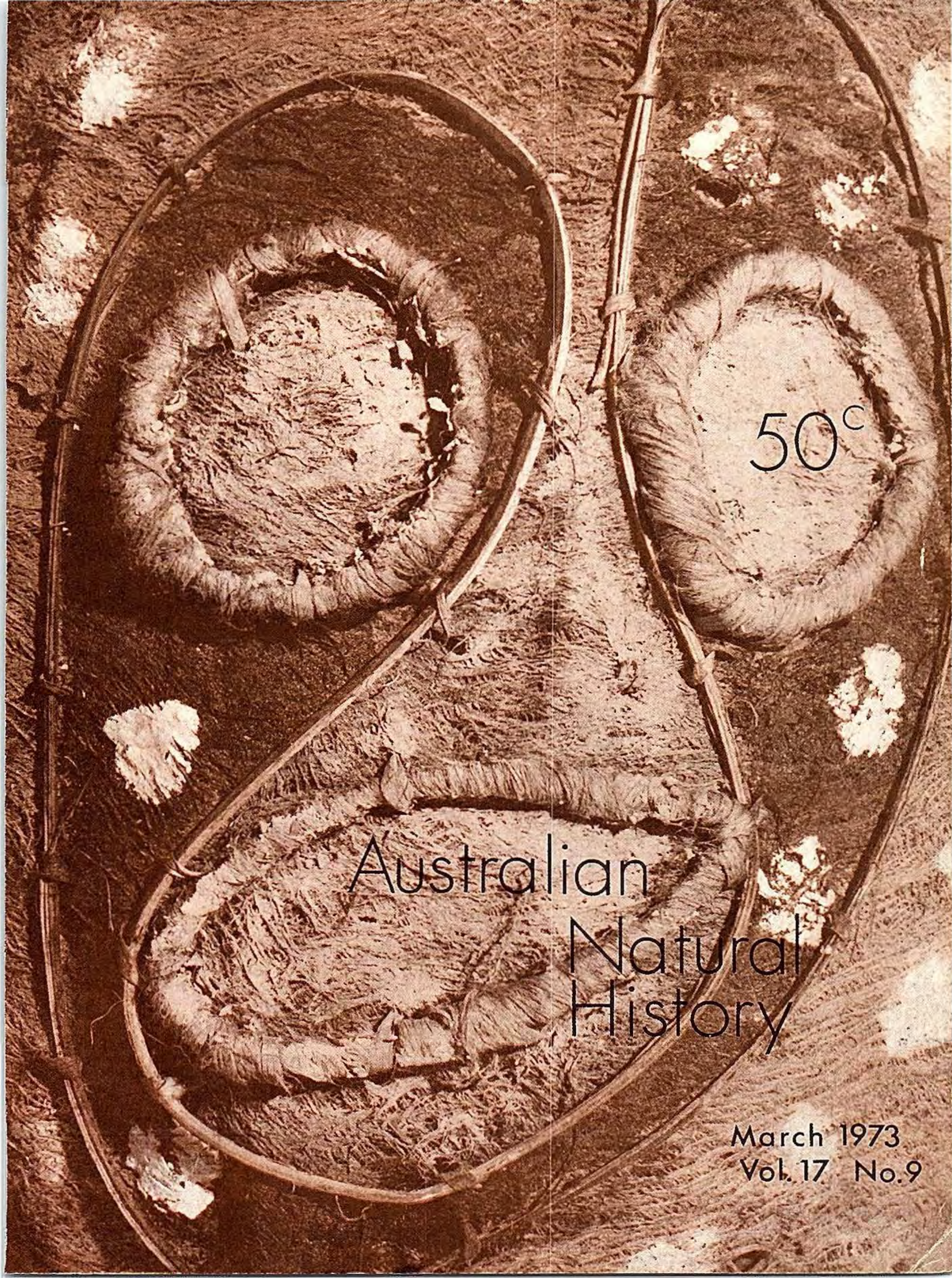

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VOL. 17, NO. 9 — MARCH 15, 1973

CONTENTS

● FRONT COVER: This face mask, from Muru village, near Orokolo, Gulf of Papua, Papua New Guinea, is made of bark cloth on a cane frame. It is painted in black and white on the natural buff to off-white background. The region from which it comes is better known for large masks used in initiation cycles, and little is known of the function of small masks such as this one. As there are no eye holes, these masks may have been used to decorate posts or carved figures rather than as head decorations for dancers. The specimen illustrated is 31 centimetres (about 12½ inches) high. It is on display in the Australian Museum's exhibition of Melanesian art. It is specimen No. E.23147 in the Museum's Anthropology Department catalogue. BACK COVER: The Greater Glider (*Schoinobates volans*) is one of the phalangers and is found in eastern Australia from Rockhampton, Queensland, to Melbourne. It is nocturnal, and feeds mainly on the leaves and shoots of eucalypts. It is distinguished from the other gliders in having the gliding membrane stretching only from the elbow to the knee instead of from the wrist to the ankle. [Photos: C. V. Turner.]

METEORITE SHOWER LEADS TO IMPORTANT DISCOVERY

By R. O. CHALMERS
Former Curator of Minerals and Rocks, Australian Museum

MURCHISON is a pleasant small town on the Goulburn River, Victoria, about 85 miles (140 kilometres) due north of Melbourne. Sunday, 28th September, 1969, dawned a mild, sunny day. The district is quite rural, being given over to sheep, fruit, and, most important, wheat farming. It was a particularly good season, and in the paddocks the lush pastures were knee-high.

The whole peaceful scene, the day, and the general quiet atmosphere irresistibly called to mind A. E. Housman's lines in "Bredon Hill", one of the poems from *A Shropshire Lad*.

" In summer time on Bredon
The bells they sound so clear
Round both the shires they ring them
In steeples far and near
A happy noise to hear.
Here of a Sunday morning
My love and I would lie
And see the coloured counties
And hear the larks so high
About us in the sky.
The bells would ring to call her
In valleys miles away
Come all to church good people
Good people come and pray."

This piece of the Murchison meteorite is about 4 inches wide and weighs 2 pounds 5 ounces (448·15 grams). It has a complete fusion crust. The large depression (known as a "thumbmark") is a characteristic surface feature of meteorites of all types. It is caused by unequal melting of the surface. [Photo: Gene Verstraeten.]

Without pressing comparisons with the poem too far there may have been some dalliance in the fields around Murchison that day and skylarks may have sung overhead. (Though there are larks native to Australia, the English skylark was introduced into Victoria by nostalgic Englishmen in the 1850's.)

Alarming noises, flashes of light

Between 10.45 a.m. and 11 a.m., just at the time when bells may have been sounding from the steeples, other noises, but of an alarming nature, were suddenly heard in a number of places in northern Victoria within a radius of 20 to 40 miles (32 to 64 kilometres) of Murchison. A policeman at Benalla, 40 miles away, said: "It shook the whole town, and the police station trembled". The noise lasted for a minute, and various people who heard it likened it to thunder, explosions, the noise of aircraft, or a sonic boom.

Brilliant flashes of light were seen in the sky even though it was broad daylight. Because the weather was so fine, many people were out-of-doors and a number of accurate observations were made. At Kialla West, only 17 miles (27 kilometres) north of Murchison, a dairy farmer saw a bright orange ball with a silvery rim and a dull-orange tail. A blue smoke trail remained in the sky for a minute or two.

At Shepparton, an Australian Broadcasting Commission film team, working in the open, heard a loud noise that resembled a sonic boom. They also saw three objects, coloured orange to red, one of which was tumbling violently and flashing silver. Unfortunately, the objects could not be photographed because the lens in the camera at the time was suitable only for close-up work.

To the east-northeast of Murchison the bright light in the sky was seen from as far off as Canberra, 260 miles (419 kilometres) away, and from the winegrowing district of Rutherglen, 78 miles (126 kilometres) away. To the south it was seen 82 miles (132 kilometres) away at Bayswater. None of these sightings lasted for more than a minute.

A correlation of all observations showed that the objects were travelling from the southeast to the northwest. When it first became visible it was 30 miles up. Its fragments showered to earth in the general area of Murchison (see sketch map) along a track 7 miles long and 2 miles wide.

Few of the fragments were actually seen to fall. One small piece hit the roof of a station property at the extreme southeast end of the track, and bounced off. A larger fragment, weighing about 1·5 pounds (680 grams), went through the galvanized-iron roof of a large shed at Murchison East and landed among bales of hay stored there.

Meteorite shower

A unique event of the greatest scientific interest, a shower of meteorites, had just taken place.

This visitor from space originated in the asteroid belt some 200 million miles from the earth in the region between Mars and Jupiter. The asteroid belt consists of untold numbers of planetary fragments. Thousands of these enter the earth's atmosphere every 24 hours and are seen at night as rapidly moving pinpoints of light known as meteors or shooting stars. They may travel at velocities as high as 43 miles (70 km) per second. The heat generated by friction with the atmosphere continuously melts the outermost layers of the meteor, and these stream off behind the flying object in the form of a luminous tail. Thus, meteorites steadily diminish in size during flight, and most burn themselves out completely with nothing remaining but a cloud of cosmic dust. Those that are sufficiently large on entering the earth's atmosphere remain as sizeable masses despite the continuous melting of the surface layers, and either land on the surface of the earth as a single mass or, as in the Murchison case, the single mass may explode during flight and cause a shower. The number of individual masses in a shower varies greatly. There may be just a few or there may be hundreds or even thousands.

An explosion may not be quite the most accurate term to describe the break-up of a meteorite while in full flight. The front is heated to a greater degree than other parts of the meteorite, even though the effect may be purely superficial. Also, the front of the meteorite is subjected to great pressure. These two destructive effects tend to break the meteorite up along lines of weakness within the mass. The velocity at which the meteorite is travelling is so great that a vacuum is left behind. The air rushing in to fill this vacuum causes the loud detonations. Thunder is produced in exactly the same way.

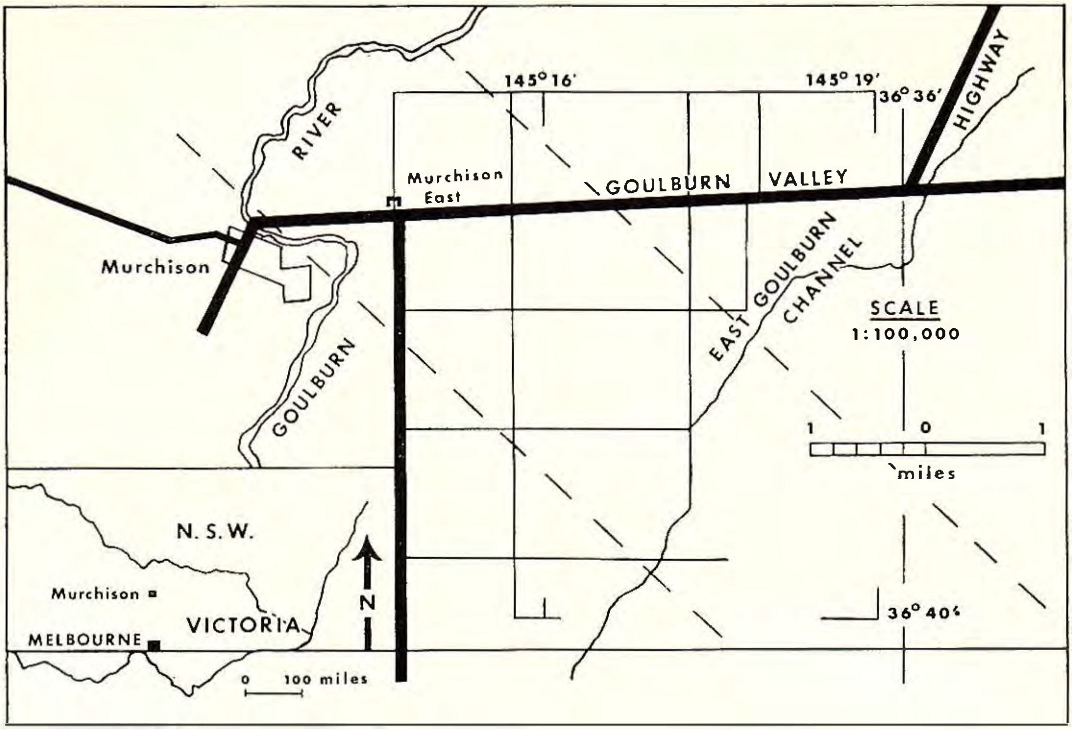
Types of meteorites

A shower of meteorites of the magnitude of the Murchison fall is an unusual event, but the fact that the Murchison belongs to the rarest group of meteorites known, the carbonaceous chondrites, makes it of great scientific importance.

The different types of meteorites have been described in previous articles in this journal. Briefly, there are two principal types—firstly, those consisting largely of a natural alloy of iron and nickel, known as irons, and, secondly, the stony meteorites, which consist of mixtures of rock-forming silicate minerals belonging principally to pyroxene and olivine groups of exactly the same type as are found in many terrestrial rocks. The commonest of all types of meteorites constitute a subgroup of the stony meteorites. These are the chondrites. In these the pyroxene and the olivine form in curious rounded aggregates—known as chondrules—of slender, radiating crystals. Small fragments of nickel-iron are scattered fairly abundantly in this matrix of silicate minerals.

Carbonaceous chondrites

The carbonaceous chondrites contain varying percentages of carbon, carbon compounds, water, water-soluble sulphate minerals, and certain hydrated silicate minerals of the serpentine and chlorite groups. These constituents, which make the carbonaceous chondrites quite a unique



The path along which hundreds of fragments of the Murchison meteorite shower fell was between the diagonal dashed lines. The inset (bottom left) shows the location of Murchison in Victoria. [Map by Gail Anderson.]

group, are seldom found in any abundance in any other type of meteorite.

Broadly there are three main types. Type I contains 3·45 per cent carbon; 20 per cent water; 6 per cent sulphur. The silicate minerals are all hydrated and most of the sulphur is present in the form of water-soluble sulphate minerals. They contain no chondrules or specks of nickel-iron so that to call them "chondrites" is really a misnomer. Type II contains 2·46 per cent carbon; 13·35 per cent water; 3·25 per cent sulphur. Chondrules of pyroxene and/or olivine are present. The amounts of hydrated silicate minerals, such as serpentine and chlorite, and water-soluble sulphates are much smaller than in type I. Occasional small flecks of nickel-iron occur. The Murchison, while it shows some anomalous features, belongs to type II. Type III, which is more akin in composition and mineral content to the normal type of chondrite and has a carbon content of less than 1 per cent, does not concern us here.

Collecting specimens

Local residents started collecting specimens of the Murchison almost immediately after the fall. These were sent to Melbourne and identified by J. F. Lovering, Professor of Geology at the University of Melbourne. Within 3 days collecting parties from the University of Melbourne and the Australian Museum were on the scene. Because of the extreme lushness of the pastures, specimens were found mainly on the roads and on tracks in the paddocks. Some local residents were extremely generous and presented specimens to both institutions. One specimen had hit the concrete yard of a dairyfarm on the outskirts of Murchison, and, the unusual nature of the material not being immediately recognized, the fragments had been swept into the cowyard.

The writer made a second visit to Murchison in February 1970, when harvesting of the wheat had finished and a certain amount of burning-off had taken place, making visibility in the paddocks much better. It was extremely hot weather so that traverses of the paddocks in search of specimens began at first light. Over a period of three and a half days, thirteen specimens were collected personally, and twenty-three others were presented to the Museum by local residents.

The distribution of the Murchison masses along the flight path is characteristic of all meteorite showers. The largest specimens travel furthest, so that these were found at the northwestern end of the track. About twelve of these weighed over 1·5 pounds (more than 500 grams). The largest stone was more than 14 pounds (6·5 kilograms). The smaller ones fell first, and therefore these masses, at the southeastern end of the track, seldom weighed more than a few ounces (10 to 200 grams).

U.S. museums' interest

As the Murchison was such a rare type of meteorite, it was inevitable that certain museums in the U.S.A. came to hear of many specimens being in the hands of residents of Murchison. The funds available to these institutions are very much greater than in Australia. Tempting offers were made, with the result that while the University of Melbourne and the Australian Museum between them have 97 individual masses with a total weight of nearly 25 pounds (11·3 kilograms), the Field Museum of Natural History in Chicago has 142·8 pounds (64·8 kilograms) and the United States National Museum of Natural History, Washington, has 43·66 pounds (19·8 kilograms). The individual masses in these two American institutions number about 650.

Unfortunately, the exact number of masses that fell and their total weight will never be known. It is known that specimens have been sold to overseas institutions other than in Chicago and Washington. Quite an amount is still in the possession of residents of the Murchison-Shepparton district, and, of course, there are no doubt many fragments still lying where they fell, as yet undiscovered.

However, taking into account only the four above-mentioned itemized collections in official institutions, separate masses weighing in all 211 pounds (96 kilograms) are known. This makes the Murchison by far the largest shower of type I or type II carbonaceous chondrites in terms of both numbers and weights. Among types I and II, the Murchison is only the twelfth known. All have been seen to fall, and nearly all have fragmented while in flight. If types I and II were not seen to fall there would be little likelihood of their surviving the weathering process for any considerable period, because of the unstable nature of most of their constituent minerals. It has been estimated that the original weight of the Murchison before fragmentation could have been approximately 1 or 2 tons.

It is very seldom that mineralogists with a special interest in meteorites have the opportunity of personally collecting in the field. The writer collected one small mass on his first visit, within four days of the fall. On the second visit thirteen specimens were personally picked up where they fell on the southeastern end of the flight path. These were all relatively small, the largest weighing over 6·5 ounces (189 grams). Most of them showed a complete fusion crust, indicating that fragmentation of the original mass had occurred at a sufficient height for there to be enough heat generated by friction with the air to completely melt the outermost layers. Some fragments showed only partial fusion of outer layers, indicating that these originated from a second fragmentation much closer to the earth's surface. Some fragments showed a freshly broken surface. This happened when completely crusted fragments broke on impact with the ground.

The fusion crust consists of closely-packed, minute blebs of black glass, visible clearly only under a lens. On the broken surfaces which are also black, the occasional chondrules of rock-forming silicate minerals, though small, can be seen with the naked eye.

Decomposition is setting in. Cracks are appearing in the fusion crust. Small rust spots are also seen, indicating that unstable iron compounds are oxidizing. It is obvious that specimens still lying where they fell will not last indefinitely.

One of the most interesting features of the Murchison is that the carbon content is partly in the form of volatile hydrocarbons; this is indicated by the fragments giving off a strong smell of a volatile organic compound suggesting methyl alcohol or pyridine. This smell still persists, more than three years after the fragments were found.

Intensive research was carried out on these carbon compounds by organic chemists of the United States National Aeronautics and Space Administration, using techniques developed for moon rocks. Amino acids and other organic compounds are present, and the investigators state that these have been produced by purely chemical processes in the asteroid belt, where the Murchison, in common with all other meteorites, originated. On previous occasions organic compounds in other carbonaceous chondrites have been investigated. Amino acids were found and similar claims that these were of extra-terrestrial abiological origin were made. However, the specimens used in these researches had been stored away for years and probably touched by human hands many times. Certain types of amino acids are generated in the skin, and the major proportion found in these other meteorites were of this type. As one research worker at the time put it: "What appears to be the pitter-patter of heavenly feet is probably, instead, the imprint of an earthly thumb".

Fortunately, a significant number of Murchison specimens were collected by trained scientific personnel. Admittedly they were found on the ground among wheat stubble, soil, and sheep excreta, but they were immediately wrapped in foil and handled as little as possible. Material for investigation was obtained from the centre of fragments by breaking them.

The N.A.S.A. scientists are quite definite in their view that, although a minor amount of terrestrial contamination has affected the Murchison, the bulk of the amino acids are of a chemical type quite different from those produced by biological processes on earth.

The importance of this discovery can hardly be over-estimated. Amino acids are the fundamental building blocks of the proteins which, in turn, by polymerization form the long-chain molecules of the nucleic acids. This process of chemical evolution is a necessary prerequisite for the origin and evolution of life itself. For the first time it has been shown that the conditions for this purely abiological process of chemical evolution, and possible subsequent evolution of life itself, exist outside the earth's environment in the planetary bodies of the asteroid belt.

The Museum is indebted to the following for much assistance in the field and for the generous donation of specimens: Mr Peter Gillick and family, Mr J. F. Ewart, Mr J. A. Buchan, Mr R. H. Mawson, Mrs D. Castle, Mr R. Matthey (all of Murchison and district), and Mr and Mrs R. J. Estrada, of Shepparton.

BOOK REVIEW

AUSTRALIAN FISHES IN COLOUR, by Walter Deas; Rigby Ltd, Sydney, 1971; 32 pages; $2.50.

Mr Deas has put together colour photographs, of excellent quality, of sixty-one species of Australian fishes. Most of the fishes are from the Barrier Reef, but a few are temperate species. For each species, the order, family, scientific, and common names are given, and for some of the species earlier-used names are also given. The only text is a single page of general comments about fishes.

With most of the photographs comments are given about the general appearance or ecology of the species illustrated or about the whole family to which it belongs. The States in Australia in which the species are known are listed for each species.

The text and comments are largely accurate, but are very brief. Scientists will take exception to the discussion of the lateral line sense organs of fishes. The organs detect water movements, which can be produced by sounds. Since water displacement is greatest near a sound source and very minor at great distances, it is probable that these sensory organs are more important in detecting nearby sounds than sounds at great distance, as suggested by Mr Deas. The suggestion that the lateral line sense organs are the most important sensory organs in fishes is an over-generalization, since many fishes have highly developed visual, auditory, and chemical senses.

The species are mostly correctly identified, although the photograph labelled Yellowtail Kingfish is actually the Rainbow Runner (*Elagatis bipinnulatus*). The Two-banded Anemone-fish has been described since publication of the book as *Amphiprion akindynos* Allen. Also the leather-jacket *Cantherines howensis* is regarded as a synonym of *C. dumerili*. On the photograph of the Cleaner Mimic, the True Cleaner is also indicated, but only part of the fish shows to the left at the top of the photograph.

Despite the few technical errors, the book is of value in illustrating many of the species in colour in their natural surroundings for the first time. Since few of the 2,500 species of Australian fishes are illustrated, divers, naturalists, and fishermen will not find the book of value for identifying commonly-seen fishes. Nevertheless, the book should appeal to anyone interested in the photographic aspects of fishes and the beauty of fishes.—*Doug Hoese, Assistant Curator of Fishes, Australian Museum.*

A Cape York Peninsula lagoon fringed by *Barringtonia gracilis*, the bark of which contains saponin and was used to poison fish in water-holes. [Photo: J. G. Tracey.]

"Eat, Die, and Learn"—The Botany of the Australian Aborigines

By L. J. WEBB
Rainforest Ecology Section, Division of Plant Industry, CSIRO

FROM the earliest times, plants provided man with implements and useful materials which required little modification from their natural state—digging-sticks, clubs from knobbly roots, shields from bark, boomerangs from tree flanges, rope and string from vines and bark fibres, palms for thatching, bamboos for piping, and, of course, food.

Yet not all plants are edible, palatable, or nutritious, and many of them contain physiologically active substances with distressing and sometimes lethal effects on the animal or man that eats them. Therefore the identification of plant materials which were edible in the raw state, as nature provided them, presupposes long and hazardous research by early man, however strong his teeth and his digestion. The tropical botanist E. J. H. Corner suggests that the names of edible plants were among the earliest of human sounds.

Advances made

This early botanical research would have produced two further advances in human culture besides the discovery of food plants which were edible when eaten raw, or more palatable when roasted on the fire. These advances were, firstly, methods of preparation (related to the palatability trials) to render poisonous plant materials harmless, and secondly, the observation that certain plant materials had desirable physiological effects. Hence elementary organic chemistry, and pharmacology (the knowledge of drugs and medicines), respectively, were born.

The psychological processes involved in these discoveries are, moreover, of great interest. Ivor Jones, a psychiatrist at the University of Melbourne, points out that palatability itself may be biologically determined by selective processes which extend much further back in evolution than does man—for example, chimpanzees, like children, prefer sweet foods. Macaque monkeys have been observed to wash potatoes in the sea before eating them, presumably to improve the flavour, and the habit spread rapidly through the Macaque colony. Similar social learning has been observed in birds—e.g., the spread of the practice of opening milk-bottle tops. It also seems from animal studies that the greater part of learning, at least by the young, is by imitation rather than by conditioning. Thus, while Aboriginal man in a new environment could not learn from other men he could still learn imitatively from animals. Hence the time taken to learn new behaviour in food selection may be shortened. Of course, as Ivor Jones notes, stereotyping of existing behaviour also occurs, so that even when palatable alternatives are available old foods are generally rigidly adhered to.

Vegetation's influence on human customs

But to return to the plants themselves. Vegetation, as well as climate, land form, and soils (and the influence of other cultures), has strongly modified human behaviour and customs in characteristic ways: examples are the bamboo culture of south China, northern Indo-China, and Japan, and the significance of palms in India. In Australia, the vegetation is predominantly open, with sparse-crowned trees and shrubs with hard leaves (sclerophylls), and with other plant growth forms adapted to drought and low soil fertility. This sclerophyll vegetation (open woodland, grassland, scrub, shrub steppe, and desert) covers nearly all the Australian landscape except some wet coastal mountainous areas and a few subcoastal situations with favourable soils where closed rainforest occurs. Of about 1 million square miles in the Australian tropics, tropical rainforests and monsoon forests occupy an area of about a tenth of one per cent, and are scattered like islands in a vast sea of sclerophylls. The two floras—tropical rainforest of Indo-Malesian affinity, and Australian sclerophylls—are almost entirely unrelated botanically, unlike tropical regions elsewhere in the world where woody plants of the rainforest and savannas frequently belong to the same genus. The Australian tropical vegetation patterns are, in fact, unique.

It is tempting to inquire whether the preponderance of sclerophylls and these unique vegetation patterns played any significant role in the development of Aboriginal culture. To what extent were the techniques of plant exploitation original, or inherited from a previous culture, i.e., by what is termed "cultural diffusion"?

The Pitcher Plant (*Nepenthes*) grows on acid soils in the wet tropics. The tropical botanist E. J. H. Corner believes that these "pitchers" led to the use of cups by man. [Photo: W. T. Jones.]

If, as is now believed, man first arrived in Australia over 30,000 years ago from the tropics farther north, he would have brought with him patterns of plant resource exploitation based on a tropical rainforest flora. About that time there was an Ice Age which lowered sea levels, so that Australia was joined to New Guinea, and the northwestern Australian coast was much closer to Indonesia. This would have facilitated the entry of the ancestral Aborigines, but it would also have meant that northern Australia was much cooler that it is now. In moist, mountainous areas, temperate rather than tropical rainforest would have flourished in the north, and tropical closed vegetation would probably have been restricted to the warmer wet coastlines, sheltered valleys, and some rocky outcrops. Since then, there is some evidence for a drier period, and A. P. Kershaw, of the Australian National University, Canberra, A.C.T., has recently shown by pollen analysis that sclerophyll vegetation was well-developed in north Queensland about 30,000 to 10,000 years ago, then was succeeded about 7,600 years ago by rainforest, which became increasingly tropical in character towards modern times.

The retreat of the tropical humid rainforest, which once extended farther inland, would have left a nomadic and pre-agricultural people with a few limited and grim alternatives if they were to survive in a relatively waterless land with a quite unfamiliar flora. The success of their experimentation with this flora is reflected in the unique pattern of food plant exploitation which emerged. Whereas (as Meggitt, Golson, Lawrence, and other anthropologists have pointed out) the staple food of coastal tribes in northern Australia was roots, tubers, and fruits, the food of the inland tribes was mainly seeds (with some fruits and at least one species of yam). It was primarily a "seed-milling" economy, and the seeds were derived mainly from grasses and Acacias. The grasses included species of *Sorghum*, which is one of the four major cereals of the world. The use of seeds of grasses, and Acacias (which belong to the legume family), is comparable to the phases of harvesting wild cereals (grasses) and wild pulses (legumes), without any evidence of cultivation, which have recently been identified in the Middle East. A seed-milling economy existed along the Nile at least 14,000 years ago. It is significant for our understanding of the domestication of plants that early "seed agriculture" was associated with temperate regions, whereas "root and tree agriculture" (horticulture) was associated with the tropics. Viewed in the world framework, therefore, central Australian seed-milling was the beginning of what the American agronomist Harlan calls "a nuclear area" in the pre-agricultural phase.

It is relevant to note here that plant motifs are almost entirely absent from primitive Aboriginal art and ornamentation. The dominance of animal motifs is correlated with the stage of culture reached by hunting peoples. The gathering of plants was allotted to women, who did not hunt large game and who were not privileged to paint, but who nevertheless founded chemistry. Some historians believe that the transition from animal themes to plant themes in art symbolizes the greatest leap in the history of culture—from a hunting to an agricultural economy. Thus the aesthetics of the Australian Aborigine supplement the evidence of the seed-milling economy that he was just on the threshold of agriculture, a conclusion for which the medical scientist Alastair Campbell has also provided some data.

Northern food plants

By contrast with inland Australia, the Aboriginal food plants of Arnhem Land and Cape York Peninsula belong mostly to Indo-Malaysian genera, which would confirm the idea that the pattern of utilization in northern Australia resulted from cultural diffusion, rather than originating afresh and being dictated by the properties of the flora of the Australian coastal region.

In the Queensland rainforests, Black Bean or Moreton Bay Chestnut (*Castanospermum australe*) and Matchbox Bean (*Entada scandens*) provided large seeds which were ground and washed in running water to yield a saponin-free flour. Saponin-containing roots and bark from *Barringtonia*, *Ternstroemia*, and *Pongamia* were used to stupefy and catch fish in water-holes, as were the rotenone-containing *Derris* and *Tephrosia*. None of these tropical rainforest genera is restricted to Australia, and this suggests that, as with food plants associated

The Wannakai or Finger Cherry (*Rhodomyrtus macrocarpa*) is said to cause blindness if eaten at a particular stage of maturity. It was, however, eaten with impunity by the Aborigines after certain treatment or when fully ripe. [Photo: Author.]

with the tropical rainforest, knowledge of their biological activity arrived with the early immigrants.

Alkaloids of therapeutic value

Pounding, milling, roasting, and soaking in running water are procedures common to both Aboriginal and Indo-Malaysian native peoples. It is understandable that such treatments to detoxicate food plants should have become so highly developed in tropical rainforest regions, because the tropical flora contains a much higher percentage of physiologically active compounds such as alkaloids than does the flora of temperate regions. Examples of alkaloids from the tropical rainforest which are of therapeutic value for man include cocaine, quinine, strychnine, and curare types. The American botanist McNair once tried to establish correlations between climate of habitat and chemical composition of alkaloids, showing that there was an increase of molecular weight from tropical to temperate, and that there were also characteristic changes in the numbers of carbon, hydrogen, oxygen, and nitrogen atoms in the alkaloids of different climatic zones. It is, perhaps, not too fanciful a thought that the vicissitudes of climate, the expansion and contraction of the tropical rainforest flora, the different chemical properties of natural products such as alkaloids, and the early evolution of civilization are all closely related!

By contrast with the tropical north, vegetable foods and elaborate methods to detoxicate plants were relatively limited in southeastern Australia.

In central Australia, the remarkable methods of food-harvesting enabled the Aborigines to extract sustenance from such unlikely sources as the woody fruits of *Pandanus*, the bulbs of nardoo, the roots of sedges (*Cyperus*), and the base of the young leaves of grass-trees (*Xanthorrhoea*), as well as the seeds already mentioned.

Narcotics and chewing tobacco

Another important food staple of the inland was provided by the ripe fruits of wild gooseberries (*Solanum*). The immature fruits are generally poisonous, containing alkaloids such as solanine. The family Solanaceae, to which *Solanum* belongs, contains some of the most physiologically active plants known, such as belladonna, stramonium, henbane, and tobacco. One of the most famous Aboriginal drug plants, and the earliest investigated, belongs, in fact, to Solanaceae: *Duboisia.* One of the species, *Duboisia hopwoodii*, called "pituri" by the Aborigines, is confined to inland areas and provided a narcotic. The dried

One of the Zamia Palms (*Macrozamia*). The "nuts" in the cone contain a poisonous principle, and require much preparation—pounding, baking, etc.—before being eaten. [Photo: J. G. Tracey.]

leaves, mixed with wood ashes, were chewed, and contain nicotine and related alkaloids. They were apparently used as an article of trade. It is remarkable that at least three different genera of plants (*Duboisia* and *Nicotiana* in the family Solanaceae, and *Isotoma* in Lobeliaceae) were used as a kind of chewing tobacco by the Aborigines. The first two contain nicotine, and the latter contains lobeline, with a physiological action like that of nicotine. The addition of alkaline wood ashes to the dried leaves would have released weakly basic alkaloids and made the preparation more potent. This suggests a considerable history of trial-and-error in an alien flora (alien for tropical rainforest dwellers), as do the discovery and use as narcotics of species of different genera which are quite different in appearance. Two other species of *Duboisia* (*D. myoporoides* and *D. leichhardtii*) contain varying amounts of hyoscine, hyoscyamine, and other alkaloids, and are extremely poisonous. *D. myoporoides*, sometimes popularly called "corkwood", is a tall shrub marginal to rainforest in eastern Queensland and northern New South Wales. It was used to prepare a narcotic drink, and to stupefy fish and eels in freshwater pools. *D. hopwoodii* of the inland was also used to poison the drinking water of animals (e.g., in claypans) and was especially effective against emus.

Did the Aborigines of the interior learn about the physiological activity of *D. hopwoodii* by "diffusion of culture" from the northeastern coast, where *D. myoporoides* grows in tropical and subtropical rainforest areas, and where the Aborigines were aware of its narcotic properties? It is more likely that their botanical knowledge was not so highly developed, and that the discovery of pituri in the interior was by empirical methods. That the diffusion of culture from coastal regions did not always occur is illustrated by the ignorance of the Aborigines of the Macdonnell Ranges about preparation of the nuts of the "Zamia Palm". Treatment to remove poisonous principles from the nuts of the cycads growing along the eastern coast was standard procedure, and was in fact first noticed by Captain James Cook.

"Bush medicines"

In addition, a large number of "bush medicines" were used to treat a variety of complaints, both internal and external, and ranging from fevers, headache, stomach ache, coughs and colds, to skin itches, sores and wounds. There are also several records of plants used to cause abortion, and which (when taken by mouth) prevented conception.

It is, of course, extremely risky to generalize about the efficacy of many of these so-called medicinal plants, because their use was inevitably associated with ritual and other customs. Nevertheless, modern research has vindicated the use of a number of the plants belonging to genera restricted or mainly confined to Australia, and has established the occurrence of toxic compounds in Aboriginal poisons and medicines such as *Alstonia*, *Duboisia*, *Isotoma*, *Strychnos*, *Nicotiana*, *Castanospermum*, *Luffa*, *Pittosporum*, etc., as well as therapeutic oils, antiseptics, etc. in species of *Eucalyptus*, *Melaleuca*, and other characteristic sclerophyllous genera.

It would seem, then, that the pattern of plant exploitation by Aborigines in coastal, subcoastal, and inland Australia ranges from uses of plants closely related to those of the tropical rainforest regions farther north, to uses of plants quite unrelated to these, suggesting unique adjustments to the characteristics of the dominant Australian sclerophyll vegetation.

It would be of considerable interest to extend anthropologist J. Golson's comparisons of plants used for food in different areas of Australia and the New Guinea-Indonesian-Malayan region, to medicinal and poisonous plants used in these different regions. Although the information is incomplete, and has not been properly collated, a tentative comparison is possible for New Guinea and Australia. Out of a total of about seventy different species used for medicinal purposes in each country, a similar percentage of species was used for many of the common complaints, such as gastro-intestinal disturbances, skin lesions (sores, wounds, boils, etc.), ear-ache, sore eyes, and headache. On the other hand, even though the sample was small, there were some striking differences in the percentage of species used to treat complaints such as coughs, colds, etc., and abdominal and muscular body pains. A much higher percentage of species was used for these purposes in Australia than in New Guinea. It is plausible to suggest that the much greater abundance of aromatic sclerophyllous shrubs and trees in Australia (notably the eucalypts, melaleucas and other members of Myrtaceae), which are poorly represented in the New Guinea rainforest, was directly responsible for the greater variety of plants used for coughs, colds, and lung complaints in Australia.

Joseph Banks' comment

The empirical process of "eat, die, and learn" led to a new inventiveness and to special adaptations in the use of an unfamiliar flora: *botany began anew for man in sclerophyll Australia.* Even the "gentleman-botanist" Joseph Banks had to concede that the Aborigines possessed considerable botanical knowledge when he grudgingly commented: "tho' their manner of life, but one degree removed from Brutes, does not seem to promise much, yet they had some knowledge of plants, as we plainly could perceive their having names for them". One of the best examples of this botanical knowledge is provided by the list of 103 species of plants identified late last century by the Queensland Government Botanist, F. M. Bailey. These plants were used in a variety of ways by the Aborigines of the Koko-Yimidir tribe near Cooktown, north Queensland. The wide range of plant habitats involved indicates the thoroughness with which the Aborigines had explored and experimented with their botanical environment.

The new interest in studying the ecological relationships of the Aborigine is yet another illustration of modern man's attempt to come to terms with nature, to identify himself and to achieve self-realization in an artificial environment out of tune with his biological and psychic history. Now that we realize we have in Australia the unique opportunity to study an important stage in man's cultural development, we may hope that the new wave of research will not be too late. If we agree with W. C. Wentworth that "we are recording in the only place now possible the raw material of all human psychology and sociology", investigation becomes more difficult yearly as the very stuff of research dies with the old people, and modern technology such as mining disrupts the Aboriginal habitat and economy even in remote places.

FURTHER READING

"Australian Plants and Chemical Research", by L. J. Webb, in *The Last of Lands* (Jacaranda Press, 1969, reprinted 1971, edited by L. J. Webb *et al.*).

"The Use of Plant Medicines and Poisons by Australian Aborigines", by L. J. Webb, in *Mankind* 7: 137-146 (1969).

"Aboriginal Man and Environment in Australia", edited by D. J. Mulvaney and J. Golson (Australian National University Press, Canberra, 1971).

"Aboriginal Habitat and Economy", by R. Lawrence (*Australian National University Department of Geography Occasional Paper* 6, 1968).

"Elementary Food Production by the Australian Aborigines", by Alastair H. Campbell, in *Mankind* 6: 206-211 (1965).

A bleached sand soil, showing roadside erosion, near Stradbroke, Victoria. [Photo: Author.]

AUSTRALIAN SOILS

By K. H. NORTHCOTE
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EVEN though soils are one of the elements of our natural environment, popular articles about them are fairly rare, except possibly for some comment in the garden section of newspapers and some magazines. However, the natural history of Australia cannot be fully appreciated without consideration of her soils. They form part of the environment in which we live. The other parts of this environment are the geological formations, topography, climate, and the flora and fauna. And it is soil in this environmental context that man has to use for his various agricultural, urban, industrial, and other purposes. Thrifty management of the soil should be man's goal for his own long-term benefit.

What is soil?

As every farmer and gardener knows, soil is the natural medium in which land plants grow. In this sense, it covers land as a continuous upper layer, except on rocky outcrops, in very salty depressions, in regions of continuous cold, and in other places where the cover of soil disappears. Because of this vast spread, it is easy to appreciate that soils have shape and area. They are thus part of the landscape. However, the third dimension of depth that they occupy is not so readily appreciated. Trenches, and similar exposures dug into soil, reveal changes with depth. Such vertical sections are termed the soil profile. Soil has many forms. Its characteristics in any one place result from the combined influence of climate and living matter acting upon parent rock material, as conditioned by relief, over periods of time, including the effects of the cultural environment and man's use of soil. It is in the various expressions of the soil profile that the result of these influences may be observed and studied. Ideally, the soil profile extends from the land surface into the weathering parent rock below. The depth of many present-day Australian soils is about 1 metre (1·094 yards), but ranges from less than 30 centimetres (about 1 foot) to 6-7 metres. The problem is to recognize the parent material. Buried soils, products of earlier soil-forming cycles and thus intriguing to archaeologists, may be incompletely removed by natural erosion, thereby complicating the situation. Plants do not necessarily confine their roots to the present soil but may extend them into the buried layers as well, probably in search of moisture. The moisture regime of a soil is dependent upon the relative permeability of the deeper soil layers as well as the surface. Not only moisture, but all soil properties change with depth, hence the importance of the soil profile.

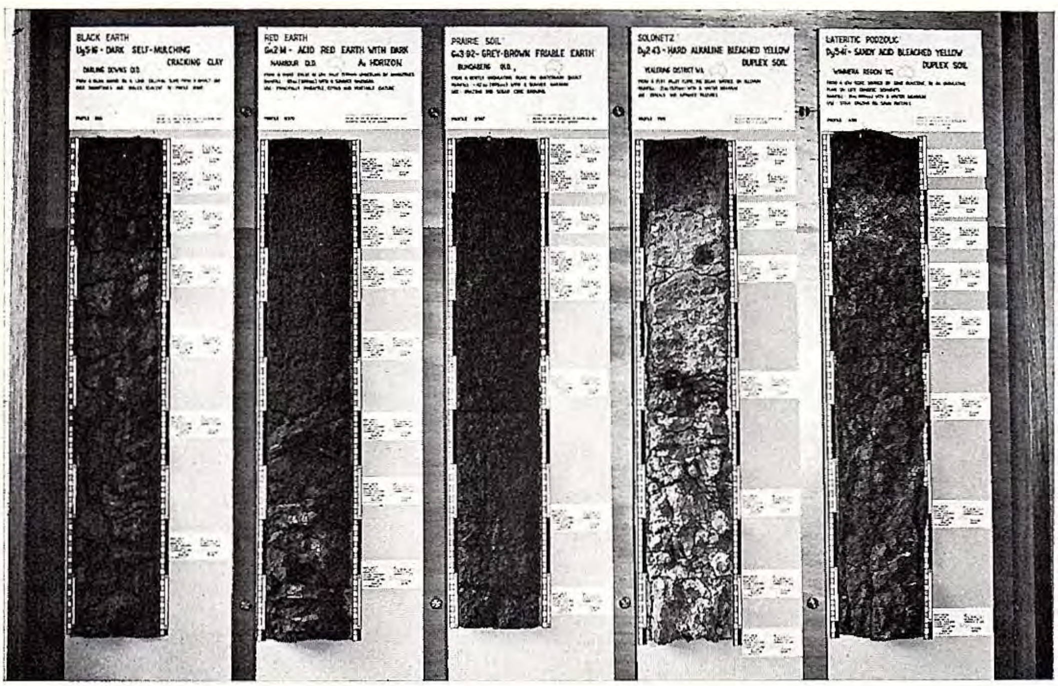
Monoliths

Thin sections of the soil profile impregnated with plastics, such as polymethylmethacrylate, may be preserved as soil monoliths (see "further reading" list). Displays of such monoliths at the 9th International Congress of Soil Science, held in Adelaide in 1968, were greatly appreciated by all visitors, not only overseas soil scientists but the people of Adelaide as well. They provide a ready means of introducing the layman, student, and scientist to soils and are therefore suitable for display in museums as well as schools and universities.

Cores of soil from which monoliths may be made are taken by power-driven augers. These are but one example of the recent mechanization that has greatly improved the facilities for soil sampling and examination. Others include thin-walled sampling tubes and trenching equipment such as the back-hoe.

Soil maps and soil classification

One way to appreciate the great variety of Australian soils is to look at modern soil maps. The recent *Atlas of Australian Soils* (see "further reading" list) consists of thirteen coloured maps at a scale of 1 = 2,000,000. They show the broad pattern of the most common soils by topographic units that are described in the booklet accompanying each map sheet. Soil maps at larger scales are made for specific land-use purposes. Such maps are concerned with details of local soil variability and are usually produced to help answer particular problems.



A display suite of monoliths of 1 metre (1·09 yards) length. The specimens are (from left to right): dark self-mulching cracking clay, from Darling Downs, Queensland; acid red earth, from Nambour, Queensland; grey-brown friable earth, from Bundaberg, Queensland; hard alkaline bleached yellow duplex soil, from the Yealering district, Western Australia; sandy acid bleached yellow duplex soil, from the Wimmera region, Victoria. [Photo: M. J. Wright.]

Before soils can be shown on maps, they must be classified. Classification simply means placing like individuals in the same group and separating the unlike, and so on, until all individuals are placed in their appropriate groups. Modern Australian soil classification has achieved this objective with the development of *A Factual Key for the Recognition of Australian Soils* (see "further reading" list). This classification, which uses the properties of the soil profile alone, differs from earlier soil classifications, which were largely based on geology and climate. It works because soil is the tangible expression of its environment, is therefore a thing in its own right, and can be classified in the same way as rocks and minerals.

These recent studies have shown that there are about 240 important kinds of Australian soils which differ materially from each other. The term *principal profile form* has been given to them. It represents the end point of the present stage of classification by the *Factual Key*. All soils with a particular principal profile form have similar properties.

Some features of soil distribution in Australia

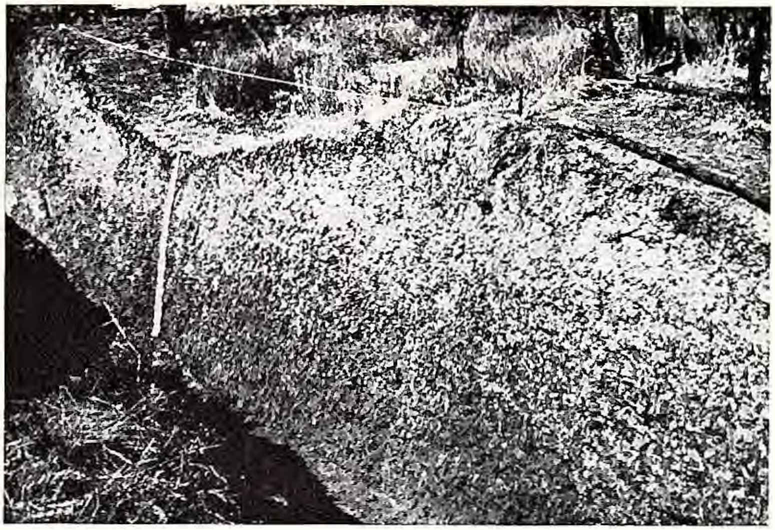
The vast inland as shown by the *Soils Atlas* generally has a broad, open pattern, whereas the coastal fringe of northern, eastern, southern, and southwestern Australia has a more intricate pattern. The boundary between these two patterns generally follows the 280-300 millimetre (11-12 inches) rainfall isohyets in the southwest of Western Australia, the 300-350 millimetre (12-14 inches) isohyets in South Australia, Victoria, and southern New South Wales, merges into the 550 millimetres (21·5 inches) isohyet in southern Queensland and follows this isohyet across the north of Australia. It will be recognized that this boundary largely separates arid Australia from seasonally humid Australia. The real difference between these two broad climatic regions is that arid Australia is normally dry with occasional wet periods, whereas seasonally humid Australia has regular wet seasons with occasional droughts of variable duration and severity. This is one reason for the difference in soil pattern.

(a) *Arid Australia*

Although the soil patterns are broad and the same soils occur repeatedly over many miles of country, there are many variations. In the extreme southern part, the soils are typically calcareous, as they have been derived from calcareous parent materials, and many are salty. In the Mallee lands of South Australia, Victoria, and New South Wales, they are associated with relatively less salty, calcareous soils that have been developed more or less successfully for irrigated horticulture along the Murray River. However, salting remains a persistent problem in many localities. In the western part of arid Australia are the extensive red earthy sands and their ironstone (lateritic) gravelly variants that have probably formed from a pre-existing lateritic soil. These soils and the related red earths that occur throughout arid Australia, including the Cobar peneplain of New South Wales, are quite out of harmony with the present arid climate, as they are strongly leached and deeply weathered. There are also the deep siliceous and predominantly red sands of the desert dunefields, the thin salt-affected loams of the Old Valley systems of central and western Australia, the shallow earthy loams on red-brown siliceous hardpan in Western Australia, and the great arc of cracking clays that extend from the Barkly Tableland and the Gulf of Carpentaria to western Victoria and the southeast of South Australia. Gilgais, a form of micro-relief of mounds and hollows, found where soils have high coefficients of expansion and contraction with changes in moisture, are well developed in these cracking clays.

(b) *Seasonally humid Australia*

The soil patterns are complex because major soil changes occur over short distances. However, where the same environmental factors are operative similar soils develop. For example, wherever basalts occur and have been deeply weathered *in situ*, deep red friable clays, much prized for their good physical properties, are developed. These clays, often called red loams, are found from northern Tasmania to Cairns, Queensland. But where the development has occurred on alluvium derived from basalt, black, self-mulching, cracking clays prized for their chemical fertility have been formed. [Self-mulching means the ability of the surface soil to re-form a loose crumbly structure when left undisturbed.] These are found on the Darling Downs in Queensland and the



A section of a melon-hole gilgai in a deep, cracking, clay soil near Chinchilla, Queensland. [Photo: G. D. Hubble.]

Liverpool Plains in New South Wales. Both these types of red and black soils may occur side by side.

Not only is the parent rock important, but so is the geological history, or geomorphology, which reflects the manner in which the land surface has been sculptured by erosion and deposition. In Europe and North America vast areas were stripped of their former soils by Pleistocene ice-sheets and soil formation began anew on fresh rock surfaces or fluvio-glacial deposits about 10,000 years ago. By contrast, many Australian soils have been formed on surfaces that have been continually exposed to weathering probably since the late Tertiary, without the stripping due to glaciation; consequently, remnants of ancient and deeply weathered profiles are a widely distributed feature throughout this continent. Thus, in one locality a complex array of soils may be present, including those formed on parts of ancient profiles, and on deposits derived from ancient profiles, as well as soils developed on freshly exposed rock and on Pleistocene and Recent alluvia. Because of the greater intensity of weathering in seasonally humid Australia, such a range of soils is not uncommon: the southwest of Western Australia, the Adelaide Hills and the area west and south of Sydney provide examples. One result is that many Australian soils have a low order of chemical fertility, and consequently nutrient deficiencies of phosphorus, potassium, nitrogen, copper, zinc, molybdenum, and manganese are common and may be extreme for introduced plants. Agricultural development was not possible in many areas until fairly recently on this account. The only areas in Australia that were subject to Pleistocene glaciation are the alpine areas of southeastern Australia and Tasmania, which are typified by freshly weathered rocks on which organic loamy soils have developed.

The complete range of soils found in seasonally humid Australia cannot be encompassed in this article, but no account would be complete without reference to the texture-contrast, or duplex, soils. These are soils with sandy or loamy surfaces overlying clay subsoils. Seasonally humid Australia probably has a greater number and variety of these soils than is found anywhere else in the world. Their clay subsoils range in colour from red-brown through brown and yellow to near black and finally bluish or greenish grey. This colour sequence represents a soil permeability (drainage) sequence with the red-brown being the most permeable and the bluish and greenish greys the least.

Soils and minerals

Soil formations can be a source of minerals. The bauxite deposits at Weipa in Queensland and Gove in the Northern Territory are masses of loose or cemented bauxite gravels in a matrix of red, earthy soil; the gravels are concentrated at depths of 50 centimetres or less and can be scooped up. Mineral sand mining for rutile and zircon below sandy soil formations along the coasts of Queensland, New South Wales, and the southwest of Western Australia is another example. These and other occurrences account for the current interest in promoting soil-formation studies directed to minerals exploration.

Aerial photography

Black and white aerial photography has been used for a long time in soils studies; the plotting of soil and landscape boundaries would have been impossible in many cases without the use and interpretation of aerial photographs. The recent development of colour photography, and more particularly infra-red false-colour, has opened up new possibilities for exploring soil conditions in relation to plant growth.

Environmental quality

Australian soils developed under a biological regime largely dominated by eucalypt and acacia species in the vegetation, the absence of domestic herbivores from the native fauna, and the fact that the aboriginal Australian did not cultivate the soil. With the advent of British settlement about 180 years ago, the soils have been progressively exposed to widely different biotic and other influences as a result of land clearing and road building, as well as farming. The old equilibrium was upset, and that the soils have changed, or are changing, under these influences is often obvious. The extent to which they are eroding shows that new equilibriums have not yet been reached. For example, many soils after clearing of native vegetation are not able to absorb the extra rainwater which was formerly evaporated from the vegetation, and which now flows from saturated soils, causing erosion and salting. One estimate places the cost of soil conservation for non-arid Australia at 350 million dollars required to be spent during the next 30 years. (See "further reading" list.) However, man's influence on soil is not always bad. The activity of scientists and farmers has materially improved the nutrient supply of the top 10 centimetres of many soils, so that they may be said to be chemically and biologically new. They are man-made.

Soils have been widely studied in the agricultural and pastoral areas of Australia and the value and importance of soil data are well known and appreciated by all concerned. But it seems to be quite otherwise in urban and industrial areas, particularly in the new urban sprawl where the capacity of soils to handle only a limited volume of water does not always seem to be appreciated by householders and by authorities concerned with sewerage disposal. Soil studies aimed at providing data for urban and industrial purposes could well be added to those continuing to provide information for agricultural and pastoral pursuits. The value of soils data in the construction of foundations for houses and roads is well known, and is a major step in this direction, but there remains the big problem of planning for the proper use of all our urban, industrial, and recreational land through the correct management of soil.

FURTHER READING

A Handbook of Australian Soils. H. C. T. Stace, G. D. Hubble, R. Brewer, K. H. Northcote, J. R. Sleeman, M. J. Mulcahy, and E. G. Hallsworth. 1968, Rellim Technical Publications, Glenside, South Australia.

Atlas of Australian Soils, Sheets 1 to 10 and Explanatory Data. K. H. Northcote, G. G. Beckmann, E. Bettenay, H. M. Churchward, D. C. van Dijk, G. M. Dimmock, G. D. Hubble, R. F. Isbell, W. M. McArthur, G. G. Murtha, K. D. Nicolls, T. R. Paton, C. H. Thompson, A. A. Webb, and M. J. Wright. 1960-68, CSIRO, Australia and Melbourne University Press; Melbourne.

A Factual Key for the Recognition of Australian Soils, third edition. K. H. Northcote, 1971. Rellim Technical Publications, Glenside, South Australia.

"The Preparation of Soil Monoliths for the Ninth International Congress of Soil Science, Adelaide, 1968." M. J. Wright, *Geoderma* 5, 151-9. 1971.

Study of Community Benefits of, and Finance for, Soil Conservation. Standing Committee on Soil Conservation, 1971. Secretariat Department of Primary Industry, Canberra, A.C.T.

THE SEROLOGY OF MAMMALS

By JOHN A. W. KIRSCH

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TAXONOMISTS, people whose interest is in classifying or grouping organisms, use many characteristics to determine the similarities and differences among plants and animals. Traditionally mammals have been classified mainly on the basis of their teeth, but in recent years a number of additional, less obvious characteristics have come to be used. These characteristics include the numbers of chromosomes, the shapes of spermatozoa, and a variety of chemical features, including the detailed structure of single molecules.

"Blood will out" is an old saying that expresses the belief that close human relatives will have many characteristics in common—notably behavioural ones—but the saying might well be applied to animals in general. For one of the most useful ways of determining relationships is by the study of blood. Unlike many chemical approaches to classification, serology, as this one is called, is not new: the principles and their application to animal classification have been known since the beginning of the century.

Serology is the study of antigens and antibodies and the reactions between them. Antigens are large molecules, usually proteins, which are capable of provoking the production of other large molecules, antibodies, upon entering the body of a foreign animal. The most familiar examples of antibody production are the reactions of an animal to diseases or to an organ transplant: the conquest of the disease or the rejection of the organ is largely due to the production of antibodies.

When an animal has produced antibodies, it is said to be immune, and the liquid part of its blood, which carries antibodies in solution, is referred to as an antiserum. Ordinarily an antiserum contains many more antibodies than are needed to eliminate the invading proteins, and so an antiserum can be used like a chemical reagent to detect the presence of more of those antigens. But—and most important to classification—an antiserum will also react with antigens that are different from the original ones, and the strengths of such reactions are greatest with proteins from animals most similar to the supplier of the original antigens. Thus, an antiserum against the blood proteins of a man will react most strongly with human proteins, somewhat less strongly with

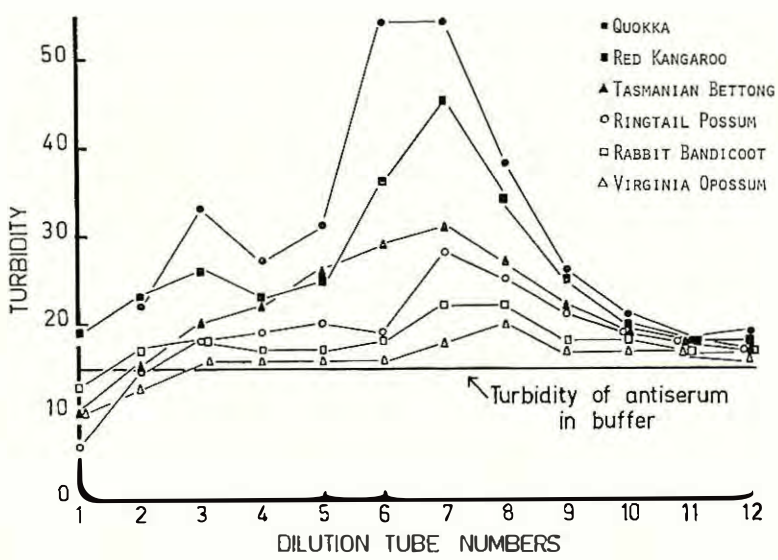


Figure 1: Curves showing the increase in turbidity (cloudiness) when a constant amount of antiserum against the quokka is added to decreasing dilutions of the sera of several marsupial species. [Diagram by Mrs Ross Angell.]

chimpanzee or gorilla proteins, more weakly still with monkey proteins, and possibly not at all with proteins from mammals such as the horse, dog, or kangaroo. In his famous book of 1904, *Blood Immunity and Blood Relationship*, Nuttall, of Cambridge, and his associates showed how very general this correlation between physical and chemical similarity is and that the antigen-antibody test could actually be used to demonstrate animal relationships. In most cases the affinities indicated by Nuttall's serological tests agreed very well with what were thought to be the "true" affinities (the man-monkey test given above is one example). This being so, it was but one step to the conclusion that serological tests could be useful in instances where relationships were in doubt. Serology thus became a popular approach to taxonomic problems. Before considering some examples, we should consider the techniques of serology in a bit more detail.

In studies of mammals, the most convenient antigens to use are the proteins in solution in the serum, or liquid portion, of the blood. Ordinarily, serum is taken from each of the species to be studied and antisera are produced in rabbits or chickens against some of the individual sera. The antisera are then used to compare the sera from all the species in turn, and from these tests a picture of affinities is built up.

There are many ways of performing the antigen-antibody reaction. The oldest, and with some refinements still a popular procedure, is to mix a serum and antiserum in a test tube. The two reagents combine to form a precipitate which causes an increase in cloudiness of the fluid. The measurements of the cloudiness produced in each test can be compared as measures of similarity. Usually a curve, showing the cloudiness resulting from different concentrations of the same serum, is drawn, and the curves for several sera are then compared. Figure 1 shows a few such curves for the sera of several marsupials reacted with an antiserum against the quokka. The heights of the curves graphically illustrate that the two kangaroos are very much like the quokka but that the Virginia Opossum is not, and that the Ringtail Possum and Rabbit Bandicoot are intermediate in similarity to the quokka.

Other kinds of tests show the reaction of antigens and antibodies as lines of precipitate

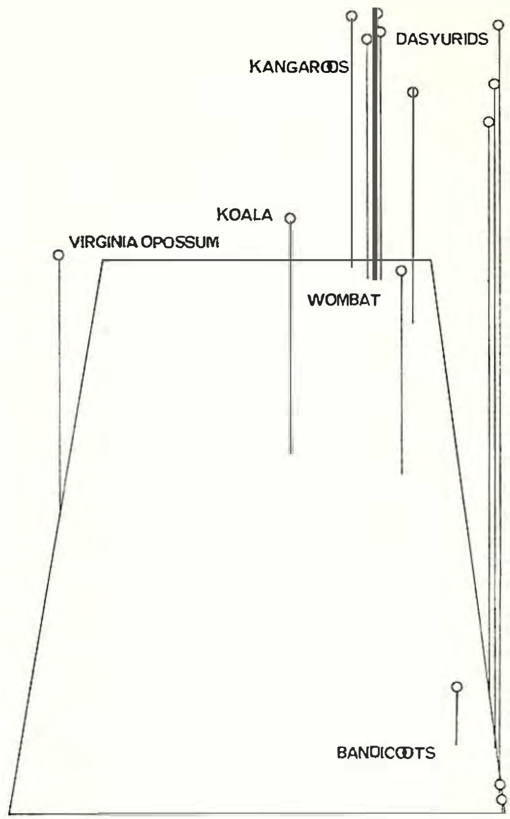


Figure 2: A computer drawing in perspective of the serological affinities of fourteen marsupial species. Note that every Australian species is closer to another Australian marsupial than it is to the Virginia Opossum, the sole American marsupial represented. (The dasyurids are a group which includes the Native Cats, Native Mice, Tasmanian Devil, and numbat.

in clear agar jelly; still other tests measure the reaction indirectly as the amount of auxiliary blood substances ("complement") used up, or measure the ability of the antiserum to clump red blood cells which have been coated with antigens.

By one or a combination of these tests, an enormous number of comparisons can be made quite quickly and the information analysed by computer. Figure 2 is a computer drawing in perspective of the serological affinities of several marsupials, including some mentioned above. Each ball represents a species, and is placed at the end of a "wire" which helps fix its position in space: the nearer a pair of balls in this

Figure 3: An adult male caenolestid (*Caenolestes obscurus*) from the Andes of southern Colombia. This animal is about the size of a marsupial mouse and weighs a little over an ounce. [Photo: Author.]

diagram, the more similar are the bloods of the species represented.

For Australians, the most interesting group of mammals is surely the marsupials, of which there are more than 200 species in Australia and South America. It is not surprising that in a group with such variety there should be a number of taxonomic puzzles, and we will look at a few of them.

In some cases these "puzzles" have simply amounted to sets of equally likely possibilities. One example is the problem of placing the koala. In its teeth, the koala resembles the Ringtail Possum and Greater Gliding Possum; moreover, the koala's two opposable thumbs, diet of leaves, and tree-climbing habits further indicate alliance with these possums. On the other hand, koalas also resemble wombats in general shape, lack of a tail, and backwards-opening pouch. Detailed study of the muscles and spermatozoa of the koala, wombats, and possums also suggests that koalas are essentially tree-climbing wombats. The physical evidence is about equally balanced, then, but the serological tests definitely favour the wombat-koala grouping; this similarity is quite evident in the computer drawing.

Burramys, thought extinct until a living animal was found in a Victorian ski-hut in 1966, provides a similar example. This animal has a large cutting cheek-tooth which is very similar to that of the rat kangaroos, but in other features of its skull it resembles the possums; thus *Burramys* had sometimes been considered a link between the two groups of marsupials, possums and kangaroos. Again, the evidence from study of its blood definitely favours one choice—that of allying it with the possums, and specifically with the Pigmy Possums and Feathertail Glider.

Sometimes serological study can suggest a situation that was not even suspected. Several years ago Bill Poole, of the CSIRO Division of Wildlife Research, and I began a serological study of Grey Kangaroos which eventually showed that what was then thought to be a single species could be divided into two groups on the basis of differences in blood proteins. Members of the two groups can be crossed in captivity, and their hybrid offspring always have the serological characteristics of both parents. However, despite extensive blood sampling from wild populations of Grey Kangaroos (including those from several areas where the two kinds live together) we have never observed a wild hybrid. Thus the two kinds of Greys recognize each other as distinct and do not interbreed in the wild, which is a good biological reason for recognizing two species of Greys.

The last and perhaps most interesting examples concern the similarities of the Australian and American marsupials. In the high Andes of South America live several species of small, shrew-like marsupials (figure 3), the caenolestids (kine-oh-less-tids), which belong to a group that was once more widespread and diversified in South America. All of them resemble the Australian "diprotodonts" (kangaroos, possums, wombats, and the koala) in having a pair of large, forward-projecting lower front teeth. For this reason taxonomists have speculated that caenolestids might really be more closely related to diprotodont Australian marsupials than to the other American marsupials, the didelphids, which are for the most part very similar to the Virginia Opossum.

In this case, serology gives an answer that is somewhat surprising. Like the American opossums, the caenolestids are quite distinct from all Australian marsupials. But, at the same time, caenolestids are just as different from the other American group as they are from Australian marsupials. Thus there are two major groups of marsupials in the Americas.

Of what use is such information? Most modern taxonomists are interested in more than just showing that some animals are similar or different; they also want to say something about the evolution of the animals. One aspect of evolution is the genealogy of species—that is, which ones had the most recent or distant ancestors. Serologists believe that, as a general rule, those organisms which are most similar serologically are most closely related in this way, and vice versa. Thus, it is probable that the origins of the three marsupial groups go back a long way in geological history, and it seems likely that marsupials have been evolving in South America for as long as or longer than they have in Australia. Furthermore, the similar teeth of caenolestids and some Australian marsupials must have evolved separately in Australia and South America.

But the studies of the American marsupials give one more bit of intriguing information. The monito del monte (little bush-monkey) is a small opossum, *Dromiciops australis*, that lives in the forests of southern Chile. From a study of its teeth, my friend Osvaldo Reig concluded that the monito is not a true didelphid at all, but a living representative of an otherwise extinct marsupial family. We have not yet done much serological work on this little animal, because it seems to be hard to catch except in years when a certain bamboo is in flower. But it may turn out to be the most interesting of all the South American marsupials, for tests so far indicate that it ties together all the marsupial groups, Australian and American, in a way which suggests it may be a kind of serological common ancestor of them all. It is clear that the serology of marsupials has raised new questions as well as providing highly satisfactory answers to some old ones.

FURTHER READING

Kirsch, J. A. W. (1968): "Prodromus of the Comparative Serology of Marsupialia". *Nature*, 217: 418–420.

Kirsch, J. A. W. (1968): "The Serological Affinities of *Burramys* and Related Possums (Marsupialia: Phalangeroidea)". *Australian Journal of Science*, 31: 43–45.

Nuttall, G. H. F. (1904): *Blood Immunity and Blood Relationship* (Cambridge, University Press), 444 pp.

BOOK REVIEW

BIRDS OF AUSTRALIA, by Michael Morcombe; Lansdowne Press, Melbourne, 1971; price, $4.95; size, 11¾ x 8¾ inches; 79 pages, 97 coloured photographs, 44 black and white illustrations; SBN 7018 0383 5.

The ninety-seven coloured illustrations are the main purpose of publishing this book. These are all very good, and show how the photographer's technique has improved through the years.

These illustrations are far more than just beautiful pictures; they have much scientific interest. They illustrate in many cases how the different birds take-off and land at their nest sites and what type of food they bring their young. The food can be clearly seen: the Azure Kingfisher with a small crayfish and the Western Spinebill with a cicada are examples. The picture of the Western Yellow Robin with a small lizard is probably the first evidence of a Robin with a lizard, and it would be interesting to know if this was successfully fed to the young birds.

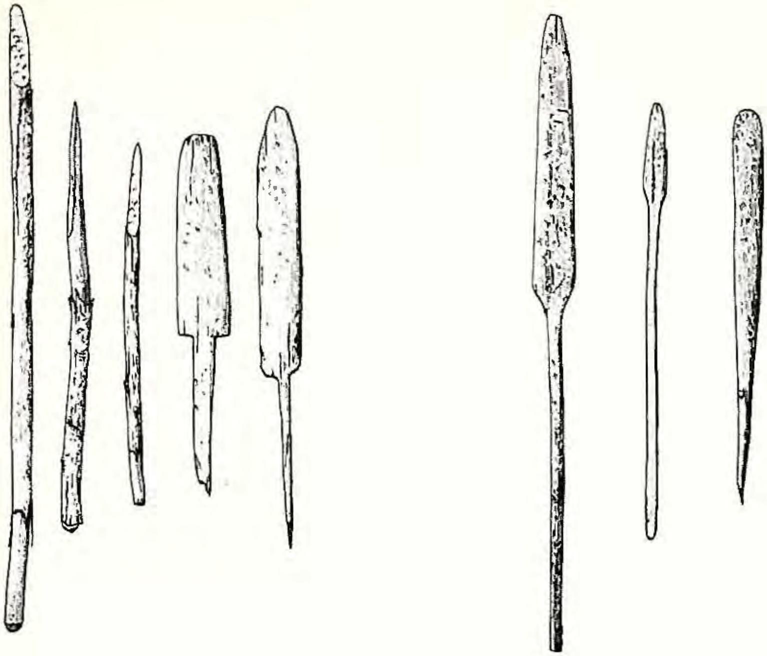
The text for each bird is simple and accurate, giving the general habitat of the bird and its distribution. Unfortunately, the text on page 37 (unnumbered) for the Purple-crowned Lorikeets and Rainbow Lorikeets has been related to the wrong pictures.

Towards the end of the book there are various lists: The Australian Bird Families; Birds of the Adelaide–Melbourne–Hobart Region; Birds of the Canberra–Sydney–Brisbane Region; Birds of the Broome–Darwin–Townsville Region; Birds of the Perth Region; Birds of the Kalgoolie–Alice Springs–Broken Hill Region.

Typical members of each group have been illustrated in black and white by the author, with a note on their size, colour, range, and habitat.

There is also a short note on the problems of bird photography, particularly high-speed photography.

This book is recommended for the information it gives both in the illustrations and text.—*H. J. de S. Disney, Curator of Birds, Australian Museum*



Types of wooden gardening implements recovered from archaeological sites near Mt Hagen. From left: two large-diameter, pointed digging-sticks; a small-diameter, pointed digging-stick; two short-handled, shield-shaped spades; a paddle-shaped spade; a small-bladed spade; another paddle-shaped spade. (The digging-stick at the extreme left is about 4 feet long. The drawings of the three spades at right are not to the same scale as the other implements; the large paddle-shaped spade is about 8 feet long. [Drawings by W. Mumford, Australian National University.]

MAN AND FLORA IN PAPUA NEW GUINEA

By JOCELYN POWELL

Department of Anthropology and Sociology, University of Papua New Guinea, Waigani

[*This article deals mainly with the Australian-administered eastern half of New Guinea, although most of its content is equally applicable to West Irian, the western half of the island.*]

SPREADEAGLED to the north of Australia lies New Guinea, the second largest island in the world and one of the most diverse in terms of landform, climate, vegetation, and people. In contrast to Australia, New Guinea is geologically relatively young, and, in many areas, tectonic and volcanic activity is obvious and continuing. High parallel mountain ranges with peaks rising to over 14,000 feet in altitude and intermontane valleys with floors at 5,000 to 7,000 feet altitude form a backbone over much of the island. These are flanked by areas of lower relief, by low mountains and strongly dissected foothills, and by broad plains to the north and south. A few large rivers drain the whole area.

Although New Guinea lies wholly within the "humid tropics", its climate is far from uniform. Annual rainfall ranges from 98 to 146 inches in most areas, but may be as high as 234 inches or as low as 39 in others. In the lowlands, temperature and humidity are uniformly high throughout the year, and there is little seasonality. With increased elevation temperatures become lower and humidity decreases slightly, while seasonal variations become more marked.

The vegetation is also extremely diverse, and botanists have estimated that the flora comprises over 20,000 species. Much of the flora is related to the Indo-Malaysian area, but Pacific and Australasian elements are also important. In the various parts of Papua New Guinea large areas are covered with dense tropical rainforest of extremely variable nature (lowland rainforest, lower montane forest, and montane forest), while others are covered with swamp grasslands or woodlands, savannah, subalpine and alpine communities, secondary forests and grassland, native gardens and associated plantings.

Within this extremely varied country over 2 million indigenous people live, unevenly distributed. About 40 per cent of the people inhabit the central highlands area, living at an altitude of between 4,000 and 8,000 feet, but other and smaller areas of equally dense population are found along parts of the north and south coasts. Over the rest of the country densities are very low, large areas being virtually uninhabited. The Papuans and New Guineans belong to the Melanesian race, and are distantly related to the Australian Aborigines. Physically they are very diverse, and they have many different languages and cultures.

In contrast to the Australian Aborigines, who are today predominantly hunters and gatherers, most Papuans and New Guineans are subsistence agriculturalists, growing such crops as taro, yams, bananas, and sweet potatoes.

Recent archaeological evidence suggests that man has been in some parts of New Guinea for at least 25,000 years and in the central highlands for at least 11,000 years. When he first arrived he must have been a hunter-gatherer, only more recently becoming an agriculturalist. This raises a number of interesting questions: how did the early settler exist, when did he become an agriculturalist, and what impact did he have on the natural vegetation of the country?

Forest Resources

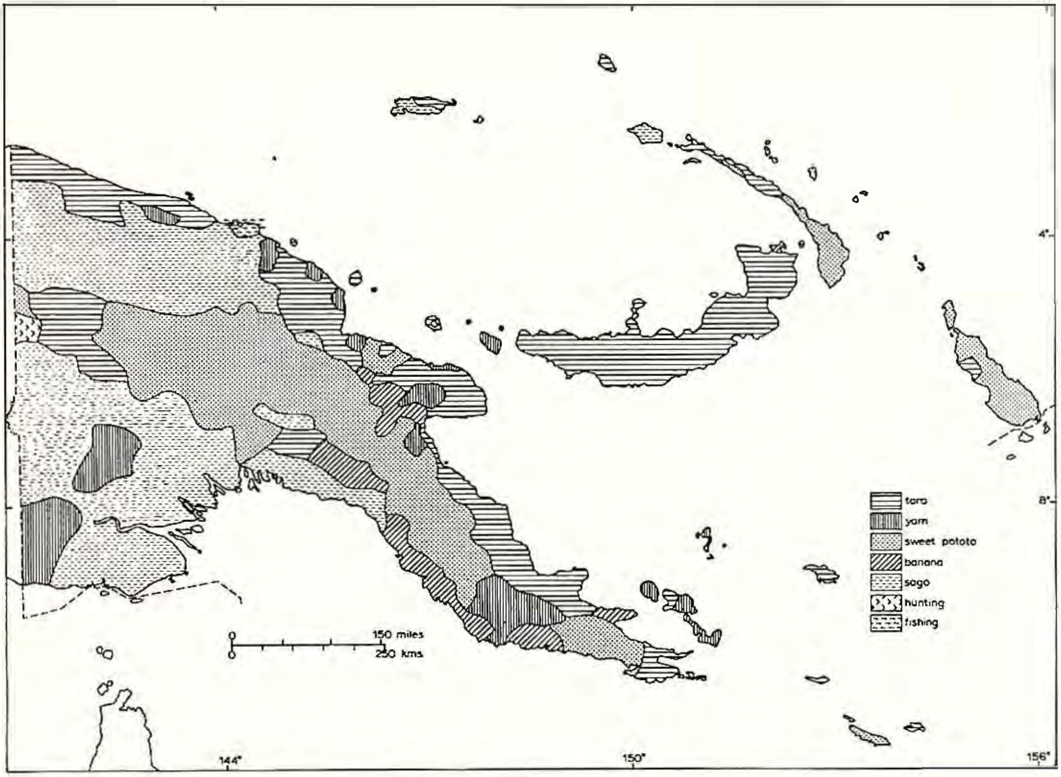
Throughout his history man has been dependent upon plant and animal resources for food, clothing, house-building materials, tools, and raw materials. In many areas of New Guinea animal resources are poor compared with other countries and the people have been forced to rely heavily on plant resources. Today, in many areas, forest products are still utilized, and these may give us some idea of the resources which were available in the past.

In coastal and lowland areas the coconut (*Cocos nucifera*) is very important, providing not only food but also fibre and household containers. *Hibiscus* species, with edible leaves and useful fibre, the breadfruit (*Artocarpus* species), with edible nuts and flesh and leaves used as cooking containers, and the *Areca* nut, used as a stimulant, are also important. Fresh nuts of various species of *Barringtonia* and *Canarium* are particularly rich foods, and sprouted fruits of the mangrove *Bruguiera* are also gathered and eaten. Occasionally eaten are the fruits of species of *Eugenia*, *Ficus*, *Gnetum*, *Morinda*, *Pometia*, *Rubus*, and *Pandanus*.

On the swampy plains of both the north and south coasts sago (*Metroxylon sagu*) forms the staple today, and no doubt has been used as such for many thousands of years. Sago palms grow in natural stands or are planted from shoots in shallow freshwater swamps. The palms take 8 to 15 years to mature; they are then cut down and the pith of the stem is pounded and washed to extract the sago flour.

In the highland forests *Pandanus* species are particularly important. While some types are planted within garden areas to supply leaves for mats, rain-capes, and house lining, others, with edible nuts and oily rich fruits, are individually owned and tended within the forests. Other forest trees with edible nuts include species of oak (*Castanopsis*), and *Elaeocarpus*, *Sterculia*, *Finschia*, *Sloanea*, and *Cryptocarya* species. These are rarely used today, but may have been very important in the past. A number of forest vines have edible fruits and many forest trees, shrubs, and ferns have edible leaves. There are also some wild edible tubers, *Dioscorea* species and *Pueraria* species, which may have been important food sources formerly; *Pueraria lobata* is cultivated in some areas today but is considered to be a famine food. Edible fungi are also plentiful.

Other forest products widely used today include vines for ropes in fencing and house building, resins for gums and glues, and hardwoods for bows and arrows, axe handles, clubs, and gardening implements. Many native medicines are produced from forest plants as well.



Staple crops and main sources of food in Papua New Guinea. [Map by courtesy of the Geography Department, University of Papua New Guinea.]

Subsistence gardening

Today, subsistence gardening is the main pursuit of most Papuans and New Guineans, supplemented by hunting, gathering, and trading. Agricultural patterns differ throughout the area, showing adaptation to the various climatic and edaphic conditions extant. The map on this page shows the distribution of staple foods in the various parts of the country.

In the hot, humid lowlands, taro (*Colocasia esculenta*), yams (*Dioscorea* species) and bananas (*Musa* species) are the main crops grown. Areas of dense jungle are partially burned and cleared, and the various species are planted amongst the remaining trees in mixed gardens. There is little cultivation or tillage of the soil, and once the crops have been harvested the garden is abandoned to revert to secondary regrowth forest. A new garden is cleared elsewhere, the former area being re-used only after a fallow of 20 years or more.

In drier areas of the lowlands bananas become the staple, with taro, yams, and sweet potatoes (*Ipomoea batatas*) as subsidiary crops. Many different varieties of bananas are grown, some of which are eaten cooked while others are sweet and can be eaten fresh. They are grown in much the same way as described above.

Throughout the central highlands, between 3,500 and 9,000 feet in altitude, sweet potato is the staple crop. It is often grown in large "open field" gardens and various methods of cultivation are used, including complete tillage, mulching and fertilization, mounding, and water control ditching. The crop matures in 6 to 14 months, and may be harvested for quite a long period before the garden is left to fallow under grass. The same ground is reworked within a year or so. Subsidiary crops such as taro, yams, bananas, and sugar cane (*Saccharum officinarum*) are usually grown in mixed gardens nearby, and these have a tree fallow which lasts for several years. Accompanying

A typical settlement area near Mt Hagen. Note the bamboo stand near the men's (round) house and the women's and pigs' (oblong) house, the chequer-board pattern of sweet potato gardens, and areas of mixed gardens and grass fallow. [Photo: Author.]

photos show different types of gardens found in the highlands.

As well as the main crops grown throughout the country a number of other plants are cultivated for food, for condiment, or for their other useful products. They include, as food plants, some of the grasses, *Setaria palmifolia* and *Saccharum edule*, a number of *Amaranthus* species, beans such as *Dolichos lablab* and *Psophocarpus tetragonolobus*, and some members of the carrot (*Oenanthe javanica*) and cabbage (*Brassica* species) families. Gingers (*Zingiber* species) and peppers (*Piper* species) are grown as condiments. Shrubs and small trees which provide useful fibre, such as *Broussonetia* species, *Acalypha* species, *Pipturus* species, and *Trema* species, are also grown in the mixed gardens or near houses.

In the highlands *Casuarina* species are planted to provide bark for house linings and timber for spears, bows, axe handles, digging sticks, house building, and firewood. In many areas bamboo (*Bambusa* species) is planted for use as water-containers, food-cooking vessels, sleeping platforms, plaited mats, knives, bows and bowstrings, arrow shafts and arrow heads, combs, and musical instruments. In some areas the young shoots are cooked and eaten. Gourds (*Lagenaria siceraria*) are also widely planted for use as water bottles, and as lime and fat containers.

In addition to the food plants and other useful species, many people plant ornamental trees and shrubs near their houses and along track-sides. Variegated-leaved *Croton* are a feature of many villages, red and purple *Coleus*, *Plectranthus* and *Elatostema* are used as borders, and green, red and yellow tankets (*Cordyline* species) are ubiqitous. Many different kinds of variegated aroids are also grown.

Impact of man on the natural vegetation

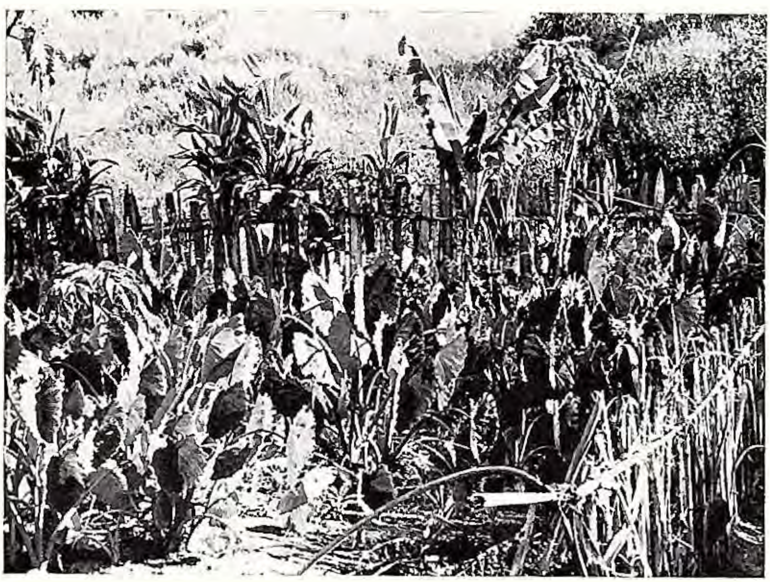
Studies of present-day plant ecology have led botanists to consider that many of the large areas of grassland in Papua-New Guinea are anthropogenic in origin. By his extensive use of fire, by clearing forest, and by tilling and weeding gardens, man has reduced much of the formerly forested land to grassland. This appears to be particularly true for highland areas where the sweet potato is the staple crop.

Evidence from studies of vegetation history in the highlands tends to support the anthropogenic grasslands hypothesis. In one region, near Mt Hagen in the western highlands, clearance of forest occurred at least 5,000 years ago, the forest being replaced by secondary regrowth shrubs and trees and by grassland and fernland. Further west, clearance appears to have occurred more recently.

Today, however, the rate at which grassland develops after gardening appears to be very slow indeed; in fact, given the intensive cultivation methods, the controlled fallow period, and the well-defined units of land-use, it seems likely that the balance is in favour of regeneration of shrubby regrowth over formerly more extensive grassland and garden.

It is interesting to note that most of the staple crops grown today are, in fact, introduced species: taro and yams are considered to be of south or southeast Asian origin, many of the bananas have come from the Malaysian area, and the sweet potato is of Central American or South American origin. Only the sago, sugar cane, and some of the bananas, among the main crops, are of New Guinea origin. On the other hand, many of the subsidiary food plants and the small trees and shrubs utilized in the many different ways mentioned above are indigenous to New Guinea and have probably been domesticated there.

The introduction of taro, yams, and sweet potato into New Guinea must have had a considerable effect on the subsistence economy of the early people, in that it would allow them to end their complete or near-complete dependence upon natural resources and to develop horticultural and agricultural systems more fully. When did these crops arrive? Little is known about the time of arrival of taro and yams, but they are generally assumed to have been introduced prior to the sweet potato. This latter crop, today the staple throughout most of the highlands and an important crop in many other areas, is unlikely to have reached New Guinea before the sixteenth century, following its introduction into the Philippines by the Spaniards.



Part of a mixed garden, with taro predominant. Bananas, fibre plants, and tankets are also growing. The fence is of split *Casuarina* and cane grass. [Photo: Author.]

The result of the introduction of sweet potato has been claimed by some workers to have been revolutionary, at least for the highlands; its adoption is considered to have allowed widespread changes in agricultural practices to be made, and rapid population growth and redistribution of populations, especially to higher altitudes, may have occurred. Also, social changes, including the development of permanent settlements and more stable social structure systems, may have resulted.

Such an hypothesis has many exciting implications, but recent archaeological and botanical studies do not entirely support it. The only direct evidence for early agriculture in New Guinea so far comes from two sites in the western highlands, near Mt Hagen. At one of these, the Manton site (situated at an altitude of 5,200 feet on alluvial deposits in the Upper Wahgi Valley), a series of prehistoric ditches were discovered lying beneath undisturbed swamp peat. Excavations recovered wooden fence-posts, pointed digging sticks and paddle-shaped spades, as well as ground stone axe-adze blades and grinding stones. Radiocarbon dating of a digging stick, lying in situ at the base of a ditch, indicated that the area was being used about 2,300 years ago. At the other site, Minjigina (situated about 10 miles away, at 6,200 feet on the volcanic plain at the base of Mt Hagen), similar dates were recorded for peat at the base of a prehistoric ditch and for charcoal taken from a fireplace associated with the ditch. The accompanying drawing illustrates some of the gardening implements recovered from the archaeological sites.

Studies of stratigraphy and sediment analysis at both sites confirmed the agricultural use of the swamps. Botanical studies of macrofossil plant remains and pollen analysis were also undertaken at both sites, but no direct evidence of the major crops grown was forthcoming. However, a number of other species were recorded which today are important domesticates and settlement-area plants, and they may have played the same role then.

Other pollen-analytical evidence suggests that agriculture was being practised before the swamps themselves were used. Thus, at both sites, former forest appears to have been extensively cleared from the surrounding slopes by 5,000 years ago, being replaced by grassland and secondary communities. More recently, when the swampland was abandoned about 400 to 550 years ago at the Manton site, the slopes were again used for gardening and many of the useful plants grown today near settlements were being planted or retained. From then until the present time, in fact, a more sophisticated pattern of land use appears to have developed, involving selective cutting of forest or secondary regrowth, and conservation or planting of many different species.

This evidence, then, suggests that primitive subsistence agriculture was being practised in some highland areas at least 5,000 years ago and that it was fairly highly organized and extensive by 2,300 years ago, well before the arrival of sweet potato.

Much remains to be done before the record of the interplay between man and the natural vegetation of New Guinea is complete. The recent studies reported above have provided partial answers to some of the questions but have raised many more: was taro the pre-sweet-potato staple in the highlands, were the swamps abandoned at the time of sweet potato introduction, why were the swamps used at any time, were specialized cultivation techniques introduced at the same time as the crops or did they develop independently in New Guinea to suit local conditions, and so on.

Studies of present-day and past vegetation patterns and of man's utilization of plant resources, such as those described above, are not only of academic interest; they can also provide valuable data for future land-use planning and for concepts of conservation.

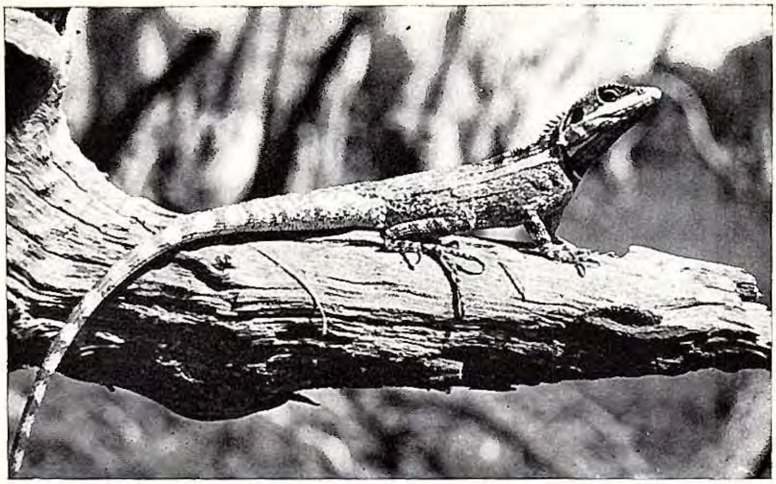
FURTHER READING

Barrau, J., 1958: "Subsistence Agriculture in Melanesia." *B. P. Bishop Museum Bulletin, No.* 219.

Bulmer, S., and Bulmer, R. N. H., 1964: "The Prehistory of the Australian New Guinea Highlands". *American Anthropology*, 66, 2, 39–76.

Powell, J. M., 1970: "The History of Agriculture in the New Guinea Highlands". *Search*, 1,5,199–200.

Robbins, R. G., 1963: "Correlation of Plant Patterns and Population Migration into the Australian New Guinea Highlands", in Barrau, J. (ed.), *Plants and the Migrations of Pacific Peoples*, Bishop Museum Press, 45–59.



A Swamp Dragon Lizard (*Lophognathus temporalis*) on the alert for insects. These lizards are common around the edges of swamps on Coburg Peninsula.

REPTILES AND AMPHIBIANS OF COBURG PENINSULA

By H. G. COGGER
Curator of Reptiles and Amphibians, Australian Museum

COBURG Peninsula is a small, heavily indented tongue of land that juts out into the Arafura Sea from the northwestern tip of Arnhem Land, to form the protective northern boundary of Van Diemen Gulf.

The Northern Territory Administration has proclaimed the whole of Coburg Peninsula a Wildlife Sanctuary, and, anxious to obtain an accurate assessment of the animals inhabiting the Peninsula and the management problems involved in conserving them, a faunal survey of the area was initiated. This survey was undertaken largely by the CSIRO Division of Wildlife Research, whose chief, Dr H. J. Frith, invited me to participate in their programme.

Historical background

To a Museum biologist, Coburg Peninsula is irresistible, for it was the site of one of the earliest settlements in northern Australia, and hence many of the animals which are widely distributed throughout the north were first described from this area. Port Essington, on the northern side of the Peninsula, was first surveyed by Captain Phillip Parker King in 1818. King later recommended Port Essington as a site for a settlement, but when Captain J. J. G. Bremer was sent there for this purpose in 1824 he failed to find water, and so established the first northern settlement at Fort Dundas on Melville Island. When this settlement failed, another attempt was made at Raffles Bay, at the northeastern end of Coburg Peninsula, but this, too, was soon abandoned.

In 1838, Captain Bremer was again sent to Port Essington, and there he set up a settlement (which was named Victoria) on the shore near Barrow Bay, some 15 miles from the mouth of the port. The settlement at Victoria was set up as a military establishment charged with the task of protecting Australia's vulnerable northern coastline from foreign annexation, for at that time the French were thought to pose a major threat. This fear was probably heightened by the fact that, soon after Bremer arrived, a French

The bleached cliffs of Barrow Bay (top right), above which the settlement of Victoria (lower right) was built in 1839. The fort is marked by the flagpole at the left in this drawing, and the powder store to the immediate right of the fort is still intact today (below).

expedition under Dumont D'Urville arrived in Raffles Bay. However, the French stayed only a short time, and their relations with the settlement at Victoria were very cordial.

During its 11 years' existence the settlement was visited by the then burgeoning number of explorers and naturalists who travelled overland or arrived in their survey ships. During their stays they collected or were given many examples of the local animals and plants, which ultimately found their way into the large museums and herbaria of Europe. There, other naturalists were quick to describe these new and fascinating examples of Australia's rich and varied wildlife.

With this background, it is little wonder that I was eager to visit Port Essington to participate in the CSIRO survey. Before leaving for Coburg Peninsula, where I was to join the ranger, David Lindner, an old friend and experienced herpetologist, I spent some time in the Australian Museum's library obtaining early records and descriptions of the reptiles and frogs found at Port Essington. At the same time I found many firsthand accounts of the early settlement at Victoria, some of which are well worth recounting.

When the settlement was established in 1838 it was soon placed under the command of Captain John Macarthur, and he "ruled" it until its demise in 1849. In July 1839 J. Lort Stokes visited Victoria in H.M.S. *Beagle* and had nothing but praise for the ". . . capital of Northern Australia, destined, doubtless . . . to become not only a great commercial resort, but a valuable naval post in time of war." This optimism was despite his admission that the settlers had ". . . experienced a large comparative mortality . . ." and that the climate ". . . though not absolutely pernicious in itself, is unsuited to European constitutions." He also pointed out that ". . . the warmth of the climate in itself conduces to intemperance, which to Europeans is ever fatal"!

In 1840–41, John Gilbert, for many years an assistant to John Gould, spent 8 months at Port Essington collecting birds and other animals. Gilbert was later a member of Leichhardt's remarkable 1844–45 expedition from Moreton Bay to Port Essington, but this able and enthusiastic collector was killed by a spear when the camp was attacked by natives on 28th June, 1845.

By 1848, when Victoria was visited by Thomas Henry Huxley in the *Rattlesnake*, its end was near. Huxley was unimpressed: ". . . the place looked very deadly lively . . . We dropped anchor opposite a high cliff on the left bank of the harbour, on the top of which was perched a ruinous looking block house with a few pieces of cannon mounted on its top, the firing off of which would I verily believe have blown down the whole concern!" Although Huxley had a few good words to say for the local fruit, and for one or two of the officers, he was otherwise scathing in his criticism of the settlement and its commandant. Of the latter he said: ". . . the respected Captain Macarthur is with all reverence one of the most pragmatical old fogies I ever met with, and contrives to keep the people under his command continually in hot water . . . there is as much petty intrigue, caballing and mutual hatred as if it were the court of the Great Khan."

But his most vituperative comments he reserved for the settlement itself: ". . . it deserves all the abuse that has ever been heaped upon it. It is fit for neither man nor beast. Day and night there is the same fearful damp depressing heat, producing an unconquerable languor and rendering the unhappy resident a prey to ennui and cold brandy-and-water . . . Port Essington is about the most useless, miserable, ill-managed hole in Her Majesty's Dominions."

With these various comments in mind, I left Sydney for Port Essington. From Darwin, a Cessna flight of less than an hour (with a map on my lap to pinpoint landmarks —the pilot had not made the trip before) brought me to the airstrip near Smith Point, the northeastern headland of Port Essington. Flying low, we saw numbers of turtles and hammerhead sharks in the shallow reef waters around the entrance to the port, while the coastal dunes frequently gave way to large, shallow lagoons only a short distance behind the coast. The most striking feature as we passed over Port Essington was Record Point, a long narrow spit of sand, so named because in 1824 Sir Gordon Bremer buried a bottle containing an account of his visit there.

I was met at the airstrip by David Lindner and spent the following month with him and his wife Marjory at their home at Black Point. From this base we moved by Land Rover along the one track, much of which David had to build, that passes around the coast to Port Bremer and then across country to Oenpelli. By aluminium dingy and outboard we visited Trepang Bay, Coral Bay, and Sandy Island Number One, as well as exploring the bays and creeks of Port Essington itself.

Wide range of habitats

Coburg Peninsula provides such a broad spectrum of habitats that it is a particularly suitable fauna reserve. Large dunes behind the coastal beaches give way to a patchwork of brackish and freshwater swamps, open grasslands, savannah, and pockets of rich monsoon forest. Numerous creeks and inlets are fringed by extensive mangrove forests.

Apart from a rich variety of birds, the animals usually encountered during the day were the ubiquitous little Agile Wallaby (*Macropus agilis*) and wild Banteng or Indonesian cattle (*Bos javanicus*). The latter were introduced into Coburg Peninsula, to which they are still confined, during the last century. They are timid beasts, and one usually sees them as a pair of white buttocks, tail locked between, disappearing into the surrounding scrub. Quite a few Water Buffalo (*Bos bubalos*) also inhabit the Peninsula.

The more obvious diurnal reptiles were small skink lizards (family Scincidae). These ranged in size from 3-inch-long Snake-eyed

A shallow swamp at Black Point, Port Essington.

Skinks (*Cryptoblepharus boutonii*), arboreal lizards particularly in evidence on the she-oaks behind the beaches or on the Black Point buildings, to 10-inch Striped Skinks (*Ctenotus robustus*). The latter were usually seen only as a movement out of the corner of one's eye as they dashed for cover through the grass. A much larger lizard, seen only occasionally, was the Frilled Lizard (*Chlamydosaurus kingii*). This is an inhabitant of the open woodlands on the Peninsula, and specimens from Coburg, their blackish frills with bright orange or red centres, were very spectacular.

Although many snakes were found during my visit, the only species commonly encountered during the day was the Green Tree Snake (*Dendrelaphis punctulatus*), an agile, slender, fawn-coloured snake with yellow under-surface, which makes off at great speed when disturbed.

Although there are no rivers on Coburg Peninsula, small creeks and swamps abound. Near the ranger's quarters at Black Point is a large swamp, fringed by paperbarks (*Melaleuca*) and *Pandanus* palms, which at that time provided water for the camp. This swamp was typical of many in the area, with large expanses of reeds alternating with clear, leaf-strewn banks. Living in the reeds were thousands of tiny tree frogs, *Litoria bicolor*; indeed, they were so numerous that as one walked through the swamp the sheer weight of the fleeing inch-long frogs caused the reeds just ahead to bend over as if blown by a strong wind.

Snake-necked Tortoises (*Chelodina rugosa*) were also plentiful in the swamps, although their presence was indicated only by occasional bleached skeletons along the bank. A more obvious diurnal reptile around the edges of the swamps was a large dragon lizard, *Lophognathus temporalis*. This lizard was abundant, but, as it would often sit motionless on a branch while waiting for passing insects, would be all but invisible till it moved. Then it would take off at great speed, running only on its hind legs. The secret of catching these lizards was to see them before they took off, and then to approach them very slowly until within "pouncing" distance.

Screaming frogs

I had a common but interesting experience while collecting in the vicinity of this and other swamps. Suddenly the air would be rent by a piercing and fearful scream, which, the first time I heard it, was only a few feet from my ears and gave me a terrific fright. On each occasion the screaming was found to emanate from the limb of a nearby tree, where, after some effort with an axe, the culprits were always found to be a tree monitor or goanna, *Varanus timorensis*, and one or more Green Tree Frogs (*Litoria caerulea*). The goanna, on entering the hollow limb, would find its way blocked by one or more sleeping tree frogs. Unwilling, or sometimes unable, to reverse in the confined hollow, the goanna would try to force its way past the loudly protesting frogs. This was so common that by the end of a month I regarded it as an almost daily event. We never found any evidence that the goannas might be feeding on the frogs.

Because so many reptiles and frogs are active only at night, we also spent every evening searching for these animals. At night the swamps were just as "alive" as during the day. Frogs of several species were abundant, and were a source of food for the many Keel-back or Freshwater Snakes (*Amphiesma mairii*) which we encountered. Snake-necked Tortoises were also easy to spot in our torch beams while we were wading through the shallow water.

Reptiles on beach dunes

The beach dunes also proved rich in reptiles. Several species of sea turtles emerged from the surrounding reef waters to dig nesting chambers and lay eggs. Green Turtles (*Chelonia mydas*) and Flatbacks (*Chelonia depressa*) are the dominant species, but occasional Loggerheads (*Caretta caretta*) and Pacific Ridleys (*Lepidochelys olivacea*) also nest in the area. David Lindner's discovery of the nesting of the Pacific Ridley constituted the first record of this species from Australia. Each morning the beach dunes soon became criss-crossed with the tracks of Common Sand Goannas (*Varanus gouldii*). These predatory lizards would search out the previous night's turtle nests and feed on the eggs.

One of the delights of our torchlight wanderings over the dunes were the large numbers of the exquisite little native mice, *Legadina delicatula*, foraging for seeds among the grass.

Although crocodiles are now afforded a high degree of protection in the Northern Territory, the past slaughter and the depredations of modern poachers from Queensland have left precariously few Saltwater Crocodiles (*Crocodylus porosus*) to maintain their population. Although in 1839 Stokes was able to comment that "alligators abound", we saw very few specimens. However, I often spent the oppressive middle part of the day sitting in the shade of a tree on the cliffs overlooking Reef Point. Apart from numerous turtles foraging along the reef, on several occasions I also saw a large crocodile about 15 feet in length cruising in the sea below me.

Crocodile's remarkable behaviour

Another crocodile was also seen regularly during my visit, under circumstances which I still remember with great pleasure. One night, early in my visit, David and I were hunting frogs and snakes around a large but shallow swamp near the airstrip. Flashing our torches across the water we saw, on the far side of the swamp, the telltale golden reflections from a crocodile's eyes. After 5 minutes or so, David turned to me and said, "You know, those eyes are coming closer." Soon they were only a few yards away, and imagine our surprise when the crocodile swam silently up and rested its snout at our feet. It was only about 6 to 7 feet long, but how I cursed my stupidity in leaving my camera and flashgun back at camp. After a few minutes one of us moved and the crocodile threw itself back into deeper water with an almighty splash.

Next night, with no real expectation of repeating the performance, I returned with my camera. Sure enough, right on cue, the crocodile approached our torches and came to rest with its snout at our feet and I got my pictures. We subsequently renewed our acquaintance on several occasions, and I hope that no hunter has yet taken advantage of this naive saurian.

About half-way through my visit we travelled in the boat to the site of the old settlement at Victoria, where we camped, away from the sea breezes that make life so pleasant at Black Point. The heat was oppressive, while at night the mosquitoes were very bad. One could well understand the effect that these must have had on the ultimate fate of the original settlement. Today all that remains of Captain Macarthur's domain are a few brick chimneys, the bakehouse, the kiln in which the settlement's bricks were made, and a well-preserved powder store. A short distance away, in thick bush, a cluster of graves bear witness to Bremer's ill-chosen site.

Collecting among the ruins

At night, these ruins provided rich collecting for reptiles. Brown Tree Snakes (*Boiga irregularis*) were found foraging along the tops of the remaining walls, while the small, ghostly forms of the Northern Dtellas (*Gehyra australis*) scuttled about the chimneys, disappearing into their interiors when we approached. These agile geckos have large pads on their feet; at night all vestige of their daytime pattern disappears, to leave them white and almost translucent.

On a couple of occasions we also visited Knocker Bay, where a group of Japanese run a large pearl-culture station for a Japanese-Australian Company. We timed our visits to coincide with their day-off, for we found that despite our language difficulties the Japanese workers regarded frog hunting in the swamps behind their settlement as a welcome change in their routine, and their enthusiasm resulted in many specimens being added to my collection.

Evidence of ecological continuity

The reptiles and frogs of Coburg Peninsula tend to be species which range widely throughout northern Australia. One of my most exciting discoveries was of a small frog, *Sphenophryne robusta.* This frog, which averages scarcely more than half an inch in length, is a member of the family Microhylidae; in Australia the members of this family were previously thought to be confined to the rainforests of northeastern Queensland, although this species also occurs in southern Papua. Found together with this frog in saturated leaflitter in paperbark swamps was another tiny frog, *Litoria dorsalis.* This species, too, was previously known only from Cape York and Papua. Taken together with some of the reptiles collected, these examples imply quite strongly that at some time in the not-too-distant past some degree of ecological continuity occurred between these three geographic regions.

It is questions of this nature—the faunal relationships between different regions—that surveys of the kind undertaken on Coburg Peninsula can help to answer. And it is only by a knowledge of the total range of species inhabiting a particular area, their relative abundance, habitat preferences, etc., that we can begin to assess the degree to which a particular region can be exploited without bringing about irreparable deterioration of its animal and plant communities.

[*The photographs in this article are by the author.*]

MEET OUR CONTRIBUTORS ....

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HAROLD COGGER is Curator of Reptiles and Amphibians at the Australian Museum. He holds B.Sc. (Gen.Sc.) and M.Sc. degrees from the University of Sydney and a Ph.D from Macquarie University. Dr Cogger is especially interested in the reptiles and frogs of Australia and the southwest Pacific region. He is Honorary Curator of Reptiles at Taronga Zoological Park and a Research Associate of the California Academy of Sciences.

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KEITH H. NORTHCOTE is a Senior Principal Research Scientist and Head of the Pedology Section in Adelaide of the Division of Soils, CSIRO. He graduated B.Agr.Sc. from the University of Melbourne, where he became Research Assistant to the Professor of Agriculture, Professor Sir S. M. Wadham. He joined the Division of Soils, CSIR (now CSIRO), in December 1943 and carried out soils research and surveys under the guidance of Professor J. A. Prescott and Mr J. K. Taylor. During 1956 he spent six months studying soils in the U.S.A. and Europe.

JOCELYN POWELL studied botany at Auckland University, New Zealand (B.Sc. 1960, M.Sc. 1963), and worked in the Crop Research Division of the New Zealand Department of Scientific and Industrial Research for four years as a cytogeneticist. In 1965, as a research scholar at the Australian National University, Canberra, she began ecological and palaeobotanical studies in the New Guinea highlands, and gained her Ph.D. in 1970. Since then she has been affiliated with the Department of Anthropology and Sociology at the University of Papua New Guinea.

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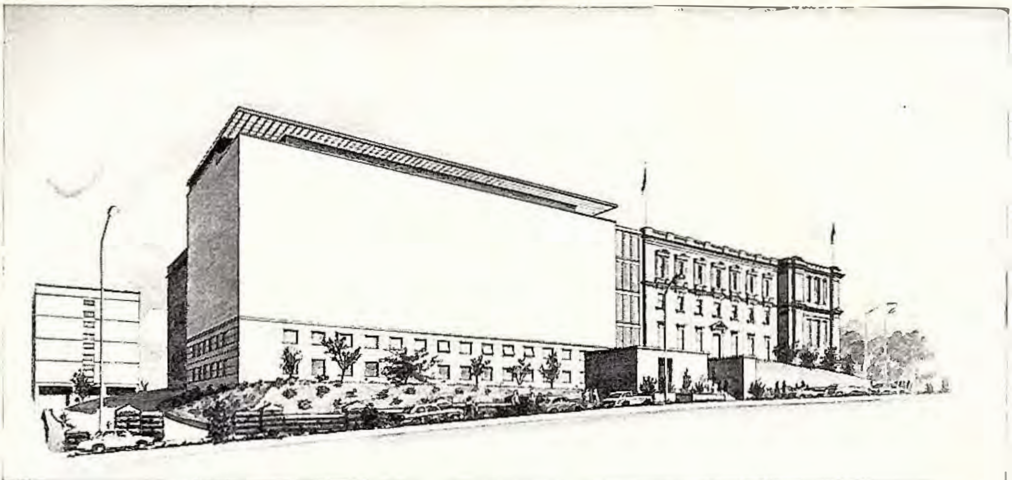

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