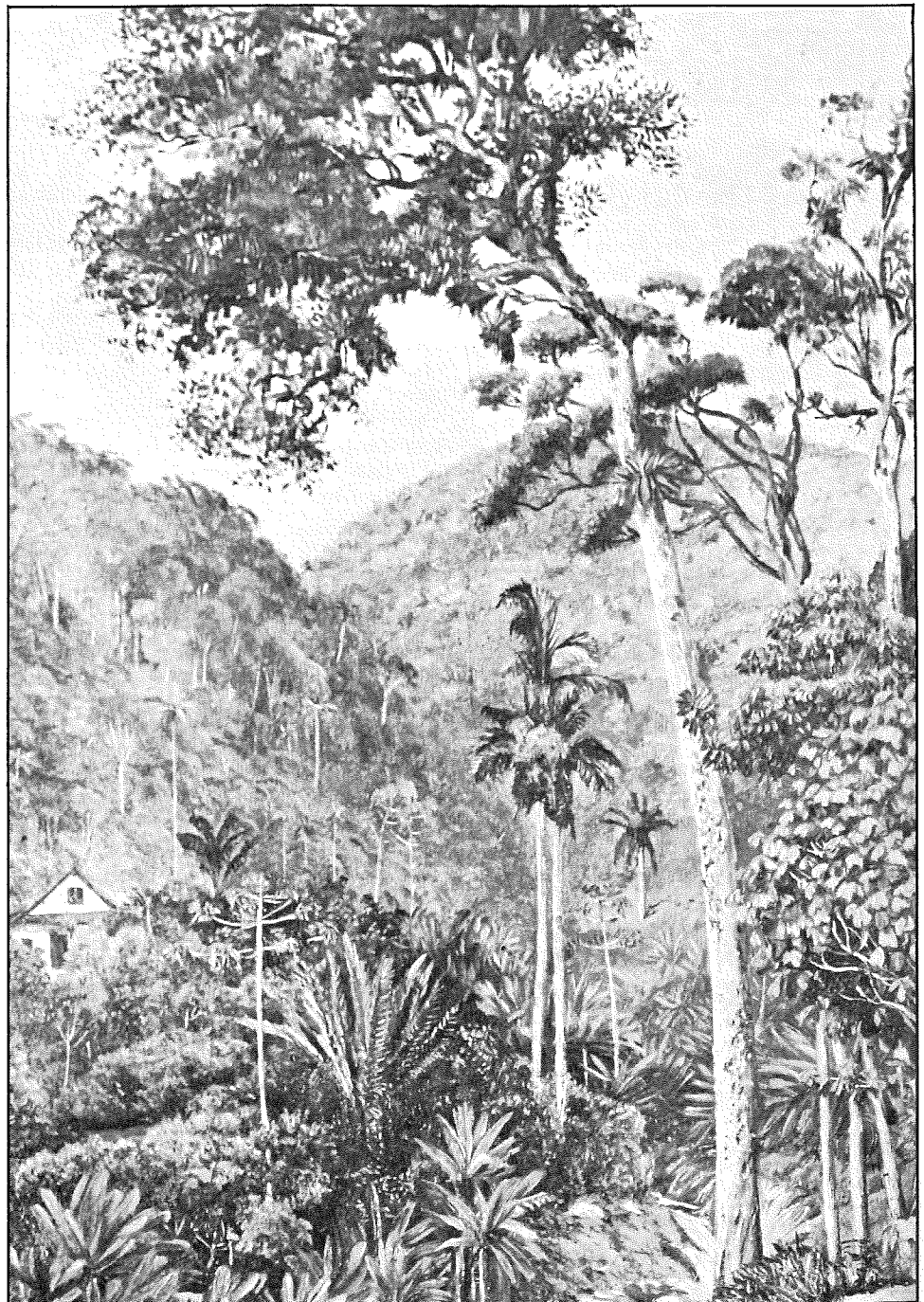
The result has been large scale forest destruction, especially in the last 10 to 20 years of rapid economic development. Forests have been cut for lumber and charcoal, and to make way for plantations, cattle pasture and industry.

Needless to say, the animals native to the Atlantic forests are not doing very well and, in many respects, we are dealing with a dying fauna in addition to a dying forest formation. The primates are a very good example. Thus far, data are available on 17 of the 20 species and subspecies of monkeys found in the Atlantic forests, and surveys conducted by a joint team of World Wildlife Fund—US personnel and Brazilian collaborators have indicated that fully 13 of these are already endangered. The endangered species include the white-faced marmoset (*Callithrix geoffroyi*), the golden-headed lion tamarin (*Leontopithecus rosalia*), the buff-headed tufted capuchin (*Cebus apella xanthosternos*), and the brown howler monkey (*Alouatta fusca*). Almost all of the Atlantic forest primates are endemic to the region and found nowhere else in the world.

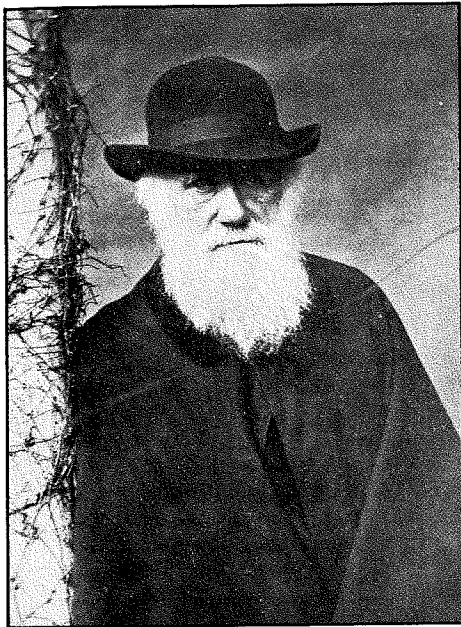
The two most spectacular species of the Atlantic forest region are the golden lion tamarin (*Leontopithecus rosalia*) and the miqui (*Brachyteles arachnoides*), and these also appear to be the most endangered. The miqui is the largest and most ape-like of the New World monkeys. It is the largest mammal that is entirely restricted to Brazil. As such, it would make an excellent symbol for the Brazilian conservation movement, and could easily become for Brazil what the giant panda (*Ailuropoda melanoleuca*) is for China.

I would like to emphasize how im-

portant the next three to five years will be for primate and tropical forest conservation. If we act now, at a level far exceeding past efforts, we still have a very good chance to pull some of the endangered primates that have been discussed here back from the brink of extinction. If we delay, even if only to the end of the decade, the damage will be done in most cases and the opportunity to save species like the miqui, the golden lion tamarin and the mountain gorilla will be lost forever. □



A painting of the Brazilian jungle by Darwin's friend, Marianne North: Glimpse of Mr. Weilhorn's House at Petropolis, Brazil.



Charles Darwin.

QUEST FOR FIRE: The Chesowanja Evidence

by J.W.K. Harris
*Department of Anthropology
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LONG AFTER DARWIN

This year marks the centennial of the death of Charles Darwin.

Since that milestone, the wedding of modern genetics and molecular biology with the animal fossil record has changed our understanding of how evolution works. Many scientists now believe that it is not a gradual process but, rather, moves in sporadic leaps, sometimes called "punctuated equilibria." Darwin believed that change arrived at random; many scientists today say that acquired traits are caused by environmental conditions and are passed on to subsequent generations. Some question Darwin's theory of natural selection — that only changes that enhance the ability to survive are retained in future generations — believing that apparently useless changes may also remain.

Darwin himself would no doubt have been able to accept adaptations in his work. "I have steadily endeavored," he stated in his *Life and Letters*, "to keep my mind free so as to give up any hypothesis, however much beloved (and I cannot resist forming one on every subject), as soon as facts are shown to be opposed to it." His basic concept of evolution has been able to encompass its own evolution. All scientists today accept the fact of evolution although they may disagree about how the process works. The fossil evidence to support his basic premise is now extensive — so nearly complete that the history of human evolution can be traced backward through the mammals, the reptiles, the amphibians to the fishes. Darwin remains the Father of Evolution.

The last words of his book, *The Descent of Man*, are worth remarking: "We must, however, acknowledge, as it seems to me, that man with all his noble qualities . . . still bears in his bodily frame the indelible stamp of his lowly origin." □

Of all human discoveries, the control of fire has probably been the most momentous and far reaching. Momentous to the degree that the controlled and purposeful use of fire involves overcoming an instinctive fear that exists among animals. Only humans have learned to conquer this fear, although, of course, an awareness of the dangers of fire is very much part of the human psyche. Moreover, fire was the first energy source to be harnessed for our needs, which implies significant development towards rational thought. Thus, the beginnings of its use can be judged as an important threshold in human evolution. For the controlled use of fire not only set us apart from other primates but from the animal kingdom as a whole and for this reason is a diagnostic human trait. Recent discoveries, reported here, of traces of fire on an archeological site at Chesowanja, Kenya, and dated to 1.4 million years, suggest that the control of fire may have had its beginnings at the very roots of humanity.

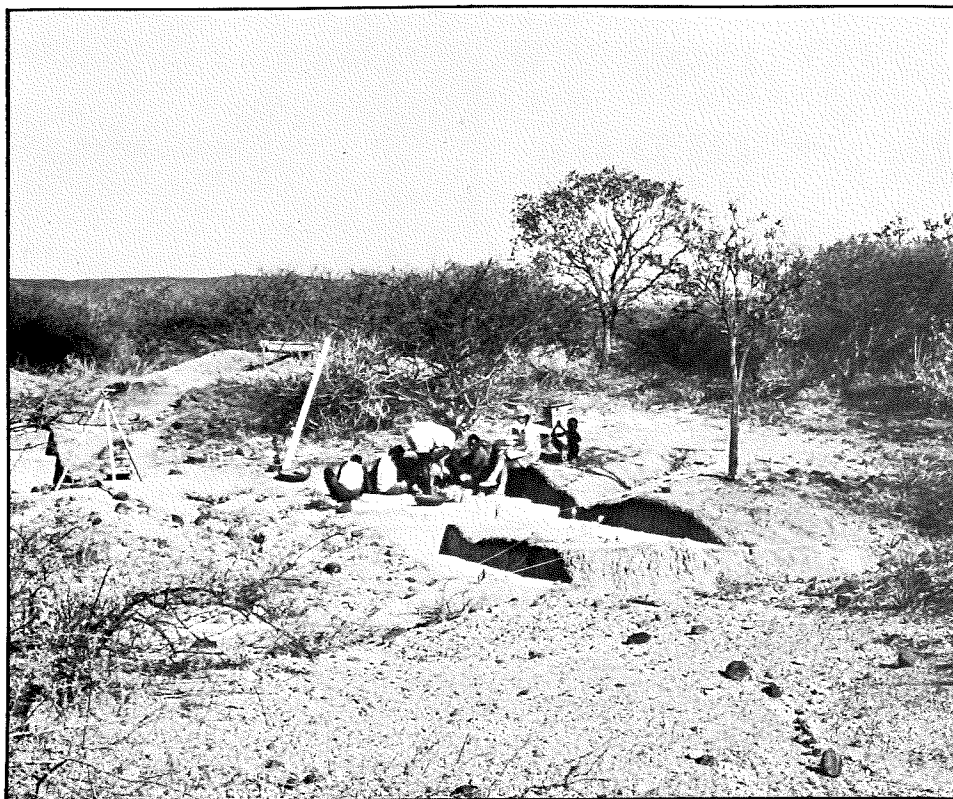
One should always keep in mind that fire was a discovery and not a human invention. From time immemorial, fire caused by lightning strikes, volcanic eruptions, and as a result of spontaneous combustion would have naturally ignited tinder and as a consequence would have regularly swept over vast areas of dry tropical savanna grasslands. It is not difficult to imagine against this environmental background and following such experiences that prehistoric groups learned to pick up "natural" fire and use it. In fact, archeological evidence has clearly shown that prehistoric groups long had a knowledge and use of fire before they had learned to make it themselves. Today, fire brands are still used by groups to transport fire from one place to the next and presumably prehistoric groups used whatever means were at their disposal to carry fire and to see it wasn't accidentally extinguished.



Dr. Jack Harris examining a stone tool found on the surface of Chesowanja.

One of the real "burning" questions was just how far back in time could the documentation of controlled fire be traced. The idea that the earliest hominids used fire was first suggested by Professor Raymond Dart over fifty years ago following the discovery of blackened fossilized animal bones which appeared to have been burned by fire at the Makapansgat Limeworks site in South Africa. Dart was so convinced by the finds that he named the fossil hominid remains found in association in these same deposits, *Australopithecus prometheus*. However, subsequent chemical tests failed to confirm that the bone had been burned in antiquity so most people rejected Dart's notion that the australopithecines were early fire users. The lack of any clear evidence for the use of fire from Early and Middle Pleistocene sites (approximately 1.8 million to 120,000 years ago) elsewhere in Africa only appeared to confirm this.

Because of this lack of evidence, there slowly crept into the prehistory literature sources the idea that early hominids had no great need for fire in the tropical and subtropical areas of the world. This was particularly so for Africa where most of the early hominid remains and evidence for their activities had been recovered. Here the regional climates were generally mild so warmth wasn't a problem. Furthermore, it was thought the "optional" environments offered such a wide selection of food resources that there were no selection pressures on hominids to enrich their dietary range by cooking food that would otherwise have been poisonous or unpalatable. Finally, it could be pointed out that so far the best known places for the earliest evidence of controlled fire, like Zoukoutien (China), Vertesszellos (Hungary) and Tautavel (France), were all located in the temperate cooler regions of the Old World



The archeological site GnJi 1/6E during excavation. Here lumps of baked clay were found which probably were the result of a humanly controlled fire, 1.4 million years ago. Just to the right of the excavation were found fragments of an early hominid skull.

where there was a real need for some means of providing protection and warmth from the cold.

One could also argue from an evolutionary point of view that the controlled use of fire was a more recent cultural phenomenon, as none of the sites in Europe and Asia were older than about 500,000 years. Furthermore, on the basis of the age of these sites and in some instances the association of ash, charcoal and charred bone in the same strata as hominid bones, the use of fire has become indelibly linked with a set of behaviors characteristic of the hominid stage *Homo erectus*.

In recent years, several important hominid and archeological discoveries now require paleoanthropologists to rethink the whole question of the antiquity of the controlled use of fire and its broader implications to early hominid adaptive patterns of behavior. Firstly, spectacular discoveries by Richard Leakey's team at Lake Turkana of two beautifully preserved hominid skulls and a partial skeleton indicate *Homo erectus* had already emerged at least on the African continent 1.5 million years ago. In addition, new discoveries from China and further dating assessments of *Homo erectus* remains found previously in Indonesia indicate the rapid success of the species by its widespread distribution in other parts of the Old World, probably by one million years ago. While it would be unwise to simply link the great antiquity of controlled fire with the emergence of *Homo erectus*, corroborative evidence of an archeological nature of baked clay on a hominid occupation site at Chesowanja

may in fact extend the date back beyond one million years ago.

Today Chesowanja is situated on the east side of Lake Baringo and is nestled against the rugged backdrop of the Laikipia Escarpment, which locally defines the eastern edge of the Rift Valley in this part of Kenya. Together with my British colleagues Dr. John Gowlett, Dr. Bernard Wood and Dr. Derek Walton, we have been investigating a series of excavated archeological occurrences containing a wealth of artifacts and faunal remains, including hominids, which date to 1.4 million years ago based upon the potassium-argon age determinations.

One of the most intriguing finds to be recovered from our largest excavation was the discovery of lumps of reddish, discolored, mineralized matter. On closer scientific scrutiny and analysis in Derek Walton's geophysics laboratory the lumps proved to be baked clay. There are two steps in the investigation to demonstrate fire use at an archeological site. Obviously, the first step is to show that fire was present and, secondly, that it was introduced or controlled by humans.

To satisfy the first criterion, the Chesowanja evidence indicated that the clay has been baked by fire to a temperature of 400° centigrade. Generally, grass fires sweeping across the savanna only bake the underlying surface to approximately 65°. Therefore, one is left with a narrower range of possibilities to account for a heat source that baked clay to such a high temperature. Either it was the result of a humanly controlled fire or a natural conflagration

like a burned-out tree stump or a lightning strike.

In our estimation, the fire appears to have been humanly controlled although one cannot completely rule out the possibility of a natural occurrence. The distribution of baked clay finds across the excavation shows their direct association with artifacts, unmodified stone cobbles and several fragmentary animal bones. In fact, in one place the baked clay and stones were concentrated in such a way as to give the appearance of a localized burned patch like a "hearth". Therefore, because the baked clay lumps were found within the confines of the archeological refuse, which was relatively undisturbed by natural processes, by implication the fire appears to have been more likely the result of hominid behavior at the site.

The great antiquity for the control of fire one million years further back in time than previously known, as the Chesowanja evidence suggests, has far reaching implications. Space limitations prevent me going into these in depth. Briefly then, not the least of these implications is to add greater credibility to the notion that early hominids congregated together on the landscape to share and consume food. Archeological sites of this nature have been referred to as "home bases", particularly where the evidence indicates the menu included meat. Unquestionably, fire in a very real sense would have offered protection to hominid groups occupying such sites from the unwelcome attention of carnivores and scavengers attracted by the smell of meat.

By harnessing fire early hominids were not only able to greatly extend their ecological range to more open living places on the African savanna, but also to increase their food supply by cooking items that were either poisonous in their raw state or unpalatable. The use of fire is surely an indication of a growing advance in mental capacity, which may have been the mark of success of *Homo erectus* as early as 1.5 million years ago.

Dr. Harris, with colleagues Dr. John Gowlett, Dr. Derek Walton and Dr. Bernard Wood, published last year in Nature the scientific results of paleoanthropological studies undertaken at Chesowanja, which had an important bearing on the hypothesis for the great antiquity of humanly controlled fire. These studies were funded in part by the L.S.B. Leakey Foundation. □

FRIENDSHIP:

Long-Term Bonds Between Male and Female Baboons

by Barbara Smuts
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It was late afternoon and the angled light brought into clear relief the sculptured planes of the baboons' bony muzzles, highlighting the individuality of each face. Virgil and Pandora, an adult male and female in late middle-age, rested together at the base of the baboons' sleeping cliffs.

Virgil lay on his back, limbs splayed, while Pandora groomed the hair on his chest. After a few moments they were joined by two of Pandora's offspring, Plutarch, a juvenile male, and Pyrrha, an infant female. Pyrrha was in a rambunctious mood and she used Virgil's stomach as a trampoline, bouncing up and down with the voiceless laughter that accompanies baboon play. Every now and then Virgil opened his half-shut eyes and, gently touching her

with his index finger, he grunted as if to reassure her that he did not mind the rhythmic impact of her slight body against his full stomach.

After a while Pandora stopped grooming and Virgil moved away, slowly clambering up the cliff face where the troop would spend the night. He glanced back every few steps at Pandora and her family, who followed right behind. Finding a good spot halfway up the cliffs, Virgil made himself comfortable. Sitting upright, he leaned backward against the rockface and, grasping his toes in his hands, he let his head sink to his chest — a typical baboon sleeping posture. Pandora sat next to him, leaning her body into his, one hand on his knee, her head against his shoulder. Her offspring squeezed in between Pandora and Virgil and in the dimming light I could not tell where the body of one baboon began and the other left off. This is how they would remain for the rest of the night.

For over a year I had been spending my days with this troop of wild baboons, and throughout that time Virgil and Pandora had been close associates, feeding near one another during the day and sleeping together at night. Soon after I began studying baboons, it became apparent that relationships like that between Virgil and Pandora

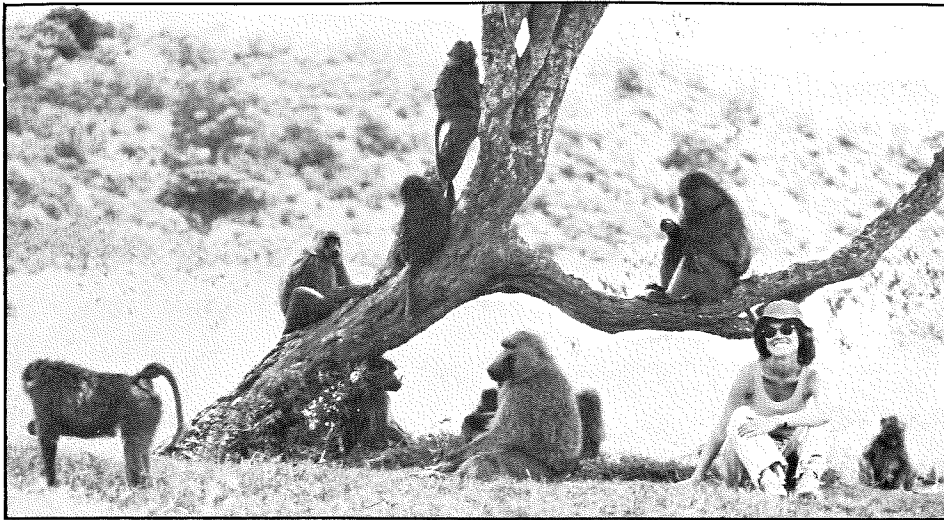
were a regular and important feature of baboon life. But why did these special relationships, or "friendships" as I called them, form? How long did they last, and why did they sometimes break up? How did interactions between friends differ from the usual pattern of male-female in-

and all the results described here refer to these females. During my sixteen months in the field I collected over 1,000 hours of observations on all of the adult females in the troop. These "focal" samples, in which I followed one individual for half an hour at a time, were supplemented by *ad libitum* or "free" observations on sexual consorts, male-infant interactions, aggression, and grooming.

I began my investigation of baboon friendships by a detailed analysis of grooming and spatial proximity between adult females and males. I found that, during the course of the day while foraging and resting, each female tended to be found within a few meters of one or two adult males and these associated males were different for each fe-

male. Early in the morning, during mid-day rests, or in the evening on the sleeping cliffs, the females groomed with these same males, and rarely with any others. Combining information on proximity and grooming, I was able to identify one, two, or occasionally three male "friends" for each female. All females except one had at least one male friend, and all males except three who had recently entered the troop had at least one female friend. But some males had as many as eight female friends while others had only one. Twelve percent of all possible adult female-adult male pairs in the troop were considered friends.

How were these friendships maintained? Females groomed their male friends much more often than the males groomed them, although males groomed their female friends more often than they did other females (excluding sexual consort partners). Females were also primarily responsible for maintaining spatial proximity to their male friends: they moved toward the males more often than the males moved toward them, and they moved away from the males less often than the males moved away from them. Just the opposite pattern held for females and all other "non-friend" males: these males often moved toward the females, but the



Barbara Smuts with some members of the Eburru Cliffs troop of olive baboons, Gilgil, Kenya.

teractions? I noticed that Virgil was particularly solicitous of Pandora's small infant — was this because he was the father? Would Pandora mate with Virgil more than with other males when she resumed estrous cycles?

The baboon troop I studied, Eburru Cliffs or "EC", has a range adjacent to the Pumphouse Gang troop near Gilgil, Kenya, studied by Shirly Strum, Robert Harding and others since the early 1970s. (Dr. Strum's research on Pumphouse has been described in earlier issues of the *L.S.B. Leakey Foundation News*.) EC is a large troop with over 120 members, including, at the time of my study, thirty-four adult females and eighteen adult and subadult males.

Most previous research on male-female relationships in savanna baboons had focused on sexual interactions. But female baboons are usually either pregnant or lactating, spending only about 4% of their time in sexual consorts with adult males. While in estrous females become the objects of intense competition among males, and their usual pattern of social interactions is temporarily disrupted. For these reasons I decided to focus my observations on females who were either pregnant or lactating and not undergoing sexual cycles,



A young adult male with the infant of one of his female friends.

females usually avoided them.

This movement away from non-friend males suggested that females did not want to be near them, and analysis of interactions between females and non-friend males indicates why. Most of these interactions were quite tense. A female usually responded to the approach of a non-friend by rapidly glancing at and then away from him several times, stiffening her posture, and pausing in her activity. If the male continued to approach she would either move quickly away, abandoning her feeding or resting site to him, or else behave submissively toward him by crouching or grimacing. Sometimes a female even screamed in response to the approach of one of these males, even though the male was not threatening her.

Female responses to approaches by male friends were very different. They were much less likely to avoid these males, and the approach was typically followed either by continuation of routine activities like feeding or resting, or by grooming. Females almost never responded with submissive gestures to the approaches of male friends.

Why do these friendships exist? Since male-female friendships have now been reported at every major baboon study site, they appear to be an evolved characteristic of savanna baboons (*Papio anubis*, *P. cynocephalus*, *P. ursinus*). If so, then forming a friendship must somehow contribute to the survival and reproduction of the individuals involved. In evolutionary parlance these potential contributions are referred to as "benefits".

Friendships with males appear to benefit female baboons in two main ways: protection and infant care. When a female or her juvenile offspring are threatened or attacked by another baboon, other troop members may intervene on the victims' behalf. In EC, 95% of the interventions by

males involved a friend of the victim or of the victim's mother. Since males occasionally inflict severe injury on females and juveniles, defense by a male friend — or the possibility of such aid — may significantly reduce the risk of injury to a female and her young. Having a male friend nearby also inhibits other baboons from approaching a female, providing a sort of "buffer zone" within which she can pursue her activities relatively undisturbed.

Unlike many other old world monkeys like langurs, vervet monkeys, and rhesus macaques, male baboons frequently interact in friendly ways with infants. However, in EC these interactions were completely restricted to the mothers' friends. Male friends routinely carried, groomed, and cuddled young infants. When the infants were older and spending less time near their mothers they began to spend even more time with these males. Several of the adult males in EC had three or four infants and young juveniles as constant followers. When the male fed, these youngsters fed in his protected "shadow", and when he rested they leaned against him or used his body as a platform in their rough and tumble games. The bonds that develop between a male and the infants of his female friends may persist for many years — sometimes for longer than the bond between the male and the female. Relationships with males appear to benefit infants and juveniles in several ways: protection from other baboons and from predators, increased opportunities to feed on preferred foods, and, in the case of the mother's death, a substitute care-giving relationship that may save an infant's life.

Thus when a female establishes a special relationship with a male she and her immature offspring acquire an ally in the troop — an ally who, because of his larger size and superior fighting ability, may make a significant contribution to the fitness of the female and her offspring. If these conclusions are correct, they help to explain why a female baboon forms friendships with males. But what benefits does the male receive?

To answer this question definitively one would need to know which males were the fathers of the infants in a troop. Analysis of blood taken from 95% of the EC baboons is currently underway and we hope the results will allow us to identify the most probable fathers of many EC infants. In the meantime I have used behavioral measures to estimate paternity. The male or males who were most frequently observed in consort with a female during the most fertile phase of the estrous cycle in which she conceived were considered "likely fathers". Many friendships involved the males who were the most likely fathers of the female's current infant. In these cases, the main benefit to the male of the friendship may be increased opportunities to contribute to the development and survival of his own offspring.

What other benefits might a male receive from friendships with females? The

most obvious possibility is an increased likelihood of mating with the female in the future. In EC, males who had formed a friendship with a female when she was pregnant and lactating were considerably more likely to form consorts with her a year or two later when she resumed sexual cycles than were other males. It looks as if female baboons prefer to mate with males who have already demonstrated a willingness and ability to invest in them and their offspring.

The most intriguing questions about male-female friendships in baboons are the most difficult to answer: How are friendships formed and how long do they last? Why do they sometimes break up? Which individuals have the most friends and what makes them more attractive than others? Firm resolution of these questions will require many more years of field observations but some tentative answers can be put forward as hypotheses to be tested. Most friendships are initiated by the male who "targets" a particular female, following her and attempting to make eye contact with her. The male will make friendly faces and vocalizations at the female, and will groom her or present himself for grooming if he can get close enough. After a period of active "pursuit" of the female lasting anywhere from a few days to several months, the male and female roles in maintaining proximity may shift, and the female will begin to follow the male. This transition marks the establishment of a long-term friendship between the male and female. If this shift does not occur it seems to indicate the female's lack of "acceptance" of the male, and he will transfer his attentions to another female.

Some friendships last for only a few months while others persist for at least three years; some may last much longer. In general young females form bonds with young males, and these relationships are transient. Older females tend to form relationships with older males and these last longer.

Males seem to prefer older females as friends, and some males show a slight preference for higher-ranking females. Females seem to prefer males who have lived in the troop the longest, and these males have the most female friends. When a male has several female friends, the females tend to be ones who share friendly bonds with one another, often female kin.

The formation, persistence, and dissolution of friendships undoubtedly has much to do with individual personalities and idiosyncratic preferences. One EC female was apparently uninterested in males and did not form strong bonds with any. Some EC males devoted a great deal of time and energy to cultivating friendships with females, while others focused more on achieving high status vis-a-vis other males. It is unlikely that we will ever fully understand the basis of these individual differences, but it is important not to lose sight of them when attempting to make generalizations about baboon behavior.



Male (on right) and female "friends" sleeping.

The findings described here suggest a very different picture of baboon life than that portrayed in the literature a decade ago. The initial emphasis in baboon studies was on males, who were thought to provide the core of the group's social structure. Females were generally viewed as passive objects of male-male competition, and it was thought that a female's status in the group depended on her relationships with males. In the last ten years baboon research has turned this picture around. We now know that matriarchs and their female kin form the core of baboon society and male membership is transitory. A female's status is inherited from her mother and is not affected by her relationships with males. A male's position in the troop, however, is affected by his relationships with females. If a new male fails to form friendships with females, he is unlikely to become integrated into a new troop even if he is able to dominate the troop's males. Once in the troop a male's mating activity depends in part on the number of female friends he has acquired.

Recent studies suggest that males and females also form strong, long-term bonds in macaques, and that chimpanzee females prefer to mate with the most affiliative males in the group. There is thus increasing evidence that long-term friendships between adult males and females are important in many higher primates that live in multimale, multifemale groups. These findings may provoke reevaluation of attempts to explain the evolution of male-female relationships in our own species. Most such attempts assume that in some

long ago proto-hominid groups male-female relationships were relatively undifferentiated, except for transient bonds formed when females were sexually receptive, and that aside from protection from predators, male investment in females and young was minimal. Then, the story goes, changes in the habitat and subsistence activities led to a gradually increasing division of labor by

sex, with males focusing on hunting and females on gathering. Once this division of labor evolved, it then became advantageous for males and females to exchange food, and this in turn set up new selection pressures favoring the development of long-term bonds between particular males and females, more or less exclusive sexual relations between these partners, and increasing male investment in the offspring of these unions.

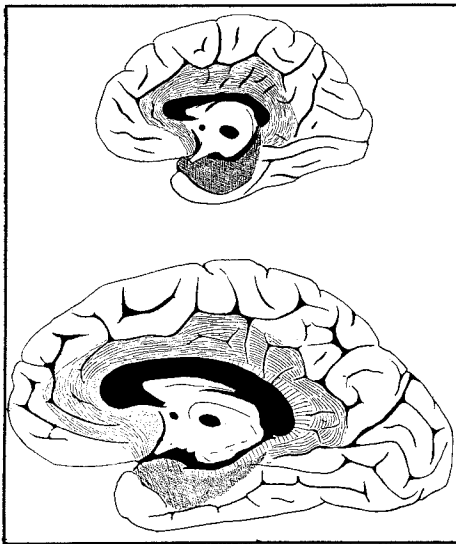
The nonhuman primate evidence challenges this scenario in two ways. First, it shows that long-term bonds between males and females and significant male investment in young can evolve in multimale, multifemale groups in the absence of any sexual division of labor or food sharing. Second, it indicates that the emotions underlying the formation and maintenance of such bonds may occur in the absence of an exclusive sexual relationship or "pair bond". Thus, highly differentiated and emotionally intense relationships between unrelated males and females may have preceded the sexual division of labor, food sharing, and the evolution of the family as we know it, by millions of years.

These ideas are highly speculative, but such is the nature of all attempts to reconstruct the social relationships of our ancestors. The important point is that knowledge of the social behavior of our closest living relatives continues to enrich and inform efforts to better understand the evolutionary heritage of *Homo sapiens*. The L.S.B. Leakey Foundation, by providing essential support for studies of primate behavior, plays a major role in these efforts.

Dr. Smuts' research was partially funded by the L.S.B. Leakey Foundation. □



Pandora grooms Virgil.



Drawings of the medial surface of the right hemisphere of the brains of a chimpanzee (top) and a human being. Shaded areas identify the evolutionary old cortex of the great limbic lobe surrounding the brain stem. Concentric parallel lines identify the limbic cortical area referred to in text as the great arc. (after A.W. Campbell, 1905)

renewed research on therapsid fossils will give clues as to whether or not the most advanced forms laid eggs; were accompanied by young; had scales or hair; possessed a snout for sucking; were capable of audio-vocal communication; and so on.

On the basis of the few available cranial endocasts, the brains of therapsids were somewhat like those of existing lizards, probably having the basic reptilian complex of the forebrain (R-complex), but only a rudimentary cortex (cf. Fig. 1). For our comparative studies involving reptiles we have focused on lizards because they would probably bear the closest resemblance to the mammal-like reptiles. In a behavioral inventory of lizards one can identify more than twenty-five forms of behavior that they possess in common with birds and mammals. Most conspicuously lacking with respect to mammals is the behavioral triad mentioned above — namely, nursing (in conjunction with maternal care), play, and the isolation call. Our comparative neurobehavioral studies provide evidence that the R-complex provides a basic mind for carrying out an animal's daily master routine (and sub-routines), and in creatures as diverse as lizards and monkeys, plays a fundamental role in four main kinds of displays used in animal communication — namely, (1) signature, (2) challenge, (3) courtship, and (4) submissive displays.

The evolution of a family way of life has depended on successive developments in the triune brain, with new structures being superimposed on the old, somewhat like floors and wings added to an original building. The brain corresponding to that of early mammals (Fig. 1) is called the limbic system (MacLean, 1952) because it comprises the cortex of the great limbic convolution of Broca and structures of the

brain stem with which it is connected. Broca referred to the convolution as "limbic" (1878) because it *surrounds* the brain stem (Fig. 2). Somewhat like a wide collar in shape, it is found as a common denominator in the brains of all mammals. Research has shown that it plays a fundamental role in the experience and expression of emotional feelings involved in self-preservation and the preservation of the species.

The evolutionary old limbic cortex can be subdivided into three main sectors, two of which are closely associated with the olfactory organ. One of these sectors is primarily involved in self-preservation (feeding, fighting, and self-protection), while the other is implicated in primal sexual functions required for procreation.

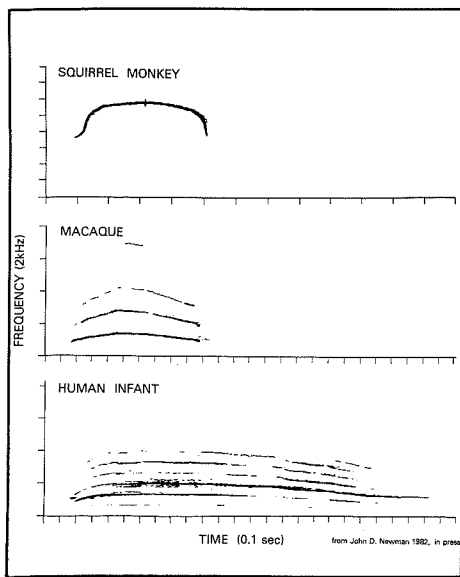
It is the limbic subdivision including the third cortical sector that is turning out to be of special interest in regard to the behavioral triad under consideration. As shown in Figure 2, this cortical sector is contained in the upper part of the limbic convolution, forming a *great arc* spanning the corpus collosum. I will hereafter refer to it in italics as the *great arc*, and will first describe some relevant experiments on hamsters (in collaboration with Murphy and Hamilton). By a manipulation at the time of birth, we can prevent the entire neocortex (cf. Fig. 1) from developing. Despite that loss, the animals are able to mate, breed, rear their young, and engage in other hamster-typical behavior. If in addition, the limbic cortex of the *great arc* is prevented from developing, there are two outstanding behavioral deficits suggestive of a regression towards the condition of reptiles — namely, an absence of play behavior and the failure of the females to rear their young. The latter finding was not surprising because it was known that elimination of the *great arc* by itself resulted in a disruption of maternal behavior. What struck me as novel in these experiments was the failure of the young animals to develop play behavior. In observations on reptiles, I had never noted anything resembling play. Contrary to usual interpretations, one might hazard the suggestion that in the evolution of mammals, play served originally to promote harmony in the nest, and then later on, group affiliation. To switch from rodents to primates, the following note by Jane Goodall about a family of chimpanzees attests to the role of play in promoting harmony among animals living closely together: "Fifi . . . is a relaxed and affectionate mother. Often she started long play sessions with Fanni, bending over and tickling her with nuzzling movements . . . until the infant was hysterical with laughter. Fifi played often with son Frodo, too — *almost always when he got too rough with his small sister . . .*" (my italics)

Finally, our current research on the isolation calls, in conjunction with the findings of Ploog, Jürgens and others, indicates that the limbic cortex at the rostral end of the *great arc* is essential for the spontaneous production of the isolation

call. Before further comment, one should call attention to the common assumption that all four-footed vertebrates vocalize. But most notably lizards provide examples of tetrapods deficient in this respect. In the case of animals that cannibalize their young it is evident that it would be counterproductive for the offspring to call attention to themselves by vocalization. In regard to the therapsids, it would be important to know whether they were capable of audiovocal communication or whether they were mute like most of existing lizards. At least they had not achieved the improved hearing of mammals; two small bones of the jaw joint (the articular and quadrate) were becoming smaller, but they had not yet migrated to become the malleus and incus of the mammalian middle ear. Many authorities believe that the earliest mammals lived in the dark floor of the forest and may have been nocturnal. Under such conditions it is evident that audiovocal communication would greatly help to assure contact between mother and offspring. For a suckling any prolonged separation would be calamitous. Because of such considerations it is quite probable that the isolation call is the most primitive and basic of mammalian vocalizations.

All mammals thus far examined emit a separation call. Possibly as a protection against predators, the isolation calls of many small mammals are ultrasonic. In regard to primates, my colleague John Newman has observed that the cry patterns of a wide range of species share the basic pattern of a slowly changing tone (Fig. 3). "This widespread similarity," he points out, "suggests that mechanisms controlling infant cry patterns have had a conservative evolutionary history." Our experiments pertaining to such cry patterns have been performed on squirrel monkeys in which the isolation calls of two main subspecies have distinctive features. By the age of one year the separation calls of individual animals become almost as distinctive as a fingerprint. The initial results indicate that monkeys without the limbic cortex in the rostral part of the *great arc* fail to emit spontaneous isolation calls.

Comparative studies of this kind attest to the importance of learning as much as possible about the behavior of existing animals in trying to piece together the picture of evolution as reflected in fossil remains. Miguel Schön has adduced evidence that in locomotion, *Aegyptopithecus* (a pivotal link in the evolution of primates) may have been more like living New World Ceboids than Old World monkeys. A better understanding of the skeletomuscular system and vocal mechanisms of living forms may eventually make it possible to obtain clues regarding the nature of vocalization in extinct animals. Our knowledge of the vocalizations of the great apes has been greatly extended by the field observations of Jane Goodall, Biruté Galdikas, and Dian Fossey, respectively, on the chimpanzee, the orangutan, and mountain gorilla. As is well known, it was L.S.B. Leakey who initially sparked the interest of these



Spectrograms of isolation (separation) calls of a squirrel monkey, a macaque, and a human infant. In primates such calls have the basic pattern of a slowly changing tone. (after Newman, in press)

workers in going into the field. Apropos of separation calls and human similarities, it is of special interest that among great apes, as well as many species of monkeys, cooing occurs between mother and infant as a recurring signal for assuring an acceptable distance of separation.

In monkeys, the rostral limbic cortex of the *great arc* is the only cortex in which electrical stimulation elicits vocalization (Ploog *et al.*). All such vocalization is interpreted as having an emotional overlay. Clinically, the same region has been implicated in emotional phonation of human beings. In this respect, it should be emphasized that the clinical study of limbic epilepsy provides the best evidence that the limbic system is involved in emotional experience and expression. At the beginning of an epileptic storm involving the limbic cortex, the mind lights up with one or more vivid emotional feelings. Based on numerous case studies, such feelings cover a broad spectrum ranging from intense fear to ecstasy.

As opposed to emotional phonation, the development of propositional speech depends on a quantum evolutionary jump from the limbic cortex to the neocortex. The neocortex mushrooms relatively late in evolution and reaches its greatest development in human beings. Phrased in terms of today's technology, the neocortex might be regarded as serving as an improved computer for learning to cope with happenings in the *external* environment. In this case learning provides the capacity to "unlearn" old tried-and-true ways of doing things and arriving at novel solutions. Had it not been for the parallel evolution of the prefrontal area, the neocortex might have developed as a coldly reasoning, heartless computer. In human beings, the rapid advancement from a low-brow Neanderthal skull to a high-brow Cro-Magnon skull (Fig. 4) attests to the presence of the mushrooming prefrontal cortex under-

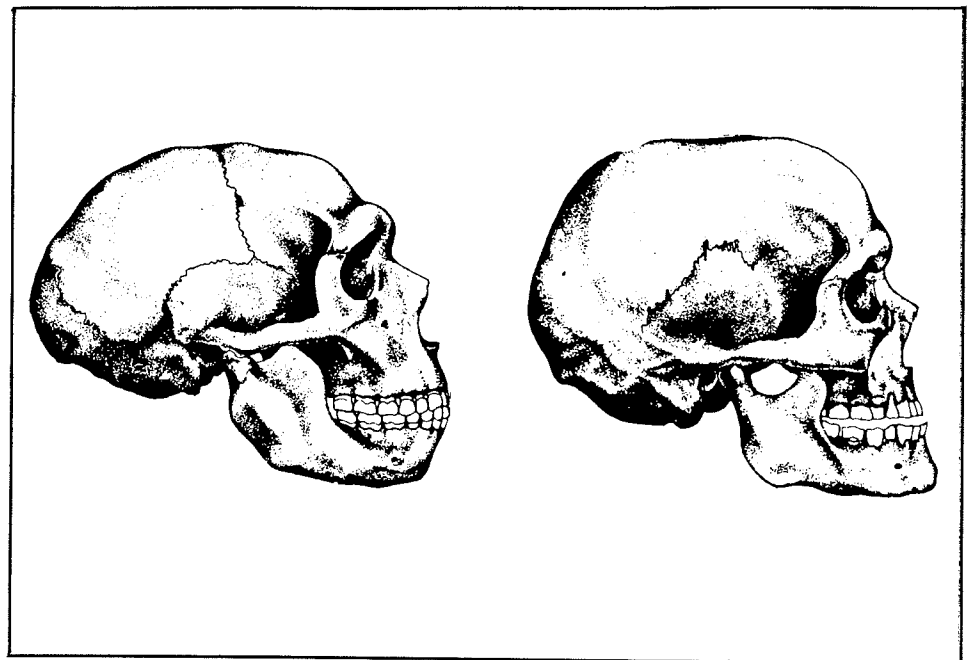
neath. Significantly, this prefrontal neocortex establishes a close relationship with limbic nuclei that project to the limbic cortex of the *great arc* involved in family related functions. Clinically, there is evidence that in human beings the prefrontal cortex affords the insight requisite for subjective identification with other beings. In addition, it has the singular capacity to conjoin past and present experience in anticipating and planning for the needs of others, as well as the self.

It may be imagined that, in the beginning, a parental concern for the young amounted to a sense of responsibility. Through the newly evolved structures related to the limbic cortex of the *great arc*, it would appear that a parental concern for the young eventually generalizes to other members of the species, a psychological development that amounts to a progression from a sense of responsibility to what we call conscience.

The exercise of conscience by small groups of adults in an effort to improve the quality of life in a community accounts for the foundations on which civilization is built. Often, the most successful groups become almost like families themselves. Anyone joining the group of workers in the Leakey Foundation soon discovers a warmth like that of belonging to a family. Not long after I joined the committee reviewing grant applications, I learned through attached letters addressed to Mary Pechanec that such feelings extended to grantees as well. I was struck by the number of these letters that began "Dear Mary." This first-naming was no affectation. Rather, it was plainly evident that the writers were addressing someone who they felt not only was conversant with all the practical aspects of their grants, but also had a sincere and knowledgeable interest in their particular research. Often they would

go into considerable detail about a particular finding or experience that they wanted to share with her. Particularly, in the letters coming from isolated and faraway places, the "Dear Mary" element seemed to acquire the tone of a family letter.

Many people in ancient times concurred with Aristotle that the mind (including the emotions) was located in the heart. We now know of course that they had things turned around — that both the mind and "heart" are in the brain, and, in line with what has been said, that the super-heart is represented at the very highest level. Robert Broom (1866–1951) is best known for collaboration with Raymond Dart in establishing *Australopithecus* as a legitimate human ancestor. He originally went from Australia to Africa, however, for the sole purpose of obtaining more information about the evolution of reptiles and the mammal-like reptiles (therapsids) leading to mammals. In a moment of optimism, he wrote: "If any intensive collecting is done in the next twenty or fifty years . . . we may then not only be able to trace the lines of evolution, but perhaps be able to see what has been the guiding or compelling force behind it all. . . Hundreds of thousands of pounds," he went on to say, "are spent investigating the mysteries of the milky way and the far distant nebulae, but a small fraction of this wealth spent in the further study of the Karroo Book of the Permian and Triassic History would probably yield results quite as important." Broom's projected fifty years have now gone by, but the challenge is more alive and promising than ever, waiting for the young-at-heart. Today there is renewed hope that dreams like those of Robert Broom can come true if there are institutions like the L.S.B. Leakey Foundation with the "Dear Mary" element represented in the super-heart. □



Contrasting profiles of Neanderthal and Cro-Magnon skulls. See text regarding suggested implications. (from Romer, 1966, and after McGregor)

GRANT SPOTLIGHT

The Grant program of the L.S.B. Leakey Foundation, under the guidance of the distinguished Science and Grants Committee, depends upon public support for its success. Every penny of your contribution dollar directly supports the grant awards. Members and donors are invited to designate their gifts in support of specific research projects.

Won't you take this opportunity to direct your contribution to the grant project of your choice?

Patty Shipman

\$3,300 needed

POSSIBLE BONE TOOLS FROM OLDUVAI: A RE-EVALUATION

The plan of research is to re-evaluate a collection of bones from Beds I & II at Olduvai which have been thought to have been tools. This collection will be compared with collections of bone from non-hominid sites to statistically determine if the Olduvai bones were broken by hominid activities. The second part of the study will focus on determining the function of bone tools by examination of working edges under electron scanning microscope.

Margaret J. Velte

\$1,315 needed

THORACOLUMBAR VARIATION IN FOSSIL HOMINOID VERTEBRAE

The purpose of this project is to provide a comparative and analytical description of all available fossil hominoid vertebrae, particularly those features related to erect posture and bipedal locomotion. Selected measurements have been taken from modern species and subjected to statistical techniques which are expected to disclose a set of morphological features indicative of locomotion. Further measurements will be taken from all available fossil hominoid vertebrae and compared with the data from existing species. The goal is to identify similarities and differences in morphological patterns that provide clues to phylogenetic and functional relationships between fossil and existing species and to establish the presence or absence of brachiation or

bipedalism. The analysis will represent the only comprehensive assessment of fossil hominoid vertebrae and may elucidate the evolutionary patterns of the hominid vertebral column related to bipedalism.

Seonbok Yi

\$4,500 needed

RESEARCH ON POTENTIAL LOWER PALEOLITHIC LOCI IN KOREA

The project will be divided into three phases, intensive survey, test excavation and analysis. Site survey will be made on four sites identified as being of Lower Paleolithic age. The site with the highest potential as a Lower Paleolithic locus will be test excavated. Artifacts collected will be taken to the Department of Archeology at Seoul National University and later to the Department of Anthropology at Arizona State. The main goal of research is the identification of indisputable Lower Paleolithic assemblages and the comparison of recovered artifacts with existing collections reflective of East Asian assemblage variations.

Terrence William Deacon

\$3,826 needed

NEURAL CONNECTIONS OF BROCA'S AREA HOMOLOGUE: A TRACER STUDY

In order to systematically identify the neural connections of the cortical areas in the monkey brain which are homologous to Broca's area in the human brain, a series of experiments involving the injection of tracer compounds is proposed. Tracers will be employed to investigate the neural inputs and outputs of the cortex of macaque monkeys (*Macaca fascicularis*). The topological position of parts of the monkey cortex to be studied are similar to those parts of the human brain, designated as Broca's area, which have been associated with the ability for language. The anatomical information provided by this approach should prove invaluable for expanding our present meager understanding of the neurological basis for language competence in general. It will, moreover, provide a crucial piece of evidence regarding the neurological reorganization which made possible the evolution of linguistic communication in hominids.

Shirley Strum

3,800 needed

HOW DOES A SAVANNA LIVING ANTHROPOID CHANGE FORAGING STRATEGIES

The proposed research will address specific questions raised concerning ongoing study of crop raiding behavior of savanna anthropoids. Crop raiding appears to be a time saving strategy. Research will focus on questions of what kind of time is saved, why time is saved and what advantages are gained for different social and troop contexts.

Geoffrey Grant Pope

\$2,000 needed

ATTENDANCE AT THE EAST ASIAN PALEOENVIRONMENTAL CONFERENCE

The January, 1983, conference will focus on the paleoenvironment of East Asia from the mid-Tertiary to the present, including topics related to the environmental (geological, paleontological and paleoclimatic) background of human evolution in this part of the world. Dr. Pope will be presenting a paper entitled "The Antiquity and the Paleoenvironment of the Earliest Asian Hominids". He speaks Chinese and has been a student of hominid evolution in Asia for the past ten years.

Robert C. Bailey &
Nadine R. Peacock

\$3,620 needed

QUANTITATIVE ANALYSIS OF THE BEHAVIORAL ECOLOGY OF EFE PYGMIES

Funds are requested in order to allow the applicants to analyze data recovered as part of a long term project on the health, nutrition, demography and behavioral ecology of the Efe pygmies and Lese agriculturalists in the Ituri Forest of Zaire. It is felt that this data will help test the relationships between significant socioecological variables including body composition, growth, food consumption, energy expenditure, fertility, mortality and sex differences in activities, work loads and contributions to subsistence which are of great importance in developing models of human evolution.

LATER QUATERNARY SEQUENCE IN NORTHERN TANZANIA

This support will enable Mr. Mehlman, a Ph.D. candidate at the University of Illinois, to complete the writing of his dissertation. His field research in Tanzania has been completed and also years of analysis in East Africa, Germany and the United States. The results will be a useful contribution to African prehistoric studies.

SCREENING OF ARCHDEACON OWEN'S DUMP AT MABOKO

Reconnaissance screening of sediment at Owen's Dump on Maboko Island in 1982 yielded a rich collection of primate fossils belonging to five taxa of hominoids and two of cercopithecoids plus associated fauna. Funds are required to screen the remaining 74 cubic meters of dump. Standard screening procedures are slow, labor intensive and expensive, but will yield a rich collection of specimens with lower cost than elsewhere in Kenya.

of the University Center for Studies in Namibia, has been awarded a Baldwin grant of \$1,450 for the collection and translation into English of the traditional literature of that country. Dr. Gordon and his colleagues expect to enlist Namibian students to systematically collect indigenous poetry from their home areas.

Silvana Condemi \$3,000 needed

THE RELATIONSHIPS BETWEEN THE SACCOPISTORE FOSSILS AND THE NEANDERTHAL REMAINS

The first part of this research by a Ph.D. candidate will involve identification of characteristics which are shared among the Neanderthal fossils, those which separate the Saccopistore fossils morphologically, and those which represent individual variations. Next, the Saccopistore fossils will be compared with other European Wurmian Neanderthals to establish the range of shared characteristics based on statistical measures of association. The final part of the study will entail comparison of the Saccopistore fossils with fossil material from the Near East. Funds are requested for travel to collections in Europe and Israel.

BALDWIN GRANTS AWARDED

The Franklin Mosher Baldwin Fellowships, instituted in 1977, provide funds for the Third World that are available from very few other sources.

The following Baldwin Fellowships were recently awarded:

Cecile Mourer-Chauvire \$3,000 needed

SYSTEMICS OF FOSSIL BIRDS OF EAST AFRICAN EARLY MAN SITES

The proposed research is part of the study of fossil birds from early man sites in the Hadar and Omo areas of Ethiopia and Olduvai Gorge of Tanzania. The collection representing fossils spanning nearly four million years is housed at the Department of Zoology, University of Florida, Gainesville, where there is also an excellent comparative skeletal collection. The Olduvai birds are currently being studied by Dr. Pierce Brodkorb and Diana Matthiesen, a Leakey grantee. While Ms. Matthiesen is concentrating on the passerines (doves and pigeons), Dr. Mourer-Chauvire proposes to share the work of identifying the non-passerine material.

Francis Musonda,

a Ph.D. candidate at the University of California, Berkeley, has been given a Baldwin grant of \$4,500 to continue his research on cultural materials collected from excavations in central Zambia. He plans to submit his thesis for June, 1983, graduation.

Earthwatch,

the Massachusetts organization which sponsors research abroad, will receive \$4,000 to recruit, train and employ young Africans in Earthwatch research projects. The goal is to involve members of local communities in research in their own countries. One such project is already jointly funded by the Leakey Foundation and Earthwatch (Dr. Dan Stiles).

GRANT GUIDELINES

The L.S.B. Leakey Foundation supports studies relative to human evolution. Priority is given to research into environments, archeology and human paleontology of the Miocene, Pliocene and Pleistocene, into the behavior of the Great Apes and other Old World primate species, and into the ecology and adaptations of living hunting-gatherer peoples. Those wishing to apply for a grant outside the immediate areas of interest of the Foundation are advised to submit a two-page proposal stating succinctly the aim of the project and the methods to be employed.

Grants are normally made to scientists with professional qualifications and demonstrated capability. Applications from graduate students working for an advanced degree will be considered if accompanied by a letter from their faculty adviser or similar appropriate sponsor. The average award is \$4,000.

The Franklin Mosher Baldwin Fellowships for the Study of Early Man in Africa permit the Foundation to offer three or more fellowships each year to support African field studies for African archeologists or graduate-study fellowships in the U.S. American specialists are awarded fellowships to conduct field research on African sites in cooperation with African scientists. Senior and postdoctoral researchers are encouraged to apply. It is anticipated that the maximum grant will be \$8,000.

For further information and application forms, contact the Leakey Foundation, Foundation Center 13-83, Pasadena, CA 91125. Application deadlines are May 15, Sept. 15, and Jan. 15, annually. Applicants wishing their proposals to be considered at the Foundation's Annual Meeting are advised of the special deadline of Aug. 1.

FIELD REPORTS

Excerpts from reports by Leakey Foundation grantees on their work in progress.

ARCHEOLOGICAL AND PALEOENVIRONMENTAL RESEARCH IN NORTHERN SOMALIA

Steven A. Brandt
Department of Anthropology
University of Georgia

Thanks in large part to grants from the L.S.B. Leakey and University of Georgia Research foundations, a team of scientists from the Somali Academy of Sciences and Arts and the University of Georgia conducted archeological and paleoenvironmental research in northeastern Somalia from February through March 1982. The two main objectives of the project were to provide the first radiometrically dated paleoenvironmental and prehistoric archeological sequence for Somalia and also field training for Somalis in modern archeological and geomorphological methods.

Soon after our arrival in Mogadishu the team departed for the north and after five hot, dusty days of driving arrived at the fishing village of Las Koreh on the Gulf of Aden coast. The geomorphology team, composed of Drs. G.A. Brook, D. Brook and J. Davis of the Department of Geography, University of Georgia, began a survey of the coastal region and neighboring foothills, collecting data relevant for the reconstruction of regional paleoenvironments. This included datable coral and shell from three prominent raised beaches, evidence for "togga" (seasonal river valley or wadi) aggradation, and cave speleothem (stalactite and stalagmite) samples from which a pollen sequence and a relative temperature curve could be constructed.

The archeological team, which included Hussein Suleiman Ahmed of the Somali Academy and M.S. Brandt, T. Gresham and myself from the Department of Anthropology, University of Georgia, conducted a test excavation of a large cave first discovered in 1980 in the coastal foothills south of Las Koreh. Gud-Gud Cave (the "cave of caves") is situated about 50m above Togga Kal Adoti, one of the many seasonal rivers that dissect the limestone highlands of northern Somalia. A single test trench uncovered a thin occupation horizon of probably Later Stone Age artifacts, faunal remains and charcoal near the base. This horizon should provide a radiometric age for prehistoric occupation of the coastal foothills as well as data on paleoenvironments.

After conducting a survey of the terrain bordering Gud-Gud Cave, the archeological team traveled east to the village of Hidid where we test-excavated and traced the rock art of Karin Hagin ("Vigilance Pass"),

a large granite tor positioned at the foot of a natural pass leading into the neighboring mountains. Along the walls of one of the many shelters formed by the boulders of the tor are an extensive series of polychrome paintings.

The majority of the paintings are of long-horned humpless cattle but also depicted are human figures, goats and/or gazelles, at least one camel and other motifs painted in rust-red, cream and various shades of brown. Spanning at least two stylistic phases, the paintings' ages remain uncertain. However, judging from the absence of humped cattle as well as stylistic similarities with the prehistoric rock art of neighboring Ethiopia, they are probably of Neolithic (c. 5–2,000 B.P.) age.

A test excavation in the floor of the shelter revealed a microlithic Later Stone Age industry, haematite (probably used to make some of the paints), a small sample of faunal remains and charcoal, the age of which might give us a clue to the antiquity of the rock art.

At the end of February we moved our base of operations to the highland town of Erigavo where the research team was temporarily split into two groups. While one group conducted a detailed survey of the Medishe/Xamaas Valley northeast of Erigavo where in 1980 I discovered a series of caves with surface scatters of Middle Stone Age artifacts, the other group drove to northwestern Somalia where a few days were spent exploring various localities. This included a brief reconnaissance of the Plio-Pleistocene (Afar Series) volcanics and "lake deposits" north of Hargeisa where basalt samples were taken for K/Ar dating. Although evidence for an extensive Plio-Pleistocene lake or fossil/artifact-bearing localities was lacking, only three days could be spent in exploration and therefore considerably more time and effort is needed to gauge the paleoanthropological potential of this region.

A very brief survey of the eroded alluvium east of Sheikh resulted in the discovery of a chert cleaver and a number of Later Stone Age artifacts from the surface, but none were found *in situ*. One morning was also spent searching for the Acheulean site of Jilelo (first discussed by Setan-Karr in 1896) but no Early Stone Age artifacts were found.

After one week in northwestern Somalia we returned to Erigavo accompanied by Dr. Sune Johnson of the Swedish Museum of National Antiquities. Prior to reaching Erigavo we stopped to examine the gypsum cave of Godhardunneh where photographs were taken of the pecked camel engravings on the walls. The party also briefly visited the abandoned medieval town of Medina

which remains in good preservation and is worthy of future research.

Upon rejoining our colleagues in Medishe Valley, we spent the remainder of the field season excavating a promising cave and collecting additional tufa and speleothem samples. The upper deposits of Medishe Cave Number 2 encompassed a stone artifact industry that included both Later Stone Age artifacts (e.g., end scrapers, rare microliths, blades, blade cores) and Middle Stone Age elements (e.g., bifacially retouched points, Levallois points and cores), while the lower levels were restricted to Middle Stone Age assemblages. Faunal remains and charcoal were also recovered from most levels and we hope to get a series of radiocarbon ages from this important site.

On our last day in Medishe, the villagers joined us in celebrating the successful completion of our field project. We feasted on goat stew, rice and cabbage, and following the meal we adjourned to watch the villagers perform a series of traditional dances. As I watched the women clapping their hands and loudly yodeling while the men sang and twirled in unison, I thought how friendly and supportive the Somali Academy and Somali people had been towards our work. I was already looking forward to returning to this land which holds such great promise for shedding new light on the prehistory of Eastern Africa.

EARLY EAST AFRICAN PASTORALISM

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The aim of this study was to get an idea of the ages at which domestic animals were normally slaughtered by prehistoric pastoralists. Modern pastoral stock owners make very specific decisions about when to slaughter individual animals that produce the intended patterns of age and sex composition in their herds. Among East African cattle owners the emphasis is on milk production and all but a few males are culled out of the herds before they fully mature. The remains of such culled animals thus represent the "fallout" of an intentional herd management strategy, which modern studies indicate is finely tuned to local ecological and economic circumstances. Since age can be estimated from tooth eruption and wear stages, archeologists can use the animal dentitions from prehistoric sites to reconstruct slaughtering patterns, and from this estimate the type of herd constitution early pastoralists were seeking to create. These findings can be compared with modern data to assess whether there have been continuities or changes in herd management patterns.

The site of Narosura is typical of most so-called "Pastoral Neolithic" sites in south-central Kenya and northern Tanzania, in that it yielded plentiful small

flaked stone tools, including many geometric microliths, numerous ground stone vessels, and various types of decorated and undecorated ceramics. It was excavated in the late 1960s by Dr. Knut Odner of Norway; he interpreted it as an extensive settlement of pastoralists who might also have cultivated land along the banks of the Narosura River, as do the local Maasai people today. Its faunal assemblage is dominated by sheep, goats, and cattle, but also contains sparse remains of wild animals. It also includes the oldest remains of donkey (*Equus asinus*) thus far documented in East Africa, a fact corroborated by both Michael Gramly, who did a preliminary analysis of the site's fauna, and myself.

The present project revealed several interesting points about the cattle and caprines (sheep and goats). We were able to demonstrate that the very similar first and second upper molars of cattle can reliably be distinguished by a ratio of molar length over width.

We also noted that Narosura cattle teeth were generally much bigger than are modern Maasai cattle, reflecting larger size of animals two millenia ago. This pattern has been observed consistently by me and by Fiona Marshall at other early pastoral sites as well. How to explain this substan-

tial size difference, which includes a few animals as large as African buffalo, remains open. One possible explanation is that grazing conditions then were more favorable than they are today for cattle, or that overall life conditions (including livestock diseases) permitted larger achieved size. Obviously, another point to consider is the genetic stock or breed of the prehistoric versus the modern cattle. We are as yet unsure of what breed these cattle were, although one horn core from the site was of a short-horn variety thought to have derived, ultimately, from North Africa and/or the Near East.

Analysis of the age-specific mortality structure of the cattle revealed a peak of deaths between one and two years of age. This may reflect preferential slaughtering of male calves as they reach this age span, which is prior to both maximum weight gain and sexual maturity. Such a pattern of slaughtering is generally typical of dairy pastoralists, who favor survival of milk-producing females by removing males at an early age.

It is probable that the youngest age class among both cattle and caprines is under-represented. The delicate bones and milk teeth of very young animals are easily reduced to unidentifiable fragments.

The age-specific mortality structure of

sheep and goats also reflects a peak in deaths between six and eighteen months. This kind of mortality profile is virtually identical to those resulting from modern pastoralists' culling of males as they reach a substantial body weight. Males over eighteen to twenty months constitute only one to three percent of the adults in most African pastoralists' flocks of sheep and goats. Since males make up roughly 50 percent of each birth cohort, the adult flock composition reflects drastic reduction of each male cohort by slaughtering.

In sum, the Narosura dental sample has yielded interesting information on prehistoric slaughtering practices, which can be compared both to other prehistoric samples and to modern data on pastoralists' herd composition. A publication on these findings, as well as a summary article on analyses of other early pastoralist faunal assemblages, is now in preparation.

Funding by the Leakey Foundation has supported baseline research in this area, which I now will enlarge upon with samples from more early pastoral sites, in a research project supported by a large grant from the National Science Foundation. Thus, the Leakey Foundation grant supported both the ending of one research program and the beginning of another. □

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BOOKS FOR THE HOLIDAYS

The following books, some of which are new listings, may be ordered from the L.S.B. Leakey Foundation. The price in parenthesis is that for members. All prices include tax and mailing costs.

THE HUMAN EVOLUTION COLORING BOOK, by Adrienne Zihlman, 1982, 360 pp., \$10.35 (\$8.45).

This is a coloring book on human origins and related evolutionary processes. An authoritative, visual presentation by highly respected anthropologist Dr. Adrienne Zihlman, it is especially fitting for students of anthropology, paleontology, comparative anatomy and genetics. Due to the highly developed and unique coloring concept, the information within these covers can be assimilated by anyone seeking an understanding of the subject. The most recent evidence of human evolution, from molecules to footprints, is graphically portrayed. You will find coloring this book an enjoyable way to unravel the evidence of our origins and evolution — for age ten and older.

MISSING LINKS, by John Reader, 1981, 243 pp., \$22.24 (\$20.24).

Since Darwin proposed the theory of evolution, we have been intrigued by hunting for the missing link. Dr. Reader's superb account takes us back to the discovery of Neanderthal Man in Europe in 1857 and quickly covers all the other finds in East Africa and the Far East to the 1978 discovery of 3.6 million year old footprints by Mary Leakey.

LUCY: THE BEGINNING OF HUMAN-KIND, by Donald Johanson and Maitland Edey, 1981, 385 pp., \$18.75 (\$17.00).

With the suspense and intrigue of a fast-paced adventure novel, filled with lively scientific detail, this renowned book unfolds the extraordinary story of Johanson's discovery of "Lucy" — the oldest, most complete and best preserved skeleton ever found of an erect-walking human ancestor. It reveals the controversial change Lucy has made in our view of human origins and

provides a vivid account of the history of paleoanthropology and the colorful characters who were and are a part of it.

THE MAASAI, by Tepilit Ole Saitoti and Carol Beckwith, 1980, 276 pp., \$44.00 (\$39.85).

A handsome people of East Africa are here documented in a handsome book. Each chapter of the vigorous and intimate text is illustrated with line drawings and stunning color photos. The result is a truly beautiful experience for the mind and eye.

TOUCHED BY AFRICA, by Ned Munger, 1982, \$12.50 if payment enclosed with order, \$14.00 if you wish to be billed later. (Dr. Munger will donate \$3 per copy to the Leakey Foundation).

Dr. Munger, president of the L.S.B. Leakey Foundation and a professor of African politics at Caltech, has written a candid, revealing and engaging memoir of twenty-six friends who enriched his lengthy experience in Africa. Jane Goodall, Dian Fossey, Biruté Galdikas and Ole Saitoti are among them, as are Alan Paton and Max Delbrück.

EVOLUTIONARY BIOLOGY OF THE NEW WORLD MONKEYS AND CONTINENTAL DRIFT, edited by R.L. Ciochon and A.B. Chiarelli, 1980, 560 pp., \$53.30 (\$48.40), special order.

This volume examines critical questions concerning the early evolution and differentiation of the anthropoid primates — monkeys, apes and humans — by focusing specifically on the origin and dispersal of the New World monkeys of South America. Twenty-nine scientists from the fields of anatomy, anthropology, biochemistry, biology, geology, geophysics and paleontology contribute their expertise to the resolution of two related questions: (1) What is the phylogenetic history of New World monkeys and is their well-documented similarity to monkeys and apes of the Old World the result of parallel evolution or relatively recent common ancestry? (2) Did the ancestors of New World monkeys reach the island continent

of South America from a source of origin in North America or Africa and was this dispersal event accomplished by island-hopping, rafting or by plate tectonic movement?

NEW INTERPRETATIONS OF APE AND HUMAN ANCESTRY, edited by R.L. Ciochon and Robert S. Corruccini, 1982, 840 pp., special order.

Here is a synthesis of the latest facts, theories and opinions concerning our human lineage, our evolutionary relationship to African and Asian great apes and the hominids of the Miocene. The thirty-seven contributors also consider a variety of related subjects in their analyses.

OPTIMISM, THE BIOLOGY OF HOPE, by Lionel Tiger, 1979, 284 pp., \$5.88 (\$5.38), paperback.

Lionel Tiger explores the biological aspects of ideas and moods, of will and religious impulse, of familial feelings and friendships, and of survival itself. He explains how we can use the brain's built-in "feel good" receptors and hormones to alleviate severe depression. He describes how our notion of "survival of the fittest" depends on optimism.

EVER SINCE DARWIN, by Stephen Jay Gould, 1977, 271 pp., \$14.95 (\$13.30).

Stephen Jay Gould leads us through such varied subjects as the Cambrian population explosion, Velikovsky's theories, why there is no such thing as "criminal man", and why the principles of size and shape dictate that a three year-old is likely to land unhurt after a fall.

THE MISMEASURE OF MAN, by Stephen Jay Gould, 1981, 336 pp., \$16.71 (\$15.22).

The notion of intelligence as a single thing called IQ, located somewhere within the brain, has become one of the most powerful ideas of modern life. This manner of measuring intelligence pigeonholes us all. The book exposes the fatal flaw in this theory by telling the story of its growth and reanalyzing the data. □



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