ANTHROQUEST

news of human origins, behavior and survival

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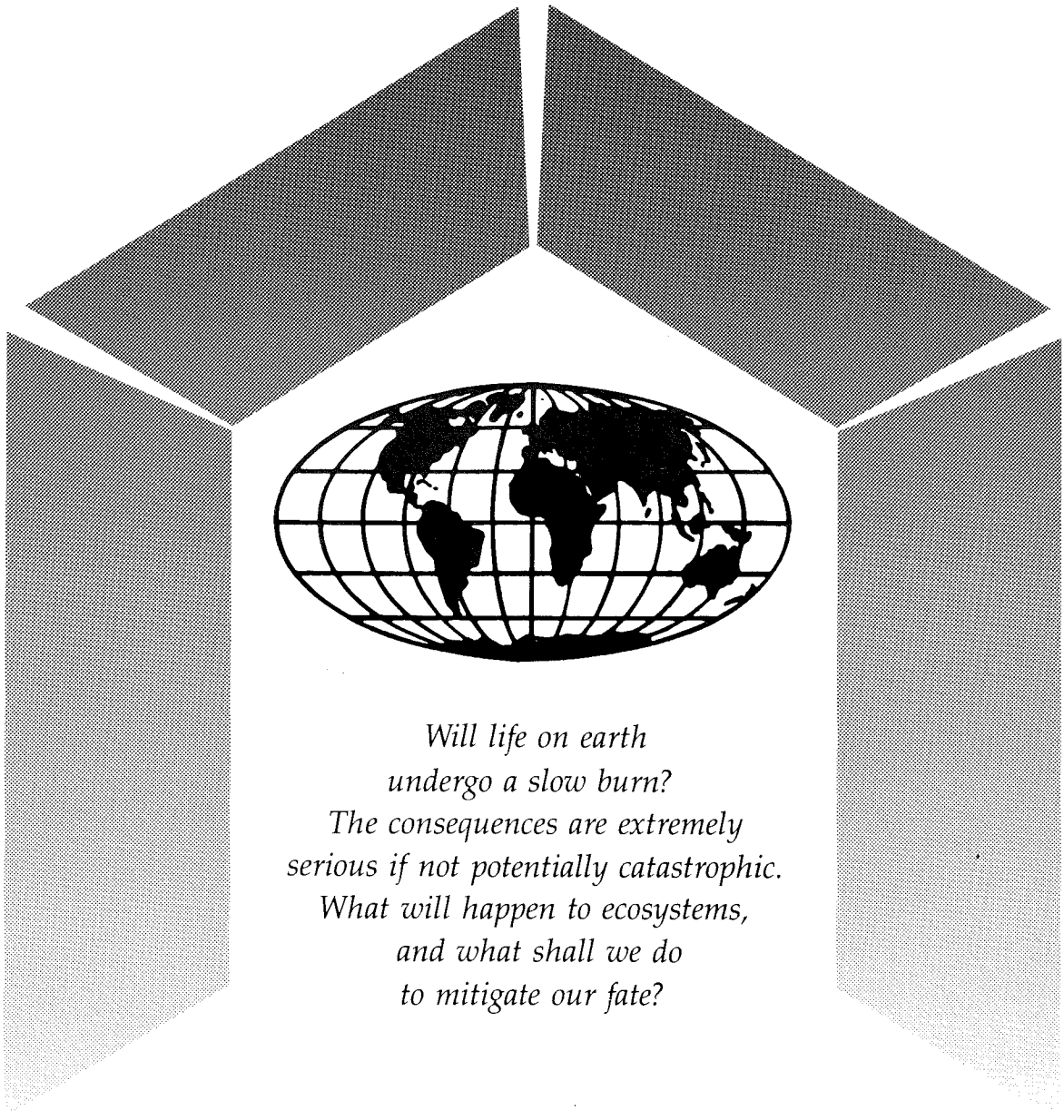

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CLIMATE CHANGE. . . A SLOW BURN

David M. Gates
Department of Botany, University of Michigan

THE L.S.B. LEAKEY FOUNDATION NEWS

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PRESIDENT'S MESSAGE

Dear Fellows and Members of the Leakey Foundation:

With this issue of AnthroQuest, we renew our commitment to the Foundation membership and other readers.

By publishing these scientific papers, we encourage interest and reach a larger audience. Much of the work reported is supported in some measure by generous donations from the Grant Program, and these articles are representative of endeavors worldwide in scope where new ground is being broken.

Currently, the Foundation is involved in a number of different research fields, each of them a step on the ladder toward a better understanding of "How we came to be who we are." By sharing information, we help bring pieces of the puzzle together. Overall, we hope to focus added light for a clearer view of the past and possibly sharpen our vision of the future. With your help, the search can continue and the Foundation can be stronger.

Thank you.

Mason Phelps

BOOKS

The following is a list of books of possible interest to AnthroQuest readers. While they are not sold by or available through the Leakey Foundation office, they can be ordered from local or specialty bookstores.

THE PRACTICAL ARCHEOLOGIST: How We Know What We Know About the Past by Jane McIntosh. Facts on File, New York, 1988. Illustrated. $12.95 paper.

Here is a useful introduction to archeology combining a wealth of background information with a practical guide to present-day techniques. The book covers everything from how archeology evolved to modern methods of interpretation.

HIMALAYAS by B.C. Olschak, A. Gansser and A. Gruschke. Facts on File, New York, 1988. pp 288, illustrated. $40.

This well-illustrated volume offers a full appreciation of the world's greatest mountain range from its geological origins and history to the mythology and cultures it has shaped. It includes nearly 350 illustrations, among them 17 maps and 297 full-color photographs.

THE SAVAGE AND THE INNOCENT by David Maybury-Lewis. Beacon Press, Boston, MA, 1988. $11.95 paper.

Back in print after nearly ten years, this pioneer work is the story of one courageous anthropologist's attempt to discover through field work the values and customs of two specific tribes in Brazil. The work was first published in 1965. In his new epilogue, Maybury-Lewis revisits the two tribes twenty years later to paint a sad and moving picture of the impact of civilization on traditional cultures.

THE HUMAN ENTERPRISE: A Critical Introduction to Anthropological Theory by James Lett. Westview Press, Boulder, CO, 1987. pp 178. $29.50.

A wide-ranging and well-integrated analysis of contemporary anthropological theory is covered. The author's aim is to encourage students to think critically about the nature of theory itself. The thought-provoking text is a useful addition to courses on anthropology.

CLIMATE CHANGE. . . A SLOW BURN

David M. Gates
Department of Botany, University of Michigan

It is possible that climatic and temperature changes in the past were a stimulus to human evolution as well as that of numerous other organisms. Today and for the foreseeable future the world is in a warming trend. Will life on earth undergo a slow burn? The consequences are extremely serious if not potentially catastrophic. What will happen to ecosystems, and what shall we do to mitigate our fate?

Never before has our planet been occupied by an animal as consumptive as *Homo sapiens* is of energy and material resources. The current global population of nearly five billion is projected to eventually exceed ten billion. Hundreds of millions of years ago, Paleozoic seas sequestered in their bottom muds immense amounts of carbon which, under intense pressure and heat, formed reservoirs of coal, oil and gas. Carbon was slowly removed from the early atmosphere through photosynthesis by green plants. However, civilized societies found they could warm the stove and power machinery by burning these earthbound fuels. We have continued to do so at an ever-increasing rate. This process of burning combines oxygen with carbon to form carbon dioxide, a gas that seems clean, clear and inocuous enough, so why the concern?

Carbon dioxide, CO_2, is a "greenhouse" gas that has a special property. It is transparent to sunlight but partly opaque to infrared radiation, the heat we radiate from our bodies, our furnaces and, indeed, from all surfaces, including that of the earth itself. The surface temperature of the earth is in energy balance between the strength of the incoming sunlight absorbed at the ground and the outgoing flow of infrared radiant heat escaping to the cold of space. If we interfere with either of these streams of energy, then we disturb the equilibrium of the energy balance. Volcanic dust ejected to great heights into the stratosphere might reflect sunlight back to space and produce cooler temperatures. Or, if the brightness of the sun should increase or decrease, it would drive the earth's temperature up or down, respectively. Some researchers have suggested that the vapor trails laid across the sky by high-flying jet aircraft are generating veils of cirrus clouds that persist to reflect sunlight and thereby cool the atmosphere. But, the most insidious of all contaminants of the atmosphere are those unseen greenhouse gases of which carbon dioxide is the most significant but by no means the only one.

The concentration of CO_2 in the atmosphere is small, yet it's a powerful regulator of the earth's energy balance temperature. Measured in parts per million, the concentration of this greenhouse gas is going up each year and has increased by at least 29 percent since pre-industrial times.

The world's energy consumption has risen at a greater rate than the population growth rate which today is around 1.9 percent annually. At this pace, the global population will double in 36 years, and whether energy consumption will race ahead even more rapidly is an important question. Conservative estimates indicate that the CO_2 concentration in the atmosphere will be double that of the pre-industrial level by the third quarter of the 21st century. The climatic changes to be expected with a doubling of carbon dioxide concentration are troubling; the gas may remain suspended in the sky for more than a hundred years. The primary agent in removing CO_2 from the atmosphere is through assimilation by microscopic algae in the ocean – foraminifera – whose skeletal bodies slowly sink to form sediments on the ocean bottom. While green plants on the land absorb CO_2 by photosynthesis, they then respire it back to the atmosphere having used it in the process of building new branches and root material. But, eventually all leaves, branches and roots decay and return CO_2 to the air. Furthermore, humans are destroying vegetation at an alarming rate, particularly the tropical forests, and the resultant plant decay adds more CO_2 to the atmosphere.

Fossil fuel burning and cement production produces billions of metric tons of carbon emissions each year. Of the total estimated amount of CO_2 released, about a half is diffused into the ocean and the rest remains in the atmosphere.

Climate may be considered as a type of weather experienced over a period averaging some thirty years or more. As for the world's climate, it is not random but rather an organized state driven by external and internal forces with some random factors superimposed. Solar radiation, water vapor, carbon dioxide and other trace gases, aerosols and even surface vegetation are all considered external factors that cause climatic change. There are linkages within the atmosphere-ocean system such as ocean currents and wind patterns, the amount of snow or ice or even soil moisture – each is considered an internal factor. The result of these interactions is that the climate is erratic and varies greatly from month to month, year to year or even week to week. Our task is to detect climatic trends against this background.

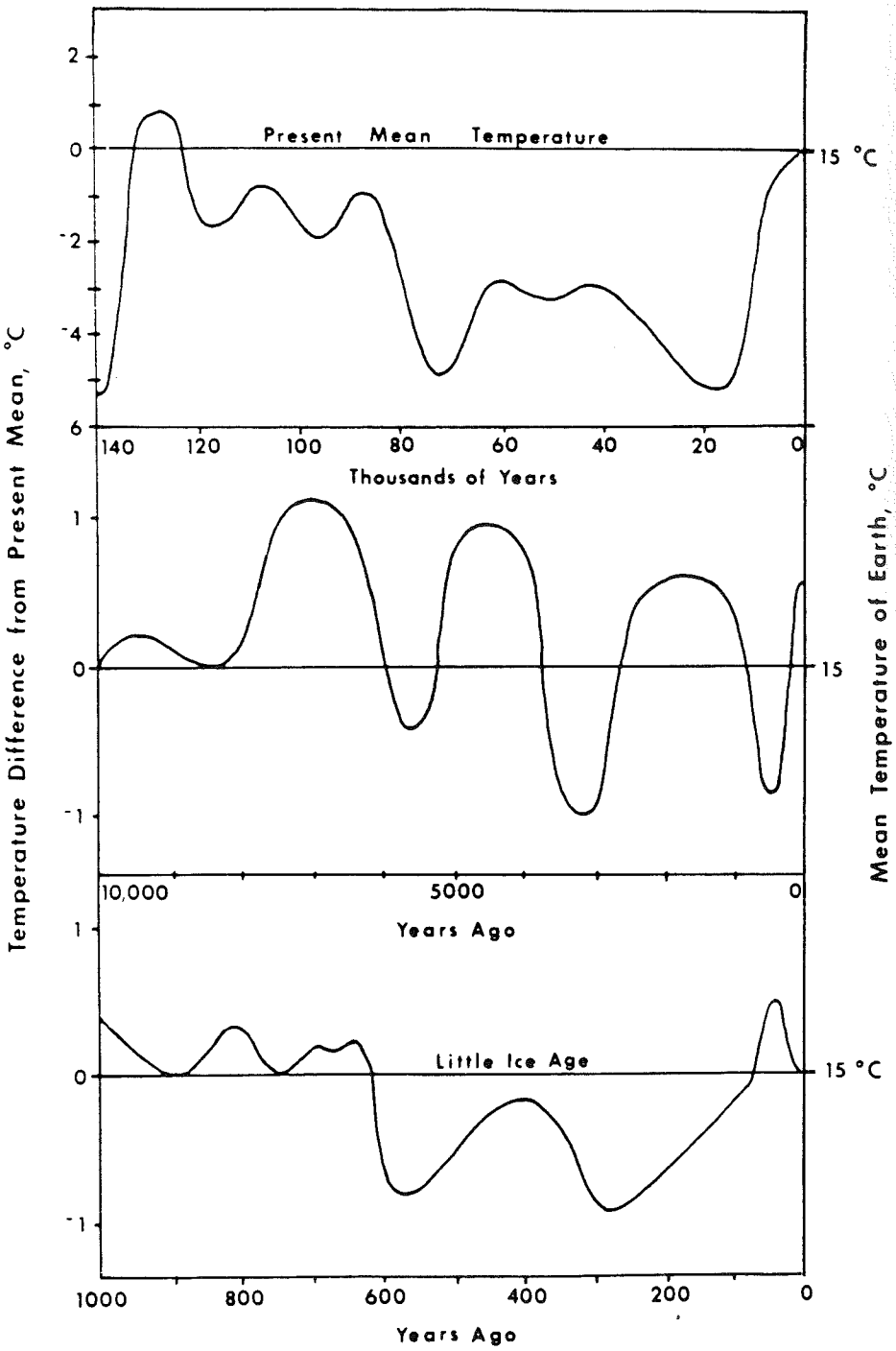
Large computers programmed to model the world's past and present climates provide a useful tool with which to examine a wide range of global conditions. The models enable scientists to compute the heat budget of the earth and the distribution of temperature and precipitation in response to changes. These include variations in solar radiation or the amount of carbon dioxide and other greenhouse gases as well as the volume of dust in the atmosphere. In addition to simulating climate conditions of the distant past, models are used to project the future circumstances. For example, by means of Global Circulation Models (GCMs), specialists are simulating the

variations in the earth's energy budget to learn the kind of response that will occur to possible changes of the content of CO_2 in the atmosphere. They find that the mean global surface air temperature may increase from two to four degrees Centigrade with a doubling of carbon dioxide. The consensus is that the most probable temperature rise will be about 3°C over a period of ninety years or at a rate of increase of 0.3°C per decade. However, the modelling shows the temperature changes expected at high latitudes to be as much as 6° - 8°C and at low latitudes only 1° to 2°C in the next century.

It is the temperature and pressure differences between the warm equator and the cold poles that drives atmospheric circulation. If temperature increases in polar regions are greater than those in equatorial zones, then the temperature difference between equatorial latitudes and polar regions is reduced – and the dynamics of the global circulation is weakened. This means that moisture evaporated from the oceans will not be transported as readily to the interiors of the continents as it is now with a cooler world – even though there will be more water evaporated from the future warmer oceans. In fact, while the models show global precipitation to increase with the warming conditions, most of the moisture is then dropped along coastlines and does not reach the interior. This is a serious implication for the great grain growing regions of the world such as the interiors of the United States and Eurasia.

Is an increase in the mean global surface air temperature of 3°C really significant – or is it trivial? A look at the past record provides some clues. During much of earth's history, temperatures were decidedly warmer than at present. Seventy million years ago, the temperatures may have been as much as 7° to 10°C warmer than now. Around thirty million years ago, they appear to have declined quite quickly (in terms of geological time scales) to about 2° to 3°C above the current means. Of course, our ability to reconstruct the record so far back in time is poor; we can only infer relative values.

During the past million years, conditions were often 4° to 5°C cooler



Temperatures of the past shown as deviations from the present global mean value as a function of years before the present time.

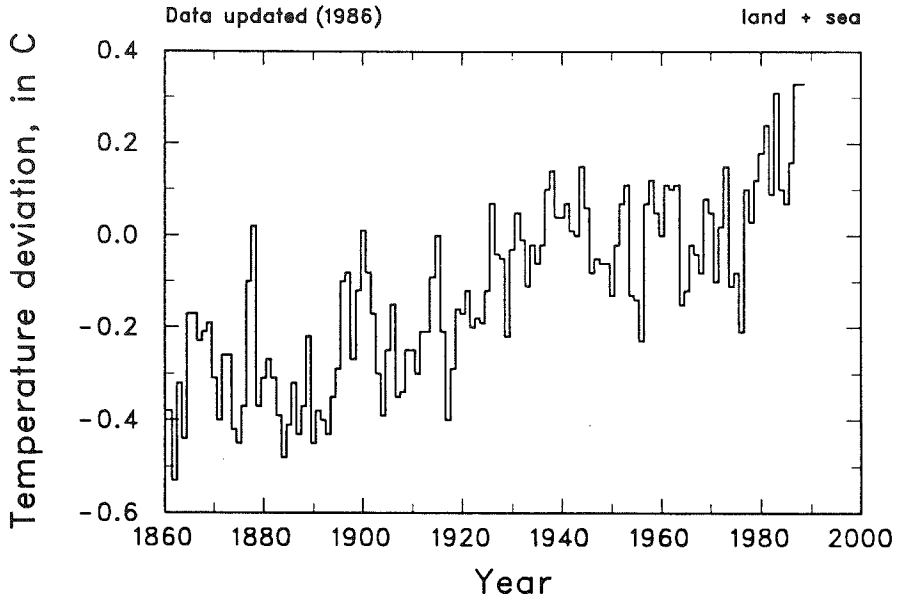
than now. There were brief warm intervals around 325,000 and 110,000 years ago. Then, between 4000 and 8000 years ago – a time known as the hypsithermal or altithermal period – a global warm-up occurred that was above the present mean value by 1° to 1.5°C. This was followed by a cold time until about 2500 years ago when another warm interval preceded the Little Ice Age which began about 650 years ago. During this period of hospitable climate, Europeans had settlements in Greenland and then had to abandon them when the sea ice advanced. The Little Ice Age brought suffering in the form of famines and great privation through repeated failures of grain and vine growth. The Little Ice Age persisted until in the 20th century it finally became apparent that the world might be on a warming trend.

In 1938, G.S. Callendar published a theory in England to explain the warming. He suggested that the concentration of carbon dioxide gas in the atmosphere might be producing a "greenhouse effect." Temperatures were then warmer than at any time during the previous 1000 years. Callendar further pointed to the burning of fossil fuels as a likely source of the increased CO_2. But, soon after he'd published his landmark paper, the world seemed to be cooling once again. This was no reason for believing that the hypothesis was wrong; in fact, a number of scientists throughout the world in the 1950s were making radiation balance calculations for the atmosphere and getting results similar to Callendar's.

Since then, high-capacity/high-speed computers have been employed to process an enormous volume of available temperature information for both land and sea as well as for many altitude levels in the atmosphere. Probably more than a hundred million data points have been included in the calculations which span the last 120 years of weather data (see temperature trend graph).

Studies of volcanic eruptions, also a mechanism for climate change, have only recently been accurately analyzed. Well-known is the fact that New England in 1916 was without a summer as temperatures plummeted following the eruption of the Tambora volcano in Indonesia in 1915. The Climate Research Unit at the University of East Anglia in Norwich, England, developed computer data showing that global temperatures dropped significantly following major eruptions. Small volcanoes do not have any discernible effect. Mt. Saint Helens in the USA was spectacular and did much local damage, but it put almost no ash into the stratosphere and the impact on climate was insignificant.

The stratosphere is a highly stable part of the atmosphere since it has a cold base and a warm top. Warm air is less dense than cold and will simply float. Very small particles ejected from volcanoes to these great heights drift around for many months or even years before settling out. The lower atmosphere, the troposphere, is different since it is highly turbulent and clouds form to wash the skies of dust during times of precipitation.



Global annual mean temperature variations since 1861.

The researchers in England made separate studies of the influence of northern hemisphere volcanoes and their effects - and southern hemisphere volcanoes. They found that conditions were indeed colder than normal during the first few months following the eruptions and that this prevailed for about 2½ years. After that, the apparent volcano influence disappeared. The impact on the northern hemisphere temperatures occurred within about three months whereas it took nearly a year for the effect to become significant on the southern hemisphere. Neither effect was of long duration.

The largest eruption since Tambora was probably the eruption in Mexico in 1983 when Mt. El Chichon ejected huge amounts of sulfur dioxide gas and particulates into the stratosphere. The cloud of debris was tracked around the world by satellite as it spread across both hemispheres from the equator to the poles. The expected global cooling was apparently delayed due to the strong El Nino current already in progress in the Pacific Ocean.

Sunspots, according to some scientists, are another candidate for changes in climate and temperature. A broad range of cycles of sunspot activity has been recorded, and as recently as 1985 NASA reported that photometric measurements made from satellites revealed solar luminosity to have been decreasing from about 1979 onward. The trend was confirmed when, in the following year, more data was published to show a continuing decrease in solar luminosity. The value - a significant change - amounted to about 0.03 percent every year. Few specialists believe that the solar luminosity will continue to decline and expect a reversal of the trend to show up soon. But, no one really knows; if the effect is real and the sun did decrease in luminosity during the past six or eight years, then the cooling effect on the earth's climate may have just compensated for a CO_2 induced warming over the same period of time.

Despite cold intervals and slight pauses, there has been an inexorable upward trend of the global mean temperature for the last twenty years. The 1980s have witnessed some of the all-time warmest temperatures ever on record. Modern temperatures are unusually warm - not only when compared with those recorded within historical times but even when compared to paleoclimate records covering a million years or more.

Not only does the record show a global temperature increase over the past century or more, but the mean temperature in each hemisphere has

been rising as well. The two hemispheres are quite different. The south is dominated by oceans and the north by land masses. The northern hemisphere experienced a cooling period from 1940-1975 while the southern hemisphere never changed from its pattern of gradual warming. The cooler north may have been a combined consequence of solar and volcanic activity.

The US National Oceanographic and Aeronautics Administration has reported data confirming that during the last quarter-century the surface and troposphere have warmed - and the tropopause layer and the low stratosphere have cooled in all parts of the world. The effects have been more pronounced in the southern than in the northern hemisphere.

Overall, the observed temperature changes are in general agreement with the pattern predicted from the GCM models; that is, warming of the troposphere and cooling of the low stratosphere - a greater warming of the northern hemisphere extratropics relative to the tropics and a greater surface warming in the cool season than in the warm season.

The serious problem is: what will happen to ecosystems and what shall we do to offset the warming trend?

Plants and animals respond relatively slowly to change. In fact, the dynamics of change have probably stimulated natural selection and aided species' diversity. But, the temperature and moisture changes about to explode across the world are seemingly far more rapid than anything experienced in the past with the possible exception of certain transient catastrophic events.

When the glaciers melted off North America, vegetation advanced northward, and pollen records from lakes and bogs give a good measure of the pace of progress by major tree species. American beech and hemlock, for example, moved north by 400km in 2000 years at a rate of 200m per year. The temperature shift expected during the next century will displace the mean isotherm by 300km in Georgia, 400km in central Ohio and 600km in central Michigan and Ontario. This is at least ten times more rapid than forests can be expected to move by the normal dispersal of seeds.

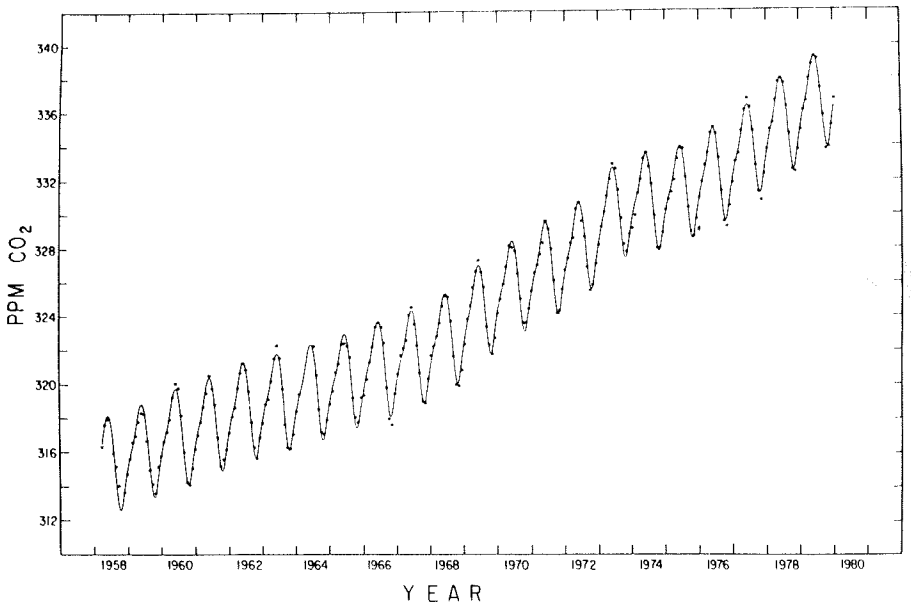
Similarly, modelling shows that the boreal forest in northern Europe will be displaced off that continent in the next one hundred years. Many endangered species will be obliterated since they exist in small, localized habitats and have no place to go as the climate becomes inhospitable. Human-made barriers of agriculture or paved urban corridors will block the displacement of many species. The world will slowly become impoverished.

Although plants will grow better with enriched CO_2 levels, with rising temperatures the rates of respiration will increase. In high latitudes, where temperature increases are expected to be the greatest, it is possible that a positive feedback will occur as respiration from tundra soils accelerates the atmospheric build-up of CO_2.

There's absolutely no doubt that the people of the world and the entire living system are in for immense trouble. It will arrive slowly and subtly, and as it becomes more obvious it will then be too late to avoid the worst.

Some obvious responses include: quit burning or vastly reduce the consumption of fossil fuels and reduce the production of other greenhouse gases adding to the problem. Chlorofluorocarbons, methane, sulfur dioxide, oxides of nitrogen and other compounds together are estimated to add an amount of warming equal to the effect of CO_2. We must initiate rigorous conservation measures. We should use solar and other renewable energy sources and accept nuclear energy as an absolute necessity.

Caught in an environmental vice between a greenhouse effect and radioactivity, the choices are clear. The future does not seem too promising, yet we are a species with a long past and I have the expectation that in some way we shall have the intelligence to meet this great challenge. ■



Increase of the atmospheric CO_2 concentration with time. Each year there is a maximum in the spring from plant respiration during the winter months and a minimum in the autumn from photosynthesis during the summer months.

GRANT SPOTLIGHT

The grant program, the major purpose 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.

Karega-Munene *$4,205 funded*

NEOLITHIC-IRON AGE SUBSISTENCE ECONOMIES IN EAST AFRICA

Karega-Munene's proposal is to open up excavations at the Gogo Falls site and to analyze the nature and development of pastoral economies in the later Stone Age and Iron Age through examination of the faunal data from this East African site.

Joseph Manson *$4,000 funded*

FEMALE MATE CHOICE IN FREE-RANGING RHESUS MACAQUES (MACACA MULATTA) AT CAYO SANTIAGO, PUERTO RICO

Joseph Manson's study will collect data to test hypotheses about the means and ends of female mate choice among free-ranging provisioned rhesus macaques at Cayo Santiago. High ranking males of multi-male groups might fail to monopolize fertile females in part because of female preferences for lower-ranking males. The study includes two mating seasons and one birth season over a 15-month period. Focal and ad lib observational techniques will be used to identify additional female mate preference signals and test the hypotheses that female preference is affected by male group tenure, birth season relationship, dominance rank and relative rank for age, etc.

David Helgren *$2,700 funded*

GEOARCHEOLOGICAL INVESTIGATIONS AT THE LOWER PALEOLITHIC SITES OF SENGA AND KATANDA, WESTERN RIFT VALLEY, ZAIRE

Dr. Helgren's research will focus on expanding stratigraphic studies at Senga to explicate the settlement terrain, stratigraphic studies at Katanda to link these sediments with other beds in the region, similar studies of recent alluvial fill networks in the upper Semliki region, and exploration of sediments elsewhere around Lake Rutanzige. Senga and Katanda are the most important artifact and fossil sites discovered along the Semliki River between Lake Rutanzige and Ruwenzori Massif and contain fossils of large mammals, fish and mollusks.

Steven Kuhn *$1,000 funded*

INVESTIGATION OF MOUSTERIAN RAW MATERIAL ECONOMY AT GROTTA BREUIL (LAZIO, ITALY)

Steven Kuhn will be participating in the first season of full-scale excavation at Grotta Breuil, a stratified late Middle/Upper Paleolithic cave site on Monte Circeo. Analyses will focus on variations in three main dimensions of the lithic technological system. The study is designed to complement research on fauna, lithic microwear and paleoenvironment being pursued simultaneously by other researchers working with materials from the site.

Christophe Boesch *$5,000 funded*

TRADITION IN WEST AFRICAN CHIMPANZEES

Dr. Boesch's project combines field workers and wild chimpanzees in various sites to conduct a scientific study. Using the same methods at the separate sites makes the data directly comparable. The major purpose is to find differences in the nutcracking behavior between forest chimpanzee populations in West Africa. Such differences could have three explanations: genetic, environmental or traditional. The first stage is collecting data on the chimpanzees, and the second is testing.

Andrew Moore *$3,000 funded*

AFRIN VALLEY PROJECT

Dr. Moore will investigate the beginning of agriculture in Southwest Asia and examine the ways of life of Epipaleolithic hunters and gatherers in Syria in order to find out how and why they became settled farmers. Excavation of the sites will permit him to establish an archeological sequence for the area, determine patterns of hunting and gathering pursued by Epipaleolithic groups, and study the influence of terminal Pleistocene environmental changes on their way of life.

Agbenyega Adedze *$8,500 funded*

NOTSE, TOGO: ECOLOGY, CRAFTS AND SUBSISTENCE

This on-going graduate work for the last phase of an MA degree involves taking courses in world archeology, museum studies and African art, having access to German ethnographic documentation on Togo and plans to do field research in Notse, Togo.

Gregory Laden *$5,000 funded*

ETHNOARCHEOLOGY AND ARCHEOLOGY OF THE EFE (PYGMIES), ITURI TROPICAL RAIN FOREST, EASTERN ZAIRE

Gregory Laden's subject is the continued ethnoarcheology of the Efe (Pygmies) of the Ituri Rain Forest, Zaire, and the prehistory of foraging in this area. Based on both archeological and botanical data, it is possible to characterize the present-day settlement and land-use patterns of the Efe as a combination of particular components that have probably been practiced for several generations.

Mary Stiner *$1,000 funded*

THE ROLE OF CAVE SITES IN THE FORAGING ADAPTATIONS OF MOUSTERIAN HOMINIDS OF WEST-CENTRAL ITALY: SEASONALITY AND TAPHONOMIC INVESTIGATION OF TWO MOUSTERIAN CAVE FAUNAS

Mary Stiner's study of faunal remains from two deeply stratified Mousterian cave sites in west-central Italy has two goals. The first is to compare patterns of bone modification that reflect how animal foods were obtained by Mousterian hominids, and the second will investigate seasonality in the use of animal foods at the cave sites.

Joseph Shayka *$4,000 funded*

GENE FLOW ANALYSIS OF A DYNAMIC HYBRID ZONE BETWEEN ANUBIS AND HAMADRYAS BABOONS IN ETHIOPIA

Joseph Shayka's aim is to monitor gene flow and the resulting genetic variation within and among three groups of baboons in a dynamic hybrid zone in Awash National Park.

Pia Nystrom *$1,000 funded*

SOCIAL AND FEEDING ECOLOGY OF ADULT MALES IN A HYBRID GROUP OF BABOONS IN THE AWASH NATIONAL PARK, ETHIOPIA

Pia Nystrom's long-term study on the Awash baboons focuses on the behavioral aspects of this expanding hybrid zone. It will examine social and ecological factors which potentially influence the outcome of competition between individual males. The presence of anubis, hamadryas and hybrid males in the same social group provides a unique opportunity to compare their behavioral patterns and foraging strategies when environmental conditions are held constant.

Marc Hauser *$3,000 funded*
Richard Wrangham

CONVERSATIONS AMONG KIBALE CHIMPANZEES

In September, 1987, Drs. Hauser and Wrangham began a detailed study of social behavior and communication among the Kanyawara community of Kibale Forest chimpanzees. One objective is to maintain key observations and test the hypothesis that "hoo" vocal exchanges between familiar chimpanzees constitute dialogues which assess each other's intentions. The study will contribute to understanding the nature and extent of chimpanzee communicative abilities - an important issue in understanding how and why complex mental processes evolved within the primate order.

Beverly Strassmann *$4,000 funded*

THE ECOLOGY OF POLYGYNY AMONG THE DOGON

Beverly Strassmann's project will study the Dogon millet farmers of Mali, West Africa, and focus primarily on the effect of polygyny on female genetic fitness. The aim is to better understand the selective factors that have led to and maintained polygynous marriage systems in humans as well as the functioning of female reproductive strategies in polygynous societies. It will gather quantitative information on female fertility and fecundability, nutritional status and mortality rates for determining the proximate mechanisms through which polygyny may influence female fitness.

Peter Andrews *$5,000 funded*

MIOCENE EXCAVATIONS AT PASALAR, TURKEY

Dr. Andrews will continue his studies of middle Miocene deposits at Pasalar in Turkey. Providing abundant fossil hominoids relating to great ape and human evolution, excavations will recover faunal and geological evidence as well as further hominoids. The geological context of the deposits will be defined by careful descriptions of the stratigraphy, and the fossils will be related to these in order to determine the manner in which they came to be deposited.

Ilse Kohler-Rollefson *$1,800 funded*

SMALL GAME HUNTING IN THE NEOLITHIC VILLAGE OF 'AIN GHAZAL, JORDAN

Dr. Kohler-Rollefson proposes a detailed study of the ca. 2,000 fragments of carnivore and hare remains by utilizing the comparative collection at the British Museum of Natural History. Analysis will focus on the establishment of the range of species represented; the documentation of skeletal representation, fragmentation and cultural modifications; metrical examination; aging and the establishment of culling patterns in the frequently represented species.

Randy Bellomo *$4,000 funded*

ACTUALISTIC STUDIES OF FIRE ON CONTEMPORARY AFRICAN LANDSCAPES

Randy Bellomo's research project will center on the collection of first-hand data on how the effects of campfires, tree stump fires and grass fires might be manifest physically - in terms of magnetic and mineralogical changes - and macroscopically in a range of sedimentary environments. The data will be compared with existing archeological data from investigations of suspected baked features at Koobi Fora in Northern Kenya to determine if evidence of fire can be scientifically demonstrated as early as 1.5 million years ago.

Craig S. Feibel *$1,000 funded*

STRATIGRAPHY, AGE AND PALEOENVIRONMENTS OF THE MIOCENE DEPOSITS OF MABOKO, KALOMA AND MAJIWA, WESTERN KENYA

Craig Feibel will undertake documentation of the stratigraphy, age and paleoenvironments of the Miocene deposits of Maboko, Majiwa and Kaloma, Western Kenya, in order to provide a context for current and future paleontological investigation of these prolific fossiliferous deposits. Reconstruction of the environments in which the fossils were deposited will form a basis for understanding the context in which the Miocene fauna developed.

Evelyn Vineberg *$2,238 funded*

A TRANSLATION OF THE LAST APE: PYGMY CHIMPANZEE BEHAVIOR AND ECOLOGY

Evelyn Vineberg's project involves a translation of Dr. Kano's book dealing with sexual behavior which promotes food-sharing and reduces tension between male and female pygmy chimpanzees. The work will make available to English-speaking scientists a complete body of research on the pygmy chimps.

Andrew Hill *$2,500 funded*

NEOGENE FOSSIL VERTEBRATES FROM THE UNITED ARAB EMIRATES: ABU DHABI

Dr. Hill's study is a follow-up to an earlier survey with controlled excavations. Vertebrate fossils have been retrieved from a number of sites along the coastal margin of the Western Province of the Emirate, and his earlier results suggest these are all of the same age. The research will document faunal assemblages from an interval of time crucial to understanding hominid and hominoid evolution, gather further information pertinent to understanding the nature and timing of the migration of mammalian species to and from Africa, and document paleoenvironmental conditions present on the periphery of the African continent which may have contributed to Africa standing alone as the cradle of humanity.

John Fleagle *$5,000 funded*

WORKSHOP AND SYMPOSIUM ON NEW WORLD MONKEY EVOLUTION

Dr. Fleagle held a workshop and symposium on the evolution of New World monkeys in July 1988 in conjunction with the XII Congress of the International Primatological Society in Brasilia, Brazil. The workshop brought together all the active workers of platyrrhine paleontology to compare and study the wealth of new fossil material that has been collected in recent years - the first time much of this material has been available and the only time it has ever been brought together in one place. In addition to the professional workshop, there was an all-day public symposium as part of the congress activities and a display of fossil platyrrhines for congress participants to examine.

Nubi Mbae *$8,000 funded*

GRADUATE TRAINING IN AFRICAN ARCHEOLOGY AND HUMAN EVOLUTIONARY ECOLOGY

Nubi Mbae is undertaking ethnoarcheological observations in the field to be used as an aid in the interpretation of the archeological faunal assemblages. Field research involves ethnographic observations on the Okiek/Dorobo hunter-gatherers on the Mau Escarpment and in the Nyahururu area. The Okiek adaptation has much to offer in the way of modeling of prehistoric hunting and gathering. The data will be used as a source of insights into the interpretation of settlement and subsistence adaptations of hunter-gathers to complex savanna and forest mosaic environments in the Central Rift Valley.

Brenda Benefit *$5,000 funded*

PALEOANTHROPOLOGICAL EXCAVATIONS AT MABOKO ISLAND

Dr. Benefit will continue the excavation and taphonomic analyses of three fossil-bearing units at the Middle Miocene site of Maboko Island in Western Kenya and analyses of the cranial and dental fossils of monkeys and apes previously collected. By understanding the evolutionary and faunal context of the Miocene primates, she hopes to determine what these differences were. The aim of the project is to provide better relative abundance of mammalian taxa within each bed for the purpose of comparison.

Solomon Yirga *$5,500 funded*

FUNCTIONAL ANATOMY OF THE HIND LIMB BONES AND THE LOCOMOTION OF CATARRHINI

Solomon Yirga's work has focused on the relationship between the lower limb bones and the locomotor patterns of Old World monkeys and apes. Plans include multivariate analysis dealing with biomechanical aspects of locomotion between each of the study groups.

Shirley Strum *Designated funds up to $25,000*

SOCIAL AND ECOLOGICAL INFLUENCES ON AND CONSEQUENCES OF ADAPTIVE SHIFTS: A CASE STUDY OF TRANSLOCATED BABOONS

This study takes advantage of the translocation of three troops of savanna baboons to investigate the social and ecological factors facilitating and inhibiting adaptation to a new environment and the social and foraging patterns that result. Together with previous data on the development of predatory and crop-raiding behavior in these same groups of baboons, the study aims to learn what is involved in adaptive shifts and help build a proximate model of evolutionary change.

Marsha Levine *$2,000 funded*

ECOLOGICAL CHANGE ON THE CENTRAL EURASIAN STEPPE: FROM FORAGING TO NOMADIC PASTORALISM

Dr. Levine's project is to carry out a comparative study of late Paleolithic and post-Paleolithic sites where horse bones are well represented. One object is to develop archeozoological criteria for distinguishing horse hunting from herding and to learn about the process of domestication and the changeover from foraging to pastoral nomadism on the central Eurasian Steppe. The project will involve the use of statistical and scientific methods to learn about relationships between human beings and horses.

Jerold Lowenstein *$2,000 funded*

MOLECULAR AFFINITIES OF EXTINCT MALAGASY LEMURS

Dr. Lowenstein's project includes the study of a variety of bones from different sites in order to accumulate molecular evidence toward the investigation of the evolutionary relationships of extinct Malagasy lemurs. The task includes radioimmunoassay of fossil proteins in Madagascar.

Fiona Marshall *$15,000 funded*

ETHNOARCHEOLOGICAL STUDY OF HUNTING, BONE MODIFICATION AND SITE FORMATION PROCESSES AMONG OKIEK HUNTER-GATHERERS OF THE WESTERN MAU ESCARPMENT, KENYA

Dr. Marshall's project focuses on the collection of, damage to and discard of bone among the piik ap Oom local group of Okiek hunter-gatherers of the Western Mau Escarpment, Kenya. It takes advantage of the discovery by Cory Kratz of this traditional remnant group of Okiek. Special aims include investigation in a high-altitude forest habitat of criteria which have been proposed for the distinction of early hominid from carnivore bone.

John Shea *$900 funded*

THE BEHAVIORAL SIGNIFICANCE OF INDUSTRIAL VARIABILITY IN THE LEVANTINE MOUSTERIAN

John Shea's work will sample lithic sources of the sites in order to determine the proportion of the Middle Paleolithic assemblages resulting from local procurement strategies. Tool uses will be reconstructed by the analysis of wear patterns in order to assess the role of implement use in shaping industrial variability. The research will assist the formulation of models of hominid evolutionary ecology in the Upper Pleistocene and improve our understanding of the archeological record for the origins of modern humans in Southwest Asia.

Richard Gramly *$2,000 funded*

A STRATIFIED EARLY HOLOCENE SITE NEAR CAIRO, ILLINOIS

Dr. Gramly's research project is to be conducted at Olive Branch and involves radiocarbon determinations by conventional methods and Tandem Linear Accelerator Mass Spectroscopy. It is hoped that the work will yield cultural features such as pits or hearths. Plans may be made to expand excavations in future seasons in order to expose sizeable sections of habitation floors or "living floors." At the conclusion of the field season, cuts and pits will be lined with plastic sheeting and backfilled. Permanent datum points will be established to facilitate future research.

Sibanyama Mudenda *$8,000 funded*

PREHISTORIC INVESTIGATIONS IN ZAMBIA/GRADUATE STUDIES AT INDIANA UNIVERSITY

Sibanyama Mudenda's dissertation topic will deal with prehistoric hunter-gatherers subsistence patterns in Central Zambia in collaboration with Drs. Nicholas Toth and Kathy Schick at Indiana University. The plan is to combine studies of early technology, human ecology, taphonomy and geoarcheology. The final year will be spent in Zambia for more fieldwork analyses and completion of doctoral dissertation.

U. Chattopadhyaya *$2,000 funded*

A STUDY OF FAUNAL REMAINS AND LATE PREHISTORIC CHANGE IN NORTHERN VINDHYAS AND MIDDLE GANGA VALLEY, INDIA

This is the final phase of doctorate studies and deals with an investigation into hunter-gatherer subsistence variability and evolution of man-animal relationships. Conducted primarily through archeological animal bones, it promises to shed light on the contrasting patterns of subsistence behavior under differing conditions of stress.

Stephen Green *$2,500 funded*

EARLIEST HUMAN SETTLEMENT OF WALES

Dr. Green's project seeks to evaluate evidence favoring the earliest human settlement of Wales. The work will take place at Pontnewydd Cave and focus on excavation of a deeply-buried new entrance revealed for the first time in 1987.

Richard Klein *$2,500 funded*

U.S./AUSTRALIA/ NEW ZEALAND JOINT SEMINAR/WORKSHOP ON QUATERNARY EXTINCTIONS

The workshop included in-depth comparisons between American and Australian extinction events in order to aid separate searches for human vs. environmental causation. For comparative purposes, the conferees considered the implications of the much less spectacular late Quaternary extinctions recorded in Eurasia and Africa. Held at the University of Sydney during August, 1988, the workshop was followed by a field excursion to important Quaternary fossil sites in Australia. Proceedings will be published by the University of Arizona Press.

John Cavallo *$3,500 funded*

LEOPARD KILLS AND EARLY HOMINIDS: DEFINING AN ARBOREAL SCAVENGING NICHE

John Cavallo's investigation will be carried out in two 4-month field seasons. Observation of leopards in habitats similar to Plio-Pleistocene hominid sites will record the conditions and duration of temporary and permanent abandonments or tree-stored kills together with variations in prey selection and carcass consumption sequences. Collection and analysis of bones from leopard kills will document a full range of modifications of various skeletal parts in relation to known facts about bone damage by other carnivores as well as archeologically modified bone from Olduvai Gorge and other early archeological sites.

Curtis Marean *$2,000 funded*

CHANGING FAUNAL EXPLOITATION STRATEGIES IN THE UPPER PLEISTOCENE AND HOLOCENE IN EAST AFRICA

Curtis Marean's research examines faunal assemblages from Upper Pleistocene and early-middle Holocene. It will seek to document shifts in faunal exploitation strategies of hunter-gatherers at two crucial periods, paleoenvironmental shifts as indicated in ungulate and rodent fauna, and extinction dates for nonextant ungulates. The assemblages to be studied come from two distinct biotic regions in Kenya. Completion of the study is expected to document the nature of these climatic and cultural changes and to allow an evaluation of the influence of biotic parameters upon hunter-gatherers in their responses to climatic shifts and the introduction of domestic stock.

Melissa Remis *$1,500 funded*

PILOT STUDY ON INTRASPECIFIC DIFFERENCES IN FORAGING IN LOWLAND GORILLAS

Melissa Remis's three-month pilot study centers on the foraging behavior of lowland gorillas at the Dzanga-Sangha Reserve of the Central African Republic with the object of examining the feasibility of the site for ecological analysis employing focal animal samples. It will pave the way for future work on ecological differentiation between age/sex classes and the ecological effects of energetic demands of reproduction on females. The work could prove an important first step in determining the range of variation in foraging behaviors for lowland gorillas and thereby serve as a model for the collection of similar data for mountain gorillas.

Geoffrey Sperber *Designated funds up to $5,000*

RETIREMENT FESTSCHRIFT IN HONOR OF PROFESSOR PHILLIP V. TOBIAS

Designated funds will be applied to the compilation, editing and publishing of anthropologically related articles by former students and colleagues of Professor Phillip V. Tobias to form a Festschrift volume in honor of his retirement in 1990 from the Chair of Anatomy and Paleoanthropology, University of the Witwatersrand. Solicitation of articles has already been undertaken and publication of the Festschrift has been contracted by the scientific publisher, Alan R. Liss, Inc., New York. Tentative title is: "From Apes to Angels: Essays in Paleoanthropology in Honor of Phillip Tobias," edited by Geoffrey H. Sperber.

GRANT GUIDELINES

The Foundation was formed to further research into human origins, behavior, and survival. Recent priorities have included research into the 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 hunter-gatherer peoples. Other areas of study related to human evolution have been funded occasionally.

The majority of the Foundation's general grants have been between $3,000-$5,000. Priority is normally given to the exploratory phase of promising new projects. Doctoral students and post-doctoral researchers are encouraged to apply.

Deadlines for submission of the formal applications are: General and Baldwin: March 1, September 1 and December 1. Fellowship for Great Ape: May 1. Fellowship for the Study of Foraging Peoples: May 1.

For further information and application forms, contact the L.S.B. Leakey Foundation, Foundation Center 1-7, Pasadena, CA 91125.

THE FEEDING ECOLOGY OF LOWLAND GORILLAS IN GABON

Dr. Elizabeth Rogers
Department of Zoology, University of Edinburgh

Dr. Elizabeth Rogers

The most interesting finding to emerge so far from studies on the ecology of lowland gorillas, *Gorilla g. gorilla*, in Gabon is the extent of frugivory in their diet. There had been previous reports of fruit consumption by lowland gorillas, but the extent of it was unclear. No one realized that in undisturbed forest (including primary forest), many species of large trees are used as food sources by gorillas - mostly for fruit, sometimes for leaves - so bringing them into dietary overlap with chimpanzees (*Pan t. troglodytes*) and other frugivores which are sympatric with them in Gabon. Such dietary overlap would not have been predicted from work on mountain gorillas (*Gorilla g. beringei*), because that habitat provides few opportunities for consuming succulent fruit, and mountain gorillas are almost entirely folivorous. Yet, it is likely that apes evolved in lowland rain forest, so that is the habitat which probably most resembles their original home.

This study is part of a long-term project to look at ape ecology in Gabon. The work was done in collaboration with Dr. Caroline Tutin and Michel Fernandez at the Station d'Etudes des Gorilles et Chimpanzés (SEGC), Lopé Reserve, Gabon. I have concentrated on analyzing the fruits consumed by gorillas over an annual cycle from May 1986 - May 1987. I was in the field from May - September 1986, assisted for part of that time by Ben Voysey. In October 1986, Stephanie Hall became my field assistant and was in Gabon until July 1987. We have determined what fruits are eaten by gorillas from direct observations, feeding remains on trails, and fecal analysis. Fruits have then been collected, dried, and analyzed chemically. This report deals only with the chemical analysis of fruits and some other foods.

Ecological work began at the SEGC in 1984. By 1986, therefore, we already had a good idea of the fruit species consumed by gorillas after collecting data from several groups of animals. At the beginning of 1986, a decision had been made to concentrate effort on one gorilla group which seemed to have a home range near to camp. Thus, most of our information through 1986/87 came from this group, although by no means all fecal samples and trails could be unequivocally attributed to them since direct observations were relatively rare.

Fruit samples were collected from the ground below fruiting trees or from the trees themselves if they were small enough to reach. We had no equipment for climbing into tall trees. In many cases we were able to obtain samples of ripe and unripe fruit because apes are destructive feeders and frequently break and drop whole branches still covered in fruit at all stages of development. Two major fruit foods come from herbaceous plants in the understory vegetation. Collected fruits were taken back to camp in plastic bags with as little bruising as possible and were processed the same day.

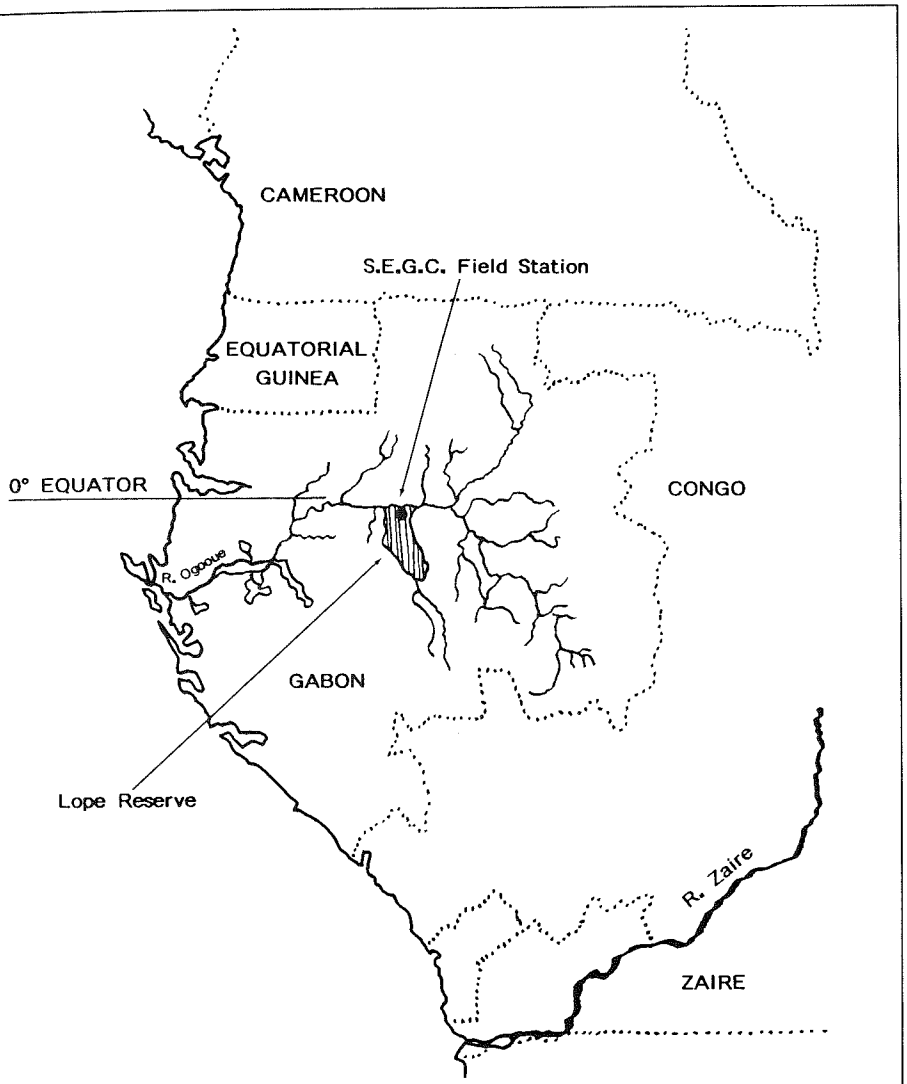
Fruits were processed in the same way as they are treated by gorillas. Thus, for any one species, several subsamples could result - skin, pulp and seeds, for example. In most cases, gorillas digest only the pulp; the skin is discarded and seeds pass through the gut undigested. It is for this reason that we can determine from fecal analysis which fruits have been eaten, for seeds are readily identifiable in the feces.

All samples were weighed and then dried on paper plates in an oven which consisted of an oil drum suspended horizontally in a wooden frame with four paraffin lamps arranged beneath it. The temperature did not exceed 55°C. Mold was a problem, and large fruits had to be cut into small pieces so that they dried before decomposition set in. Samples were weighed regularly until no further weight loss was recorded and were then sealed in plastic bags and stored in tins containing silica gel until they could be taken to the U.K. On arrival, samples were stored in light-proof bags at 4°C. In preparation for analysis, all samples were powdered in a Retsch centrifugal mill with a mesh size of 1mm. Powders were stored at 4°C.

Eventually, arrangements were made to have samples analyzed for protein, fiber and phenolic content, and I did the analyses for lipids and sugars. The following were measured:

Crude protein, as nitrogen; acid-digestible fiber - which represents lignin and cellulose; total phenolics; condensed tannins; water soluble carbohydrates - which provides an estimate of readily-available energy as simple sugars; and crude lipid.

As for fruits eaten by gorillas, data from fecal analysis show that at least 78 species of fruit are consumed. Out of 1634 samples of gorilla feces collected between January 1984 and October 1986, 97% contained the remains of at least one species of fruit. By measuring the frequency of occur-



Map showing location of Station d'Etudes des Gorilles et Chimpanzés, Réserve de la Faune, Lopé, Gabon.

rence of each fruit species in feces collected from June 1985 through June 1987, I found the 20 species most commonly consumed.

Besides the 78 species of fruit eaten, we know of at least another 20 species of plants whose non-reproductive parts (leaves, stems, bark) are used as food. Flowers of one species are also eaten. The identification of non-fruit foods has been achieved by direct observations of feeding animals and by analyzing feeding remains on trails. It is much more difficult to identify fragments of leaves and stems in feces than it is to identify seeds.

While my assistant Ms. Hall was at Lopé, information on gorilla trails was collected on 77 separate days. Each day's trails were counted as one set of trail data, and cases where trails were not certainly attributable to gorillas were eliminated.

I kept the number of samples for chemical analysis to a minimum. For example, seeds not digested by gorillas were generally not analyzed, unless they were so small as to be inseparable from the flesh (as in figs). Ultimately, 75 samples were analyzed from 39 species.

The easiest way to summarize these results is to use some of the data to calculate the average composition of the fruits eaten by gorillas. Twenty-six of the species analyzed provided a suitable basis for doing this.

The conclusion is that gorillas eat fruit that is on average succulent, sweet, low in fat and protein and which may or may not contain digestion-inhibitors in the form of condensed tannins and fiber. Gorillas obtain most of their protein from leaves and bark. This work shows that the diet of lowland gorillas does include foods, both fruit and leaves, which contain high levels of condensed tannins.

Questions such as why gorillas generally avoid unripe fruit and discard the skin of ripe fruits can only be answered when we have larger sample sizes and can do meaningful statistical analysis. So far, the indications are that the only significant difference between ripe and unripe fruits consumed is in sugar content.

This report relates to four topics: (1) nutritional value of gorilla foods, particularly fruit; (2) their content of toxins and digestion-inhibitors; (3) the evidence for food selection; (4) which plants are key foods.

I now have good data on the nutritional quality of fruits eaten by gorillas over one annual cycle, and a start has been made on analyzing other foods such as leaves and stems, and some plants and plant parts which are not eaten. The content of digestion-inhibitors in these foods has been measured. We have not looked at toxins such as alkaloids because of the limitations we faced on analytical facilities, but this can be done in the future. We are accumulating evidence for food selection by gorillas. For example, we know that the fruits most commonly eaten are not necessarily those occurring most frequently in the environment. Further, we are approaching a definition of key foods by analyzing feces for the fruits, and trails for the non-fruit foods, eaten most frequently during whole annual cycles. As for the correlation, if any, between the ranging behavior of the gorillas and the distribution of key foods, that is under investigation now.

How do our results fit into the general context of previous knowledge of gorillas? It is now quite clear that the ecology of lowland gorillas in Gabon differs fundamentally from that of mountain gorillas, most strikingly in their extensive use of fruit as food.

Other studies of lowland gorillas, although drawing attention to frugivory, did not reveal such extensive fruit consumption, possibly because they were carried out largely in disturbed forest where secondary vegetation predominates. Our work on the chemical analysis of fruits consumed by gorillas relates to similar studies of frugivory in chimpanzees

and cercopithecines, both of which are sympatric with gorillas in Gabon. It shows that gorillas fall unexpectedly within a "bird-monkey" or guild syndrome of vertebrate frugivores in the forests of Gabon, eating predominantly sweet, succulent, brightly-colored fruits. This diet may relate to the fact that fruits represent a readily-available source of energy and the foliage of woody plants in West African forests tends to contain higher concentrations of condensed tannins than that of plants in the Virunga volcanoes where mountain gorillas live. However, we have found that gorillas do eat fruits which are high in both condensed tannins and fiber, so they certainly do not avoid such foods altogether.

Thus, work in the Lopé Reserve, Gabon, is revealing all sorts of interesting new facts about gorilla diet and ecology, facts which would not have been predicted from studies on mountain gorillas and which have not emerged from previous studies on lowland gorillas. From the point of view of our understanding of the genus *Gorilla* and of the long-term future of gorillas in West Africa, these new findings must be of great significance.

Much remains to be done. We need to collect samples of more gorilla food plants because some important food species have still not been analyzed. And, we do not have enough data on unripe fruits which are more inaccessible than ripe ones. We also have to look more closely at species that are not eaten and analyze foods used by chimpanzees but not gorillas. Information from the latter is essential for understanding food selection and niche differentiation in the great apes.

This work would not have been possible without the generous hospitality and help in the field of Dr. Caroline Tutin and Michel Fernandez. I thank Monsieur le Directeur de la Faune, R. Dipouma, Ministère des Eaux et Forêts, Libreville, and the Centre International de Recherches Médicales, Franceville, for permission to work in Gabon. Ms. Stephanie Hall was an excellent field assistant and collected many of the samples. Chemical analyses for fiber, phenolics and protein were performed at the University of St. Andrews by Mrs. Mary English. I am grateful for her assistance and also for that of Ms. Gwendy Watson, who helped me with lipid and sugar analyses. The Department of Forestry & Natural Resources provided us with lab space and equipment for chemical analyses at Edinburgh, and Dr. Alan Hayes and Mr. Andy Grey were particularly helpful. I am happy to acknowledge financial assistance from the L.S.B. Leakey Foundation for the chemical analyses and from the National Geographic Society for fieldwork. ■

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NEW FELLOWS

The Trustees and Scientists of the Leakey Foundation welcome and gratefully acknowledge the support of the following Annual Fellows:

Ariel Appleton, Mr. & Mrs. Roger Boas, Mr. & Mrs. James Buckley, Mr. & Mrs. John Crichton, Dr. James Diggins, Mr. Tom Dine, Mr. & Mrs. Frank Durfey, Mrs. Joseph Field, Mr. & Mrs. Richard Goldman, Mr. Wellington Henderson, Mr. Moses Lasky, Mr. Michael McDowell, Mrs. Elaine McKeon, Ms. Ruth Moore, Dr. Lillian Rachlin, Ms. Marjorie Shostak, Mrs. Mary Lou Walters, Mr. Bruce Wolfe.

BOOKS

THE CULTURAL ATLAS OF JAPAN by Martin Collcutt, Marius Jansen and Isao Kumakura. Facts on File, New York, 1988. Illustrated. $40.

Like its companion volumes, this atlas re-creates a historical culture through an integration of text, drawings, photographs and maps - most of them in full color. Through interrelated disciplines of geography, history, archeology, anthropology and the arts, this volume tells the story of Japan from its Ice Age beginnings to its postwar economic miracle.

ANTHROPOLOGICAL PRAXIS: Translating Knowledge into Action edited by R.M. Wulff and S.J. Fiske. Westview Press, Boulder, CO, 1987. pp 282. $36.00.

This volume describes the present status of applied anthropology and yet, in the enthusiasm of contributors, leaves much to anticipate for the future. Included are valuable insights into the different ways in which anthropologists have associated themselves with human groups in need and with institutions and agents of change.

RETHINKING PSYCHOLOGICAL ANTHROPOLOGY: Continuity and Change in the Study of Human Action by Philip K. Bock. W.H. Freeman, New York, 1988. pp 272, illustrated. $12.95 paper.

A volume of critical history tracking anthropology's uses and misuses of psychological concepts and methods. An updated and expanded edition of Bock's classic "Continuities in Psychological Anthropology," the book contains new topics, including the psychology of culture change.

SCIENCE AND EARTH HISTORY: The Evolution/Creation Controversy by Arthur N. Strahler. Prometheus Books, Buffalo, NY, 1987. pp 502, illustrated. $39.95.

Directed to a wide audience of science instructors and professionals as well as the general reader, this book presents the scope and content of the conflict between mainstream science and creation science. Contents include a review of the aims, methods and philosophy of science with special attention to the natural sciences. Containing more than 350 line drawings, a reference list and detailed index is included.

VOCAL COMMUNICATION OF WILD CHIMPANZEES

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African great apes, orangutans, baboons and many other species of higher primate can provide useful models for thinking about the social life of hominids and early humans. However, if one is interested specifically in the evolution of human spoken language, then a special emphasis can be placed on chimpanzees and bonobos (pygmy chimpanzees) because of their unique social organization which promotes friendly communication at long distance.

The pilot research on chimpanzees' long-distance vocal communication reported here was conducted with the Kasakela study group at Gombe Stream National Park on the eastern shore of Lake Tanganyika. Small grants from the Leakey Foundation enabled me to travel there for several months of field observation in the summer of 1986 and to analyze the data in 1987. This pilot research was conducted in collaboration with Dr. Jane Goodall at the Gombe Stream Research Centre.

Human language depends upon the vocal channel far more than does primate communication insofar as our communication can be quite effective in the absence of body language: gestures, postures, movements, touching, piloerection, facial expressions, eye-movements, etc. With most monkeys and apes, however, these other channels are largely predominant over the vocal channel except when hostile long-distance calls are used to maintain spacing between territorial groups. One reason that the vocal channel is less relied upon is that the members of a primate group normally stay close enough together so that friendly communication can be maintained mostly through non-vocal means - an advantage in avoiding predators who use their hearing to locate prey.

By contrast, the unusual social organization of chimpanzees and bonobos is manifested in frequent splitting up and regrouping within the territorial community; these two *Pan* species very seldom stay together for long in a large, compact group. This produces a multitude of constantly changing sub-groups who may communicate quite frequently at long distance on a purely vocal basis, chiefly through the so-called "pant-hoot," a type of call having a large number of variants which at present are imperfectly understood. Pant-hoots are based on alternating inspiration and expiration of air and begin in a low register but build toward a high-frequency climax. By grading, they sometimes shade into other calls such as food calls or fearful screams or defiant *waas* and can be heard for more than half a mile under favorable conditions.

Certain pant-hoots express excitement over meeting another sub-group while some are used as locational calls, often in conjunction with drumming on a tree buttress. That they have communicative functions is clear because individual chimpanzees may travel toward a group emitting the calls or one group may travel toward the other after an exchange. Such exchanges which can involve several successive calls on either side suggest not only the transfer of meaning but also a two-way conversational aspect which suggests some similarity to human language.

For this reason, the pilot research was focused on developing a special methodology for studying two-way communication. A "two-point" recording technique was to be tried by which a different observer would record each end of a long-distance exchange with either a tiny 8mm video camera capable of being carried under conditions prevailing at Gombe, or a small professional audio recorder. In beginning this work, I intended to record one end of the exchange with a video camcorder while a Tanzanian field assistant simultaneously recorded the other end.

Emphasis was also to be placed on training in audio and video recording techniques a few of the Tanzanian field assistants who regularly collect data for Jane Goodall so that two-point recording might be continued after I left in September until the rainy season began in November. Upon arriving at Gombe with the appropriate equipment there was a surprise. During the previous two summers I had seen the Kasakela community constantly traveling around in a number of groups ranging from five or ten to twenty-five individuals, but due to a seasonal shortage of food in 1986 many individuals foraged alone. The groups were far smaller and the rate of long-distance vocal exchange was very low. Training began as planned in hopes that the food supply would increase. By summer's end the field assistants were retrained, and with food becoming more plentiful larger chimpanzee groups were just beginning to form. The corpus of long-distance calls between groups was not yet collected even though a number of nearby calls had been recorded from all phases of chimpanzee life. The two-point recording technique was worked out with the field staff for future use.

Over the following year as the taped calls collected by field assistants began to come to Kentucky by mail or courier from Tanzania, preliminary indications became clear. For example, the self-announcement locational calls (relatively brief pant-hoots) that were accompanied by drumming followed a rather distinct pattern. These vocalizations were emitted chiefly by adult or adolescent males and sometimes "echoed" by adolescent or juvenile males. Another rather frequent context of calling was the pant-hoot which graded into a food call and might be given upon approaching a food source or while climbing the tree, and was sometimes given when beginning to feed. These calls were too varied acoustically to discern any very distinct patterns.

Other pant-hoot configurations were recorded, some relatively stereotyped (e.g., nesting pant-hoots

which are rather musical). There were also a number of highly varied versions of the call for which probable functions or contexts could not be reliably determined, again due to small sample sizes. In addition, agonistic calls (screams, *waas*) caused by conflict were used at a distance, often with the communicating parties out of sight, apparently as SOS signals and possibly sometimes as signals of support by an ally. A wide variety of "hunting calls" sometimes motivated distant chimpanzees to travel.

One major finding is that distant pant-hoots are ignored by the targets being followed more than half the time. That is, they may look in the direction of the call but they do not respond vocally. In a few cases, an incipient call is emitted that could not be heard by the other party. This finding is based predominantly on a recording situation in which only one group is being observed, which for the observer is something like overhearing one end of a telephone conversation when one is uncertain as to who the second party may be. To understand this behavior we will need a far larger sample of two-point recordings which from a logistical standpoint are rather difficult to make.

Another major preliminary finding is that long-distance pant-hooting exchanges seem to be guided by the taking of turns, although this is not always the case. (This pattern was determined by combining data from one-point and two-point recordings.) This suggests that more information is being passed from one side to the other than just who is calling and where the two groups are located. Within a community, the chimps know one another's voices and can travel very accurately to join another group after a call. The taking of turns would not be strictly necessary if voice identification and location were the only information carried by this form of communication since hearing just a small portion of such prolonged calls surely would serve this purpose. A hypothesis which now requires testing with a much larger sample of two-point calls is that when the groups listen to one another carefully without interrupting they are imparting other kinds of information.

Many pant-hoot exchanges cannot be explained functionally at present and neither can their occurrence be predicted by an observer, so there remains a great deal to be learned in this area. One of the Tanzanian field assistants has an interesting theory: he believes that one type of pant-hoot is being used specifically to call other males to go on patrol. Many other alternative explanations are possible.

In one instance, I observed two groups apparently communicating about a group of *Colobus* monkeys – a species normally hunted whenever a kill seems likely – which they were watching with great attention. Other possibilities include location of specific vegetable food types or information about the quality or quantity of food and identification of dangers or novel stimuli in the environment. For example, some pant-hoots have been recorded along with very quiet curiosity-*huus* and very loud hostile-*wraas* during encounters with large pythons.

Food calls also are given in the absence of pant-hoots, sometimes rather quietly but sometimes loudly enough to qualify easily as long-distance vocalizations. While the loud food call definitely would appear to have the function of causing a rich, patchy food source to be shared, assessment of the calls showed that quite a large variety of acoustical patterns have been lumped as "food calls." These included what Jane Goodall refers to as "food *aaa's*" (also a variety of grunt-like sounds) and a rather different call acoustically somewhat related to the "food *aaa*" that reaches a lower register and seems to involve some constriction of the lower vocal apparatus so that a slightly choked sound is produced. I have noted them as "food clucks" because of a similarity to the clucks emitted by chickens. All or most of these calls may be given simultaneously in what appears to be the same general behavioral context of feeding by different individuals. Furthermore, a single individual sometimes alternates between two or more of these different patterns. Only a substantially larger sample of recorded vocalizations will make it possible to determine whether these varied calls associated with feeding should be lumped together in terms of their communicative functions or whether they express nuances that presently remain unrecognized by observers.

Other interesting "linguistic" behaviors were recorded which provided important leads for further research. In a videotape made for presentation at an international conference on chimpanzee behavior at the Chicago Academy of Sciences, I showed Goblin, the alpha male, eating leaves from a bush next to a path that a party of chimps were following. Often, Goblin would hold up a large group's progress by lagging behind when they were eager to reach the next food source. On this occasion, Gigi, a large sterile female who associates with Goblin, paused to face him. Looking directly at him, she emitted an extended grunt-series which seemed to stimulate a response: he gave an occasional high food call as he continued to eat facing toward Gigi. Gigi finally turned to travel, took about ten steps and then stopped with a posture suggestive of "presenting" in Goblin's direction (she was not in estrous). Goblin, having abruptly ceased feeding, approached to briefly inspect her genitals and then followed her.

An important hypothesis to be tested is that purely or predominantly vocal interactions that appear to be "conversations" with turn-taking are not held just at long-distance. Gigi seems to have combined both vocal and non-vocal communication. With a few dozen similar episodes and the aid of careful spectrographic analysis of the grunts and other calls emitted, it should be possible to discern some specific patterns and also to build a plausible case that such communication is "conversational" or, in this case, possibly argumentative in a friendly way.

A few vocalized "conversations" involving an obvious contest of wills also have been observed between mothers and infants. In one case, early juvenile Wunda whimpered at her mother Winkle because she wanted to continue termiting when Winkle began to travel. Wunda managed to stall the departure for 52 minutes, whimpering intensely every time that Winkle got up to go so as to make her mother sit down again after traveling a few paces. At the end of the period, Winkle was about 80 feet away and almost out of sight. Having remained silent all the time, she finally emitted what sounded like an adult version of a single whimpering sound and once more began to travel. This time, Wunda immediately put down her termiting tool and followed her mother to the next feeding site. What was unusual in this case was that the conflict was so protracted and that the mother vocalized.

In another episode in which Goblin was far less eager to travel than his group, two females independently gave an unusual "double-grunt" as they passed close to him where he sat on the chimp-trail. They did this with a time interval in between, so probably the second could not have heard the first. Direct imitation therefore seems unlikely. Since Goblin showed no signs of agonistic arousal and the females had recently been in contact with him, it seems unlikely that these vocalizations were some special version of the submissive pant-grunt used by subordinates in the dominance hierarchy to address their superiors when they meet. Because the unusual "double-grunts" were almost identical to my human ear, this suggested a pattern, but a rare one. Goblin gave no response and did not travel immediately. It is possible that two kinds of grunts were being combined - possibly a submissive pant-grunt with a travel-grunt - but we have not yet identified many of the sub-types of grunts. Rarely emitted calls such as these will remain difficult to interpret until reasonably large samples have been collected.

It will be only through procuring a very large corpus of calls recorded in all natural environments that we will collect enough of these rarer wild chimpanzee calls to confidently begin to interpret their communicative functions. Generally, chimpanzees are quite labile behaviorally and this seems to extend to their vocalizations. For this reason, they flexibly produce many calls which, to humans who know them well, sound "atypical." It will be partly through reliable classification of these rarer calls using the latest techniques that the outer limits of communicative flexibility in the wild can be determined.

One interesting development that the high-fidelity taping of a variety of calls in a broad spectrum of natural situations produced was a tentative (intuitive) sub-division of the defiant "*waa*-bark" call into the *waa*, the *woe*, and the *wow*. There are also many other *waa*-type calls that sound "intermediate." What is intriguing about this group of three *waa* calls is that they are suggestive of human semantic units, highly similar words which are differentiated by single phonemes (e.g., *pin* and *pen*). In this case it would be single vowels (or dipthongs) that were making one signal different from another. Unfortunately, the present sample is too small to permit reliable behavioral correlations, but it is possible that they signify different combinations of fear and anger and are used in different types of conflict situations. Although guided by linguistic training and more than twelve months spent observing wild chimpanzees, it also is possible that my all-too-human ears may be sub-dividing a continuously varying range of *waa* calls quite differently from the way chimpanzees do.

A larger sample might determine that the *waa* simply was subject to a great deal of what linguists call "free variation" and that these acoustically different calls have no separate functions and were all heard as the "same" by chimpanzees. But it is very likely that chimpanzees are capable of hearing phonetic "distinctive features" similar to those that are unconsciously used by humans to discern the phonemes out of which we build words. Maybe they are perceiving a number of meaningful segments in the continuum of *waas* that have been recorded, and possibly it's a much larger number than three. Only extensive further research with the help of a larger corpus of calls and use of sophisticated spectrographic and behavioral analysis can settle this question.

This preliminary study has resulted in some further thinking about the general problem of studying chimpanzee vocalizations which have been investigated from two perspectives so far. Based on twenty-five years of field research, Jane Goodall has published an exhaustive descriptive taxonomy of nearly three dozen different calls, including all of the calls given at every natural phase of a wild chimpanzee's travels. In the late 1960s, Peter Marler recorded a large corpus of calls in the Gombe research camp (where bananas were plentiful at the time) and subjected them to spectrographic analysis. While Goodall's findings thoroughly outline the types of calls and the behaviors that correlate with them, many of the types such as the pant-hoot, the *waa*, the scream, the food call and the pant-grunt are "catch-all" categories and are clusters of calls that sound very similar to human ears but in all probability contain different units. They are perceived distinctly on a subtle acoustic basis by chimpanzees, just as the words "pig" and "big" are perceived discretely by humans even though the only acoustical difference between them is a miniscule time-difference in the onset of voicing of the word-initial bilabial stop. Because of the sheer acoustical complexity of the calls, Marler's analyses of a large sample of vocalizations have not been very helpful in further splitting up these call-types, but he has used his recordings in combination with Goodall's findings to assess the general nature of chimpanzee communication and to discuss the frequency and possible functions of grading. The research problem is formidable, but the potential rewards could be enormous.

A collaborator and I hope to conduct a four-year study of all chimpanzee vocal communication concentrating on two special areas. One is the long-distance calls which employ only the vocal channel of communication and therefore are highly relevant to forming ideas about the evolution of human language. The proposed research will investigate the calls as interactionally-oriented communications that may be similar to conversations of humans in that there are rules for taking turns and an utterance is

given in meaningful response to one that precedes it. Because the great majority of these distant calls are emitted within the same community and are friendly, understanding their functions should help also in interpreting the development of cooperation early in human evolution.

The other area is graded calls in which one call blends into another as when a pant-hoot grades into a food call as a feeding site is approached or a fearful scream grades into a defiant *waa* as the victim's ally arrives on the scene. We do not know whether chimpanzees are perceiving such blended or graded calls simply as two calls that are adjacent or whether they perceive the intermediate portions of the call as being separate and different signals. We also do not know whether these graded transitions may have "syntactic" functions insofar as they may give some meaning to a pair of calls when they are emitted in a continuously graded form rather than separately but at close intervals. But, the fact that captive chimpanzees combine arbitrary units of meaning through manual modes of communication in a reasonably well-patterned fashion would suggest that something like a natural syntax *could* be operating in the wild.

Trying to advance the understanding of chimpanzee calls as an overall system of communication entails a formidable challenge. It presents the need to collect an unusually large amount of data in order to investigate the highly variable rare calls that are produced by chimpanzee behavioral lability. It is an exciting prospect, and the findings could be highly significant - not only for understanding wild chimpanzees in their ways of thinking and communicating but for developing more plausible hypotheses on human origins. The *Pan* species in their natural communication behavior may well offer the most solid behavioral clues that we are likely to find. ■

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The Foundation is seeking support in several areas of human origins research. These "named" funds honor a special individual and provide support in perpetuity for knowledge of our earliest ancestors. We would like to ask you to consider adding your name to the list of donors by making a contribution to any of the following named funds.

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Dian Fossey's twenty years of research changed the world's perception of this endangered species. The work continues at the Karisoke research site in Rwanda, but research must be expanded and efforts must be accelerated to protect this threatened species.

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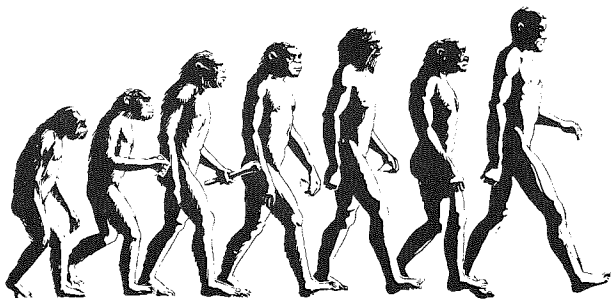
Named to honor the late wife of Dr. Murray Gell-Mann, this fund will be used to finance research relevant to the preservation of the great apes or to the preservation of the physical existence or cultural continuity of hunting and gathering peoples. These are the two classes of living beings of greatest interest to the Leakey Foundation and both are in grave danger of extermination.

GLYNN L. ISAAC FELLOWSHIP FUND

During the twenty years that span the period of his work, Glynn Isaac was an acknowledged leader in the most significant advances in the understanding of human behavior from study of prehistoric cultural residues. With a deep and genuine love of teaching, Glynn was interested in training nationals from African countries in various branches of paleoanthropology.

This fellowship will enable young researchers to continue and expand the new approaches to the study of human origins that Glynn Isaac so successfully developed in Africa.



ARCHEOLOGICAL TRACES OF FIRE? AN ACTUALISTIC APPROACH

Randy V. Bellomo and J.W.K. Harris
Department of Anthropology, University of Wisconsin-Milwaukee

In previous issues of AnthroQuest, Professor Desmond Clark, (Winter 1984) and Professor Jack Harris (Winter 1982) reported traces of fire on archeological sites in Ethiopia and Kenya respectively dating back 1.5 million years. These discoveries have required paleoanthropologists to rethink the whole question of the antiquity of human-controlled use of fire and its broader implications to early hominid adaptive patterns of behavior. In this report, studies are described which are some of the first attempts to distinguish between traces of fire that are of natural origin and those resulting from human (hominid) activities on African landscapes.

One of the most interesting and controversial issues in African prehistory concerns the evidence for controlled use of fire which has been reported from early Pleistocene archeological sites in recent years. The discovery of unequivocal evidence for the controlled use of fire by early Pleistocene times would significantly alter our understanding of the lifeways and mental abilities of early hominids. Unfortunately, archeological evidence for the controlled use of fire is difficult to document in early Pleistocene deposits of Africa since open-air sites are not conducive to the preservation of obvious remains such as ash or charcoal.

Following assumptions that fire-making to provide heat for warmth would have been necessary for hominid habitation in the temperate regions of the Old World, it follows that such a technique would have been in use by early hominids before their movement out of Africa. In addition to warmth, fire provides a number of advantages, such as: light after sunset; protection against predators, including other hominids; tool tempering and tool-making; pest control; clearing pathways through dense bushlands to facilitate travel; selecting fire-resistant plants or species which require heat for seed germination; hunting or driving game during a fire or attracting game after a fire; cooling food to reduce toxins or make it more palatable; and preserving meat by drying.

It is unreasonable to assume that controlled use of fire became common only after the hominids left the African continent. African hominids would certainly have been familiar with natural occurrences of fire which were common in the savanna grassland ecosystem as a result of spontaneous combustion, lightning and volcanic lava flows. Larger-brained hominids witnessing the response of frightened animals may have been able to realize the potential fire could offer, even if they did not yet understand how to make fire. Familiarity replacing initial fear could have resulted in the development of ways to move fire from natural sources.

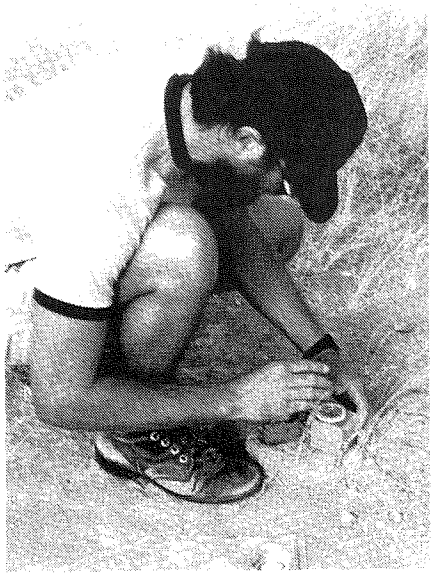
Fire would have offered early hominids a major technological advantage. Systematic research concerning the fire question is of great importance if an understanding of early hominid lifeways is to be achieved. Proving that fire was used at an archeological site, however, can be problematic. First it is necessary to recover evidence which demonstrates that fire was indeed present at the site, and then it must be demonstrated that the fire resulted from hominid activity.

Highly localized discolored patches about the size of a fire hearth which appeared to have been baked in antiquity were first reported in the 1970s by Harris from excavations undertaken at the site of FxJj 20 East, Koobi Fora, Northern Kenya. This site was firmly dated to 1.5 million years ago. In addition to the suspected baked areas, the presence of thermally altered stone artifacts found at the site suggested some populations of early Pleistocene hominids were controlling and utilizing fire on the African continent a million years earlier than shown from the Asian evidence found at the Zhoukoudian cave near Beijing, China. Field researches on archeological sites undertaken over the last decade in Ethiopia and other parts of Kenya have also yielded evidence for fire 1.5 million year ago. With L.S.B. Leakey Foundation funding, Harris returned to two of these Kenyan sites, Koobi Fora and Chesowanja, in 1984. Samples collected and subsequently analyzed confirmed the evidence for fire but did not resolve the major research issue of distinguishing natural fire from human-controlled fire in antiquity.

Addressing the question of the antiquity of human control of fire, Bellomo has begun actualistic studies on present-day African landscapes to determine what parameters can be used to distinguish between natural fire and controlled fire. Once these factors have been identified, the results can be compared with archeological data.

While much fire data exists from experiments involving forests and bushlands in Australia, Europe, North America and Southeast Asia, little data have been gathered from Africa. (A few experimental studies have been conducted on grasslands in Australia and North America, and an extremely small number of studies are known from South Africa. It is clear that there is a relative dearth of fire data from the African continent.) This study is the first attempt to gain an understanding of the physical and chemical effects of fire on different types of African soils and associated vegetation types which are found in a range of sedimentary contexts.

During the summer of 1986, actualistic studies of fire were carried out in a variety of sedimentary environments within the Parc National



Randy Bellomo marking orientation of present-day magnetic field on samples collected for study of suspected baked patch at Koobi Fora.

des Virungas, Zaire, and the Karari Escarpment, Koobi Fora, Turkana Basin, Kenya. These preliminary studies focused on the physical and chemical effects on the local sedimentary environments resulting from campfires, tree stump fires and grass fires. The purpose of this research was to learn how the effects of different types of fire might be reflected and detected archeologically in each of the sedimentary environments studied. These data would be crucial for an understanding of how the three types of fires might be manifest in the Plio-Pleistocene archeological sediments, providing that such traces can be preserved over long periods of time. If traces of fire can be detected in these sediments, and if campfires can be distinguished from tree stump fires and grass fires in the sediments, then our current knowledge of early hominid technology and related behavioral implications would have to be significantly re-evaluated. Positive results from this research would require that future archeological projects look for subtle traces of fire as well as call for previously excavated sites to be re-investigated.

The fire experiments consisted of 9 campfires, 2 stump fires and 1 grass fire. The campfires were built on clay, poorly sorted sand and organic-rich mud sub-strata. The stump fire and grass fire experiments were conducted on humic soil settings. The temperatures in all experiments were monitored by using several thermocouples connected to a digital thermometer. Five thermocouples were placed at regularly-spaced intervals below the ground surface, one thermocouple was positioned on the surface, and one thermocouple 5cm above the surface. All temperatures were recorded at regularly timed intervals.

The campfires were fueled with wood for 1 to 3 hours and then left to burn out naturally. Upon cooling, the ash distributions were mapped and photographed. The locations were then cross-sectioned and the soil profiles mapped and photographed to record changes.

Two stump fire experiments were undertaken following the same procedures, one using *Euphorbia calycina* stump and one using an *Acacia sp.* stump. The *Euphorbia* stump did not burn, demonstrating the fire resistance of this genus. The *Acacia* stump did burn and was to be cross-sectioned later.

The grass fire experiment was conducted using an 11m by 18m plot of *Themada triandra* grass which also contained 4 small *Acacia* bushes. This test was conducted using the same procedures as for the campfires. After 45 minutes, campfire surface temperatures ranged from 205°C to 783°C on clay surfaces, between 166°C to 396°C on sand surfaces, and between 300°C and 360°C on organic-rich mud surfaces. After the same amount of time, subsurface temperatures at a depth of 1cm ranged between 76°C and 322°C in clay, between 73°C and 188°C in sand, and between 80°C and 91°C in organic-rich muds.

After 96 hours, the *Acacia* stump had burned level to the ground surface and the temperature was recorded at 350°C. No subsurface temperature data was obtained since this measurement was made on the last day of the field season.

The surface temperature during the grass fire experiment reached 99°C, while the temperature at 1cm below the surface was recorded at 40°C. Prior to igniting the grass, quartz cobbles and mammal bones were scattered throughout the plot. After the fire burned out, there was no visual evidence of fire (such as carbonization) on the cobbles or bones and no such evidence was apparent in the soil profile.

Results from the analysis of data gained from the actualistic studies and from suspected baked patches within the FxJj 20 site are still in the preliminary stages. It is clear that further experiments must be conducted and more archeological samples collected before definitive results are known. So far, early results are promising.

Randy Bellomo has conducted initial archeomagnetic analyses on control, experimental and archeological samples under the direction of Dr. William Kean, University of Wisconsin-Milwaukee Department of Geological and Geophysical Sciences. One portion of each sample was subjected to alternating field demagnetization up to peak alternating fields of 1000 oe.

Another portion of each sample was subjected to thermal demagnetization up to peak temperatures of 700°C to determine estimates of the maximum heating temperatures of experimental and archeological samples. Indications are that the magnetic properties of the experimentally baked samples and those from the localized discolored areas on the site differ from magnetic properties of the control samples.

Comparative chemical and mineralogical analyses have also been conducted by Professor David Lichtman and associates in the Physics Department at the University of Wisconsin-Milwaukee. The results are preliminary, but thus far it appears that certain elemental percentages increase as a result of fire and similar elements appear in higher percentages in the archeological samples which were collected from suspected baked patches. ■

THE GREAT MURALS OF BAJA CALIFORNIA, B.C.S., MEXICO

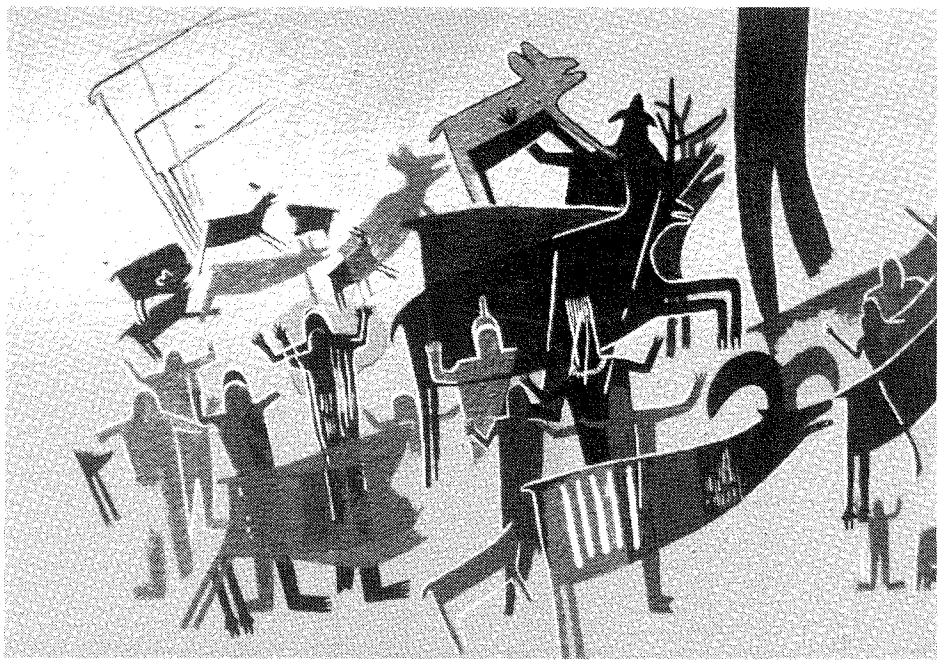
Elanie A. Moore

The great murals of Baja California, Mexico, are scattered along desert canyon walls and rocky mountainsides throughout the Sierra de San Francisco and Sierra de Guadalupe. Until recently, they were accessible only by foot or mule, traveling north out of the old mission town of San Ignacio to the San Franciscos or west out of Mulege for the Guadelupes. Most of the recording field work has been completed at Cuesta del Palmarito I and at Serpiente. It continues on three nearby sites, Palmarito II, III and Dos Borregos as well as another site called Pintada.

The caves housing the murals are rock overhangs, not caverns. They are open at one side and resemble a stage for theatrical productions. The paintings are usually placed on the stage walls, wings, ceiling and/or proscenium as though performing for an audience. Animals which were probably hunted for food and other products common to primitive cultures are portrayed. Deer, mountain sheep, mountain lions, birds and a variety of sea animals are posed with their sides facing the audience, their heads in profile. The ears or horns are twisted forward next to one another in a line along the top of the head. This use of perspective "tordue" is reminiscent of the ancient European cave paintings at Lascaux and Altamira.

Painted in many varieties of red, black, yellow and white, the horizontal rows of anthropomorphs stand erect maintaining a frontal position, their feet splayed to the side in a slewfoot manner, legs slowly slipping under the cave's curving back wall. Arms outstretched and reaching upward, animal necks stretched upward, body line pulling up, all working together to direct the viewer's eye in a rocking upward motion to the top of the mural to communicate a sense of celebration, possibly for supplication, proclamation or transformation.

Some of the murals are staged on flat vertical canyon walls with only a ledge or platform of rock in front, as in the case of Natividad. Others, like Mono Alto, are found not inside but at the entrance of overhangs which actually recede into the earth and become caves.



Cave size seems to make no difference. Some murals are found in what could be called holes or pockets. One of the smaller ones is only 25″ x 14″ at the entrance and 27″ in depth. It is found along the same ridge and just south of the major site at Palmarito I, a cave which displays 250 running feet of painted surface. Here, the size of the figures seem to be relative to the size of the cave itself and the figures' relationship to someone standing on the ground floor of the cave.

The best example is found in Palmarito I. The anthropomorphs here reach as much as 9 ft. tall, whereas the maximum height of any of the figures at its 25″ southerly neighbor's alcove is 8″. At the major site there are also occasional examples of small figures running along the base of the back wall below larger figures.

The figures' size relationship can be seen where the ceiling of the Palmarito I cave rises about 35 ft. above the floor; figures at the highest level are slightly larger than those at eye level. One might guess that this adjustment was either made deliberately so that all would look similar from ground level or that they were simply painted by an artist standing on the ground. The latter seems most likely.

The mountains housing the cave murals were originally formed from major volcanic activity during the Miocene Age that produced mud flows between layers of sand and all kinds of wrinkling, crumpling and squashing. The geological activity left caves with large rough wall surfaces eroded by water during the Pliocene-Pleistocene Age that were etched even more over time by wind carrying sand particles. Large rocks and boulders trapped long ago in the layers of volcanic mud vary between soft and crumbly to hard and smooth and make the surfaces extremely irregular for painting purposes.

Climatic extremes from freezing winter weather to parching dry

seasons continue to change the land, cracking rock walls and sloughing boulders and sand while water from the occasional chubasco speeds up the erosion process.

Small amounts of water on a year-round basis are found in deep canyons and arroyos where it is trapped in rocky catch basins called tinajas. Occasionally there will be an oasis, a spring or stream running a few hundred feet. It is close by the smaller oases, usually near springs or fairly permanent water catchments, that the painted murals are found. Where there seems to be little or no water now, there may have once been more when the paintings were done.

The first description of a painted cave was made in 1780 by Miguel Del Barco when he speaks of figures that sound similar to those found in Palmarito I. However, for 100 years before any Jesuit Fathers even set foot on the rocky desert peninsula, English privateers, Spanish explorers and pearl fishermen from the Mexican mainland had been in regular contact with the local inhabitants. The Cochimi Indians who had roamed the mountain area housing the painted caves became extinct in 1865, so the only ethnology available for the people who were most logically the creators of the murals is found in Jesuit letters and reports. Heavily laden with religious biases of the time, their observations may have been of a culture already showing influences of European contact. But, however meager the information, it does contain clues important to the mural research.

Writing in 1895, a young French industrial chemist, Leon Diguet, not only gives an account of the caves he observed and their locations but he left drawings and photographs. Diguet worked for the Boleo Corporation in Santa Rosalia and in his spare time made trips into the desert mountains collecting and making notes on everything he saw. The material is still being studied by specialists in the flora, fauna, geology and ethnology of Mexico.

During the mid-sixties, Erle Stanley Gardner took a young UCLA archeologist, Clement Meighan, into the aboriginal mural sites. Meighan studied nine sites, five from a helicopter and four from the ground. From one, Pintada II, which he refers to as Gardner cave, he catalogued most of the 139 objects he collected from crevices and the surfaces of the site. No digging was done. Among the objects were a wooden peg and two fragments of palm wood which were submitted to the radiocarbon laboratory at UCLA. The result placed possible occupation of the area between AD 1352 and 1512. The artifacts were presumed by Meighan to be from the same culture that produced the paintings, but this could not be positively proven.

Both Clement Meighan and Campbell Grant - an artist working from a knowledge of rock art of the American Southwest - believe that the paintings were done by ancestors of the Cochimi Indians. Meighan connects them linguistically to the archeological complex known as the Comondu. Campbell Grant adds evidence gleaned from Cochimi ethnology. He points out that the Indians were still painting their bodies in the same manner depicted in the murals when the missionaries arrived. Also, during that same time period, they regarded the painted caves as sacred ground and were performing secret shamanistic rites there and deliberately withholding that knowledge from the missionaries.

In 1978, Mauricio Mixco pieced together a necessary and complete as possible lexicon of the Cochimi language. He based his study on prayers which had been translated by the missionaries into Cochimi and on other accounts reported by the Jesuit Fathers who had learned to speak the language. Unfortunately, the records were not complete, so Mixco's lexicon is missing words which most certainly had existed and would be helpful in tying down some of the symbolism used in the murals.

My effort is concentrated on producing an as accurate as possible visible record of the murals and their imagery. Using photographs and tedious on-site drawings, the work is reproduced to scale. Cataloguing notations made for each figure and its relationship to those around it as well as the surface upon which it is painted are meticulously kept in various media. Reproductions of complete murals made to scale are painted in acrylics as are also large, actual-size drawings.

From a practical point of view, the lack of logic for painting on such rough surfaces and under such difficult climatic conditions leads one to marvel at the aborigines' ability to master their medium to the point of producing such a beautiful quality of stylization. The paint which they used has been unofficially tested, and results from several sources plus the fact that the murals are exposed to the brilliant desert sun yet show no sign of fading seem to indicate that the pigment is mineral.

Close study of the murals indicates that "brushes" (probably chewed or hammered sticks), hands, fingers and palms were used for applying the paint. Dots made by fingertips are evident at Palmarito I, and lines made with fingertips and palms show in the large mural at Pintada. Boca San Julio has good examples of tiny, quasi-parallel strokes common to the "dry brush" method of applying paint which could easily be the result of sticks with slightly frayed ends.

Paint application seems to have been made through a variety of strokes. "Scumbling," a combination of jabbing and scrubbing action, is common to the heavily-layered areas and solid-filled figures. Dots made by fingertips and ends of sticks are common on top of other painted areas, usually for adding ornamentation and/or for ritualistic reasons. There is no evidence of throwing paint at the surface. The few drips that show up are not deliberate. The murals all show a high degree of artistic control and development. The art did not spontaneously appear nor was it the product of a few unusually talented artists. Its consistency and complexity of organization and its sensitive stylization of images involved a clarity of purpose founded in many generations of extreme dedication to a common philosophy.

In the case of the Baja murals, the artist's intensity is seen in every mark that's put down in its deliberateness, its exactness. It is work done by a sure hand whether a brush stroke, chalk mark or a hole pushed into the surface with fingertips. In the murals there are very few "mistakes;" paint application is always directed, never careless.

Flat areas of color show respect for the white outlines. Color is taken up to the white outline but never painted on top of it, whereas the white will occasionally appear on top of solid color. Such a technique indicates that the white was painted last and was not used for a preliminary cartoon, sketch or drawing of the figure. Stylization of imagery, especially in cases where deer are portrayed, has reached aesthetic perfection. To be so skilled at their craft, the artists had to have a strong spiritual or philosophical reason to motivate them.

The lighting in these cave-like overhangs is usually reflected light, especially the areas closer to the back. The rock forms, therefore, are subtly lit with soft shadows making the uneven surface seem photographically rendered. This lighting condition actually increases the 3-dimensional effect of the wall's natural relief. The shadows change only slightly throughout the day in most caves, although in some the sun will shine directly on the wall for short periods of time. This change in light illuminates the forms in the wall so that the effect is very realistic.

Using a process akin to "cloud-watching," the aborigines seemingly chose a formation on the rocky wall which already resembled the animal or an important part of it that they intended to paint. Perhaps they even believed that the animal's spirit was already living in the earth and was somehow being revealed and telling them what to paint; by painting the animal's image on top of the rocky revelation, an artist could bring it to life. Many of the animals do look magically animated.

The placement of each figure, its position on the wall as well as its relationship to other figures, adds to the animated effect. A deer at Santa Teresa I is seen racing up a rocky angular crack in the wall surface. Front legs bent, hind legs extended, it stretches its neck and head forward as though expending great energy to make the climb. The figure of a fish at Palmarito II is placed near the edges of a shallow pool with its tail inside as though the fish is swimming out. As the viewer walks underneath along the cave floor, the fish appears to be moving from behind the edges of the cavity.

There is no doubt that the painters knew intimately the animals that they portrayed; the information needed for recognition of animal types is present in each figure.

The "layering" is important to the art historian because an understanding of the paintings' development as an art form can be read in them. This is especially true at Palmarito I and San Gregorio where there is an unusual amount of layering. The images underneath – that is, those painted first – show different forms of stylization, headdress and even physical form than those on top which would, naturally, be more recent.

It quickly becomes apparent that very little is known about the murals' authors and the culture that produced them. However, these magnificent works of art are full of visual information, and curious clues and enigmatic ambiguities tease the imagination of all who see them.

The murals will not be around much longer. They are regularly battered by wind and sand, washed by dripping water, brushed by wind-blown branches, covered by moss, fungi and ivy and paled by the hot desert sun. There is evidence of mineral and water seepage pressing through the paint from behind the rocky walls upon which they are painted. Even if the danger of destruction at the hands of humans could be eliminated, nature would still do its job albeit more slowly. ■

The Early Worm Catches the Bird and Learns Gliding

mind flies through time
& space as swift through cleft
in this green speeding hill
time stands still & we
move through it
persons, birds, stones
streaming the measure of each
past presence of times
quiet circle
motionless time
& the color we flash in it:
black glint of beetles taciturn back
disappearing red from startled wing
impossible tender green of underleaf
dancing the dark face of the storm to come

ah, ah, it grows, it dies, it blows away,
beneath her thin grass skin rocks guts mutter
pattern: elaboration: anomaly:
seeds & insects imitating each other,
fish sprouting wings growing hands writing poems,
the mute, halt, shot, burnt, why:
starvation, extinction, sometimes,
for a moment, equilibrium,
punctuated by nova
& spring quickening tough seeds, & oh,
the pure cold fire of being alive

rain jumps in a puddle
expanding circles of time intersect:
flick of thumbnail pulse of quasar,
cells lust & planets crack the chrysalis,
emerging, emerging, almost visible, what:
light moving up food chains till moonlight becomes you,
thrush, opening beaker of song, drops seed
up comes fruit & the nuts sweet heart,
along comes fallow goddess yearning
soon you follow, & open your Eye
to look back at it all and laugh:
this is a moment, a flicker, a glance,
neither an ending nor yet a beginning,
for light, ascending, again & again
descends to the darkness of matter
to see itself clearly as the whirling
of things through the stillness allows
a swift in storm a swallows sudden loop
time leaps to mind

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Address Correction Requested

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