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• An Australian Aboriginal bark painting, from Milingimbi, Arnhem Land, of a clutch of eggs in an emu's nest, surrounded by emus feeding in the bush. The tracks of emus are also seen. The colours used by the Aboriginal artist are black, white and yellow on a red ground. The painting is in the collection of the Australian Institute of Aboriginal Studies. This photo of it is by Howard Hughes. An article on "The Emu and the Aborigines" appears on page 16.

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Notable Australian Ornamental Stones

By R. O. CHALMERS

ORNAMENTAL stones are translucent or opaque minerals that show attractive colours and patterns, or a combination of both. Because of this they are mostly cut in rounded shapes often called cabochons, or as slabs or other simple shapes. Surfaces are smoothed by grinding and finally polishing, which displays the colour and pattern to greatest advantage. The collecting, shaping and polishing of these have become a hobby that for many years in America has ranked second only to photography. In the last 10 years an ever-increasing number of Australians have become active practitioners in lapidary work.

In a previous article (R. O. Chalmers, *Australian Museum Magazine,* Vol. XIII, No. 12, December, 1961, page 403) a general account was given of the geological occurrence of ornamental stones, particularly in New South Wales. Not only in New South Wales, but throughout the eastern Australian highlands, there are the same extensive flows of basalt, flows and intrusives of alkaline volcanic rocks and widespread belts of fine-grained silicified sediments, so that the other States of eastern Australia yield their quota of ornamental varieties of the silica minerals such as chalcedony, agate, onyx, jasper and common opal.

The thick flows of basalt, rhyolite, and trachyte in the Macpherson Range have provided a wealth of these minerals. Released from amygdaloidal cavities by weathering of the rocks, these ornamental minerals have been carried by streams into New South Wales and Queensland.

In southern Queensland, particularly in areas not far distant to the west of the Gold Coast, good specimens are found in the valleys of the Nerang, Logan and other northerly flowing streams, at such places as Numinbah Valley and Beechmont. These areas are only a short distance from Brisbane and are naturally much frequented by lapidary enthusiasts from that city.

Outstanding Occurrences

There are two outstanding Queensland occurrences that have each been known for 50 years or more, but have only become

A polished specimen of banded jasper, 15 inches long, from Marble Bar, Western Australia. This specimen is on display at the Museum. [Photo: C. V. Turner.]

generally known in the last few years because of the greatly increased activity of the amateur collector and the development of companies for the mining and quarrying of ornamental material in response to the growing demand from the amateur lapidaries.

The first of these is the Agate Creek area in the far north of Queensland. Agate Creek is one of the head tributaries of the Robertson River, which flows into the Gilbert and is 20 miles west-south-west of Percyville. Extensive areas of amygdaloidal basalts, as much as 300 feet thick in parts, have numerous fillings of chalcedony, sard, carnelian, agate, onyx and sardonyx. These have been released by weathering of the basalts and are found lying loose on the surface as well as in the streams. These amygdules are up to several inches in diameter, and the mineral is usually unflawed, lending itself to the sawing of good slabs without much wastage. There is an abundance of high-quality material showing beauty of colour and pattern of such quality as to place this outstanding locality in the first rank, equalling the famous world localities of Brazil, Uruguay and India.

Despite the remoteness of Agate Creek, and the fact that it is accessible only to ordinary vehicles in the dry season, more and more collectors are visiting the area and already there is depletion of first-quality specimens. This is happening in other areas, especially those more readily accessible. Minerals, after all, are an asset that can't be replenished.

At Marlborough and Princhester, some 60 miles north-west of Rockhampton, chrysoprase has been mined fairly extensively since 1963. Chrysoprase is a variety of chalcedony, usually a pale tint of green. The pigmenting agent is a nickel compound. The Marlborough chrysoprase occurs in sizable seams in serpentinite, an ultrabasic rock consisting largely of serpentine. Serpentinite is the source of the nickel which has imparted an apple-green colour to the chrysoprase of such an unusually deep tint that it resembles jadeite, the most valuable of the jade minerals, in colour, but certainly not in texture or lustre. This has led to some local commercial interests marketing it under the misleading names of "Australian jade" or "Queensland jade", which is quite unethical since jadeite is a much more valuable mineral than chrysoprase.

Victorian And Tasmanian Localities

In Victoria, Melbourne collectors and lapidaries are catered for in the Dandenong Ranges, where a variety of ornamental silica minerals have been washed out of igneous rocks by both eastward and westward flowing streams.

Victoria's best localities for ornamental silica minerals are in thick gravel beds along the banks of creeks in the Kelly country to

the east and south of Wangaratta, particularly Beechworth. Since these beds have been washed for gold for well over a century, good specimens of the ornamental minerals would be very scarce at the present day.

Tasmania should not escape mention, particularly because the recent activities of a group of enthusiasts in Hobart have publicized some outstanding examples of ornamental silica minerals. There are numerous localities, mostly in the eastern areas, particularly where alluvial mining for cassiterite, the chief ore of tin, has been carried on in the north-eastern section of the island.

In the northern part of the Northern Territory and in the coastal regions of Western and north-western Australia, the physiography, geology and climate are akin to the eastern highlands in the sense that basalts, those prolific host rocks for so many varieties of the ornamental silica minerals, are well developed in places, and there are the rainfall and a sufficient degree of physiographic relief to provide the fast-running streams to transport these minerals. Varieties of chalcedony, carnelian and agate, have been reported, particularly from the whole of the de Grey River system that enters the sea near Port Hedland, and the headwaters of the Ashburton, 130 miles north of Meekatharra.

Elsewhere in central, southern and western portions of the continent, most of which is the vast, arid, inland riverless region, the types and occurrences of ornamental stones are somewhat different. Due to the absence of running streams there are few accumulations of waterworn pebbles and fragments of silica minerals. In the majority of cases specimens are collected directly from outcrops.

Banded Jasper And Common Opal

The two striking types of ornamental stones in these areas are banded jaspers and various types of highly decorative common opal, including opalized chrysotile asbestos. Marble Bar, in the Pilbara district, which lies inland from Port Hedland, is so named because of a great band of very decorative red and dark bluish-grey banded jasper near the town, although it is, of course, a misnomer to call this highly siliceous rock marble. Similar rocks are common throughout the whole Pilbara district

A specimen of agate, with a maximum width of 3 inches, from Agate Creek, north Queensland. It was lent by Angus and Coote, jewellers, of Sydney. [Photo: C. V. Turner.]

and, indeed, large portions of the whole north-west geographical province of Western Australia, in which Mable Bar is only one small area.

The occurrences of banded jasper in Western Australia are too numerous to mention. They are extensively developed in the vicinity of Kalgoorlie and other localities in the goldfields of the central province.

The most striking and decorative of the many types of common opal in the west is the opalized chrysotile asbestos which has a shimmering delicate chatoyancy far surpassing in attractiveness the much better known golden-brown silicified crocidolite ("tiger's eye") from the commercial asbestos fields of South Africa. It is found mostly in beautiful tints of pale yellow and green. The two most noted localities are Lionel, near Marble Bar, and Bulgaroo, on Byro Station, 180 miles south-east of Carnarvon. There has been small commercial production from this latter locality.

Three other types of common opal deserve mention. A deep orange to reddish-brown common opal, ranging from translucent to almost transparent, occurs at widely spaced localities between Meekatharra and Nullagine, and in the central goldfields in the Laverton and Kalgoorlie areas. This unfortunately is sometimes called "fire-opal", a name which should apply only to the Mexican precious opal which has a similar body colour and translucency but shows play of colours.

Green, translucent common opal that owes its colour to copper silicate is recorded from Nannine, in the Murchison province. Green common opal, pigmented by chromium compounds, is found at Poona. At Lake Yindarlgooda, 20 miles east of Kalgoorlie, where it is associated with serpentine, it probably owes its colour to nickel compounds. In this latter locality and also at Comet Vale, 62 miles north of Kalgoorlie, chrysoprase is found.

Moss opal containing inclusions of delicate dendritic masses of manganese oxide are found between Spargoville and Norseman. Two principal types of body colour are known, translucent yellow to yellowish-green, and pale brownish-fawn.

South Australian "Luck Stones"

In South Australia banded jaspers are known, particularly jaspilite, in which the alternate bands are black massive hematite and pale yellowish-brown jasper. This occurs at Iron Duchess, in the Middleback Range, Eyre Peninsula, where Australia's greatest iron ore deposits are worked on a huge scale.

Also on Eyre Peninsula, in the Cleve-Cowell district, attractive common opal, some of it chatoyant, due to replacement of chrysotile asbestos, is found.

At Bimbowrie, in the Olary Region, stout elongated crystals of chiastolite occur embedded in mica schist. This mineral is a variety of andalusite and is characterized by the distribution of carbonaceous material in regularly defined zones towards the outer edges of the crystals, leaving pale-greyish-yellow, carbon-free zones in the centre. These light-coloured zones appear cross-shaped standing out in a dark background when transverse sections are cut and polished. They used to be very popular and were sold as Australian "luck stones".

An abundance of massive, compact, deep-green malachite (basic copper carbonate) showing numerous concentrically banded zones was mined at the famous Burra Copper Mine only 100 miles north of Adelaide. It was ornamental material of the finest quality but is unfortunately now no longer available, the Burra Mine having stopped working for many years.

At Andamooka, deep amber transparent common opal occurs in limited quantities.

Nephrite Discovery

The occurrence of nephrite associated with serpentine near Dungowan, in the Tamworth district of New South Wales, is worthy of mention, although the discovery is so recent that the full extent of the deposit and the availability of material of the most attractive green colour and desirable degree of translucency has still to be assessed.

Nephrite, together with the more valuable mineral jadeite, can quite correctly be referred to under the general title of jade.

Jadeite and nephrite, though differing in composition, each consist of a dense mass of interlocking fibres, which imparts to each the characteristic texture and toughness that make them both sought after as ornamental stones. Jadeite, of course, is the material in which the Chinese executed their magnificent carvings. Nephrite is the harder of the two types of New Zealand greenstone which Maoris used to make weapons such as "meres" and ornaments such as "tikis".

This is the first notable occurrence of nephrite in Australia.

It is obviously impossible to give a complete coverage of Australian ornamental stones. Amateurs, when they are first seized with enthusiasm, usually start tumbling any fine-grained chalcedony or jasper they they can get hold of. There are large quantities of waterworn pebbles in nature, usually in nondescript greys and browns. They are durable and will take a good polish but on account of the unattractive colours it is not worth the trouble and expense of working them.

This article and the previous one on New South Wales ornamental stones have been written in the hope that all lapidarists, even if beginners, will be influenced to select only material of highest quality and attractiveness, either for tumbling, or cutting and polishing by more skilled methods.

CAFETERIA AT THE MUSEUM

Part of the cafeteria on the roof of the Australian Museum's new wing. The cafeteria from which a magnificent view of the city and harbour is obtained, is open to the public.

AUSTRALIAN LEECHES

By ELIZABETH POPE

MANY people seem to feel an instinctive loathing for certain kinds of animals, and leeches, along with snakes, toads, spiders and worms, belong to this category. In the case of leeches there is some reason for revulsion, for the ones that are generally encountered are those that attach themselves to our bodies to suck blood. Often their attack is imperceptible and their victims remain unaware of their presence for hours, and it is only when the leech's fat engorged body is noticed or when blood, seeping from leech bites on the foot, oozes out of one's shoes that one becomes aware of them.

When forcibly removed, a leech may leave an irritating, itchy wound that weeps and continues to bleed for an abnormally long period.

Around Sydney leeches are mostly associated with the sporadic patches of brush forest that are still to be found in some of the valleys, especially along certain of the streams in the Royal National Park, south of the city. They are also common in the moist pockets of rain forest in the gullies of the Blue Mountains where scenic paths and hikers' trails lead down into the valleys below. Since these places are the very ones favoured by bush-walkers and boy scouts, a "boom" year for leeches can cause a lot of discomfort to a lot of people, especially when a sufferer is subjected to a mass "attack" by these hungry annelids. During the prolonged wet winter and spring in 1963 in Sydney, local populations of leeches increased enormously and invaded areas generally free of them. On farms they tend to congregate round ponds and dams where the cattle come to drink and complaints were made by farmers about leech attacks on their live stock. Measures that may help on the farm are to provide drinking troughs on higher ground and to exclude the cattle from streams and boggy places, to use bridges over streams, rather than fords, where leeches congregate and, finally, to drain bogs and spray bad areas with milder insect repellents—after ensuring that the spray is harmless to the cattle.

A live specimen of the lighter-coloured form of the common leech, the Jawed Scrub Leech, *Limnobdella australis*, from Lake Narran, inland New South Wales. This form was extensively illustrated on page 179 of the June, 1963, issue of *Australian Natural History* (Vol. XIV, No. 6). [Photo: Howard Hughes.]

In an account that appeared in an earlier volume of the *Australian Museum Magazine* (Volume V, No. 2, pp. 64-69, "Leeches", by W. Boardman) the late Mr. Anthony Musgrave described the leeches on Barrington Tops as standing "stiff and straight on the grass stems", obviously attached by their posterior sucker, while waiting for him to brush against them, so that they could attach themselves to his person. He went on to describe how, during a very wet spell, the leeches entered his hut, to

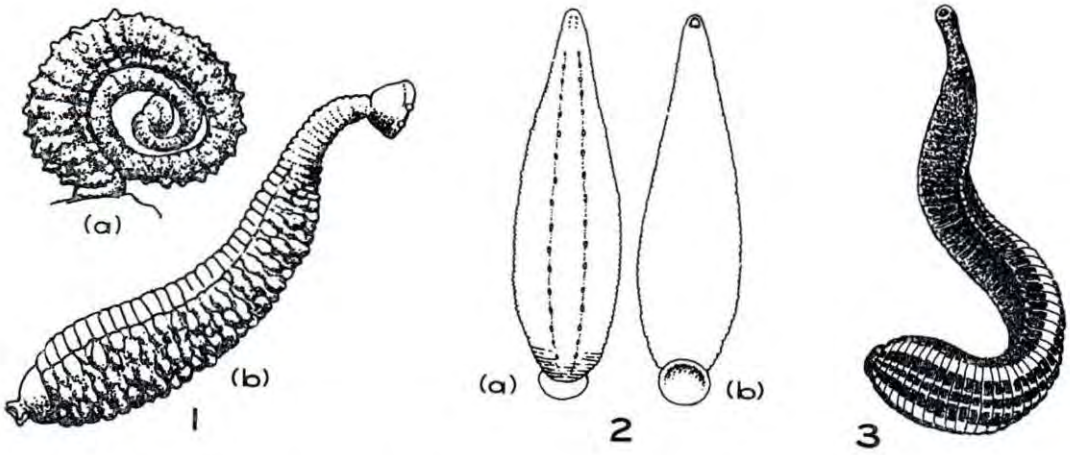

Fig. I.—(1), the Shark Leech, *Pontobdella raynerii*, (a) in the rolled-up position and (b) extended to show the prominent suckers and warty body wall. (2), the Freshwater Leech, *Glossiphonia* species, (a) dorsal view, showing three pairs of eyes, two rows of sensillae and obscure body annulation, and (b) ventral view, showing the very prominent posterior sucker (below) and small anterior one around the mouth. (3), dark form of the Jawed Scrub Leech, *Limnobdella australis*; the stripes may be less distinct than shown here, appearing rather as lime-green or orange longitudinal flecks near the broader rear end.

penetrate only "as far as the line of dampness extended, and halt there, pathetically waving their heads as they sniffed our whereabouts", for leeches are so dependent on moisture that they cannot cross a dry, dusty floor surface. Only a year or so ago, another Australian Museum party was marooned by rain on Barrington Tops and they too complained of the way the leeches congregated on the wet doorstep of their hut, assuming the upright "ready-to-attach-themselves" posture, and patiently waited for them to enter or leave the hut, at which time the leeches tried to make contact with their skins. Used as they were to the ways of invertebrates, the Museum curators found this experience somewhat unnerving. However, some of the leeches paid dearly for this meeting, ending up as Museum specimens.

Formerly the medical practice of using leeches was widespread for drawing off "bad blood" from swellings, black eyes and bruises or for generally reducing blood pressure, but this practice ceased many years ago. However, so frequent was the use of leeches that the populations of *Hirudo medicinalis* in England and Europe were seriously depleted. Inquiries as to sources of supply of leeches are occasionally made at the Australian Museum even today—generally by a migrant from central Europe—for the belief is still held by some people that blood-sucking leeches can help epileptics.

The Common Leech

Best known of the leeches in New South Wales is *Limnobdella australis* [Fig. I (3)] for it was the species formerly used by doctors and the one most often encountered by bush-walkers. Its size varies from one to three or four inches in length (contracted) while its breadth varies between a quarter and half an inch. It is slightly flattened on its lower surface where a large and powerful sucker may be seen at the posterior end. The anterior sucker round the mouth, at the front of the body, is not so obvious. The colour pattern is variable, ranging, in preserved specimens, from a general dark colour with pale yellow ochre longitudinal stripes, to yellow ochre with dark stripes. The stripes in very dark specimens may be obscure so that the leech looks almost black. The dark form shown

in Fig. I (3) has characteristically two fine light stripes on either side of a central black one, with a broader stripe on each side, near the outer edge of the body. In light forms, the general body colour is often drab yellow ochre and the stripes are the darker colour as shown in the photograph of the leech from Lake Narran, in inland New South Wales. It was this lighter variety that Ludwig Schmarda in 1861 illustrated in colour, and wrongly called *Hirudo quinquestriata*. However, in life there are often patches of lime green and orange on the tail area, or traces of orange colouring in the stripes.

Classification Of Australian Leeches

Limnobdella australis is a Jawed-leech (a Gnathobdellid), a group whose members are more highly adapted to terrestrial life than the remaining leech groups. However, they are confined to rather moist places, generally hiding in sheltered crevices beneath boulders, and only emerging to lurk on vegetation during damp weather to await the chance to make contact with a vertebrate host and take a blood meal. Some species are believed to live exclusively on blood, but can store it for months in their crops and slowly absorb it. They therefore need feed only occasionally—perhaps three or four times a year. Other Jawed-leeches belonging to genus *Geobdella* are widely distributed in eastern Australia, while species of the genera *Haemadispa* and *Philaemon* occur in New Guinea, parasitizing frogs.

Other Kinds Of Leeches

A second major group of leeches (Erpobdellids) are the Worm Leeches which live mostly in fresh water or occasionally are amphibious in habit. They lack jaws and hence do not suck blood but live carnivorously by eating worms and insect larvae, swallowed whole. *Dineta cylindrica*—a typical Worm Leech—has been taken in fresh water at Oberon, N.S.W., but is little known and fairly rare. Should any reader find *Dineta*, the Museum would be grateful to receive them either alive or preserved in a little 7 per cent formalin. The wanted leech is long, cylindrical, and rather featureless, somewhat like an earthworm, with an obvious, small, posterior sucker which an earthworm lacks.

The third major group are the Jawless Leeches. They use their long flexible probosces to penetrate their victims' flesh and suck out their tissues. Some are marine (Family *Piscicolidae*) but others are common in fresh water (Family *Glossiphoniidae*). Together these two groups make up the Rhynchobdellid Leeches.

Typical specimens of *Glossiphonia* are somewhat difficult to detect in their natural habitat, owing to their small size and colourless bodies. However, the three pairs of eyes on the head, the comparatively large posterior sucker, the faint suggestion of body rings and the presence of paired sense organs (appearing like tiny raised and darker coloured areas along the body) point to the leech nature of these worms.

Four species of the genus *Glossiphonia* occur in eastern Australia where they frequent ponds, slow-flowing streams and larger bodies of water stored for water supplies. A typical Glossiphonid is shown in Fig. I (2), in which view (*a*) is seen from above and (*b*) shows the lower side of the leech. In life the posterior sucker is very prominent, the eyes are well marked, and the proboscis is capable of great extension in its search for food or during locomotion.

A well-known marine Rhynchobdellid is *Pontobdella raynerii*, generally found attached to sharks. Its prominent suckers and body covered by wart-like bumps make it easy to recognize. In life *Pontobdella* has a habit of rolling itself up neatly as shown in Fig. I (1, *a*). Fishermen often see it and fail to recognize its true nature just because of this.

Structure And Relationships Of Leeches

Biologists tend to overlook the nuisance value of leeches because of their extreme scientific interest. K. H. Mann has aptly described them as being "full of strange zoological paradoxes".

Like their relatives the earthworms and marine bristle-footed worms, leeches are characterized by bodies made up of a series of segments, but in leeches the cross partitions or septa seen in other annelids are not

Fig. II.—How the Jawed Scrub Leech, *Limnobdella australis*, travels. Left to right: With posterior sucker attached, it reaches out and seeks a hold for the anterior one. The back sucker is then released and the body shortened to bring the back sucker close to the anterior one. Next, with the posterior sucker firmly attached the body is elongated as the leech seeks a new hold for the front sucker.

fully developed. On the whole, leeches show a higher degree of adaptation to their specialized mode of life (as blood-sucking external parasites) than do most other annelid worms, for they have short, muscular, agile bodies in which the segment number has been reduced to 33, with a powerful clinging sucker at either end. They have light-sensitive organs in each segment (some of which are complex enough to be classed as eyes), and groups of sense organs, called sensillae, arranged in pairs along the body, containing organs capable of appreciating sensations of temperature, touch (or other mechanical stimuli) and chemical stimuli (taste or smell). Also, leeches are sensitive to vibrations in their environment. All these stimuli can be analysed by the leech nervous system, evaluated and co-ordinated to produce responses complex enough to enable them to intercept, and attach to their vertebrate victims.

In taking a blood-feed the Jawed-leeches hang on by their suckers and are able to pierce the tough skin of the host with the three horny, toothed jaws, each shaped like half a tiny circular saw, which can be pushed out through the mouth and rocked back and forth by muscular movements. At the same time a secretion that acts as a local anaesthetic is poured into the wound, so that the victim may be blissfully unaware of the attack. Because of the three jaws, a leech wound often has a Y-shaped appearance.

A salivary secretion is poured out by the leech into the wound which prevents the blood from clotting once it has been pumped back into the gut by the contractions of the pharynx. This anti-clotting device is most necessary since it prevents the formation of a rigid clot inside the leech and the animals' body can remain flexible and mobile, whereas, if the blood solidified, the bloated leech would not be able to loop its body in its customary form of locomotion, which is shown in Fig. II and is somewhat reminiscent of "looper" caterpillars. Some live leeches, which we were observing, moved rapidly towards us along the laboratory bench at a rate of over a foot per minute and made a bee-line towards us. Leeches can also swim quite well and aquatic ones can detect their prey just as effectively in water as do the land leeches, already described.

Leeches make excellent experimental animals and a great deal of modern experimental work has been done on their fascinating and peculiar physiology and on their behaviour. For details the reader intested in these subjects should consult a modern text book such as K. H. Mann's *Leeches (Hirudinea), Their Structure, Physiology, Ecology and Embryology* (Pergamon Press, 1962).

Breeding Of Leeches

Little is known of the breeding habits of Australian leeches except in the case of the freshwater ones. However, like their northern hemisphere counterparts, they are hermaphrodite (as are their close relatives the earthworms) and, like them, the breeding leech develops a smooth, special, clitellar region on its body which is concerned in the production of the egg cocoon. It is clearly seen in Fig. III (2) near the anterior end of the body.

This series of drawings (after Mann) shows various stages in the breeding of the leech *Erpobdella* from pairing (1) through cocoon production (2 and 3) and finally an enlarged view of its cocoon containing several eggs (4). During the pairing and intertwining of their bodies, Erpobdellid leeches exchange small, packet-like structures of sperms (known as spermatophores)

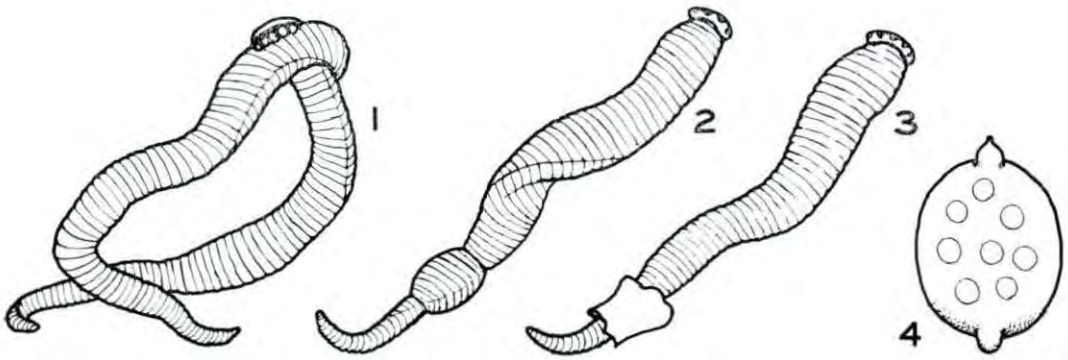

Fig. III.—Breeding and cocoon production in an Erpobdellid leech (after K. H. Mann). See text for explanation.

which generally become fastened to their bodies near the region of the clitellum. In some unknown way, not yet completely elucidated, the sperms from the spermatophore make their way through the body wall and thence, through the connective tissue in the body cavity, to enter the ovaries and fertilize the eggs.

After several days, some eggs, together with a quantity of albuminous fluid, which will serve as nutrient, are passed into the cocoon "case" which has been secreted by the clitellar region of the body. At this stage the cocoon is somewhat lemon-shaped and still open at either end, for the parent leech's body remains strung through it during egg deposition. When the Erpobdellid leech withdraws its anterior end from the cocoon [Fig. III (2 and 3)] the anterior sucker secretes material to plug up each end of the tube and seal off the cocoon case (4) which is still rather soft and colourless. The leech now flattens the cocoon slightly and the outer wall hardens into a dark brown casing which protects the developing eggs. From this stage on, the adult takes no further care of the eggs. As they develop, the young leeches use the food stored in the fluid inside the cocoon till they are fully formed and reach the hatching stage, when they emerge and begin their own free-roving life.

Leech Repellents

The question most often put to us at the Museum concerning leeches is, "What can I do to avoid being attacked by leeches?" While there is no known, 100 per cent efficient chemical repellent and effective anti-leech clothing to cover all the body has not yet been devised, there are certain precautions that can be recommended that will lessen likelihood of attack.

Recently a surveyor told us of some bushman's remedies that he had found fairly effective. He used common laundry soap and lathered freely any part of his body likely to be exposed to leech attack, allowing the soap to dry on the skin. Mr. Hersey, of the Fauna Protection Panel, finds that a pair of fine-weave nylon socks, worn under a thick woollen pair, will keep his ankles free from leech attacks.

Another bush remedy is to smear eucalyptus oil or mild carbolic compounds on exposed skin. One wonders whether these products merely conceal the animal smell of the bush-walker or are distasteful to the leech sense organs!

Attacks by leeches in jungle warfare or by workers in tropical regions may be so severe that extreme measures have to be taken against them. J. L. Harrison ("Notes on Land Leeches", *Journal of Bombay Natural History Society*, Vol. 52, Nos. 2 and 3, 1954) gives a recipe found to be fairly effective in Malayan jungles as follows:—

Ingredients: N-butylacetanilide, 3 parts; 2 butyl—2 ethyl—1,3 propanedial, 3 parts; benzyl benzoate, 3 parts; emulsifier (such as Tween 80), 1 part.

A typical leech habitat—a small stream, surrounded by thick undergrowth, in the Royal National Park, New South Wales. [Photo: Howard Hughes.]

Method: Mix together the above ingredients and use 2 oz. of this concentrate per garment to be treated, mixing it with enough water to soak the treated clothing. Allow to dry before wearing.

The U.S.A. armed services also recommend this mixture, calling it M-1960. Their tests have shown, however, that after four washings the garments are no longer repellent to leeches and have to be treated again with the mixture. Obviously, if one was constantly wading through water or in heavy rain for long the effectiveness of such treated garments against leeches would be greatly reduced.

It is suggested that these measures could be tried out against local leeches but in a group so variable in structure and ecological behaviour its effectiveness cannot be guaranteed.

[*The drawings in this article are by David Rae.*]

MUSEUM FILM SCREENINGS

Natural-history films will be screened at the Australian Museum at 2.30 p.m. every week-day from Friday, May 14, to Monday, May 24. The screenings are arranged specially for children, but parents and teachers are also invited to attend. Admission is free. Each programme will last about half an hour, and subjects of the films will include: Aboriginal corroborees, conservation of wild life in Africa, crayfishing in Tasmania, Australian native animals and plants, Maori legends, a Newfoundland bird sanctuary, molluscs.

CORRECTION

Owing to a misprint, a line was omitted from a caption under a photo of shells on page 384 of the December, 1964, issue of the magazine. As a result, the names of three of the shells were not fully given. The shell on the right of the top row was *Physastra fusiformis* (Nelson and Taylor), from Kilcoy, Queensland. The two shells at the bottom were the Liver Fluke Snail, *Lymnaea tomentosa* (Pfeiffer), from Tasmania.

The Role of Posture in the Social Signals of Birds

By G. F. van TETS
C.S.I.R.O., Division of Wildlife Research, Canberra, A.C.T.

THE way in which a bird orients its body, head, bill, tail, wings and legs conveys meaningful information to those that can perceive and comprehend it. Thus postures, often in combination with sounds and movements and aided by striking plumage and conspicuous morphological characteristics, can play a major role in avian communication. Without communication birds would be unable to aid each other in their search for food and shelter, the raising of their offspring, and the watching for and averting of danger. In fact, their efforts at social co-operation would be fruitless.

Birds start to communicate as soon as they are hatched by drawing the attention of their parents. Young song-birds present their bills for food and their cloacas for the removal of faecal sacs. Young cormorants ask for food with closed bills and for water with open bills.

Sexual differences in plumage and voice are lacking in many bird species. Some of these species use postures to indicate sex during courtship and pair-formation. It is virtually impossible to tell the sex of a gull in the field. However, when a pair of gulls are together the male holds his head higher than that of the female, thus emphasizing a slight sexual difference in size. When courting pelicans greet each other with arched necks, the male is distinguished by having his neck arched higher than that of the female. Male frigate-birds point their bills upwards and female frigate-birds point their bills downwards when a pair greet each other on their nest.

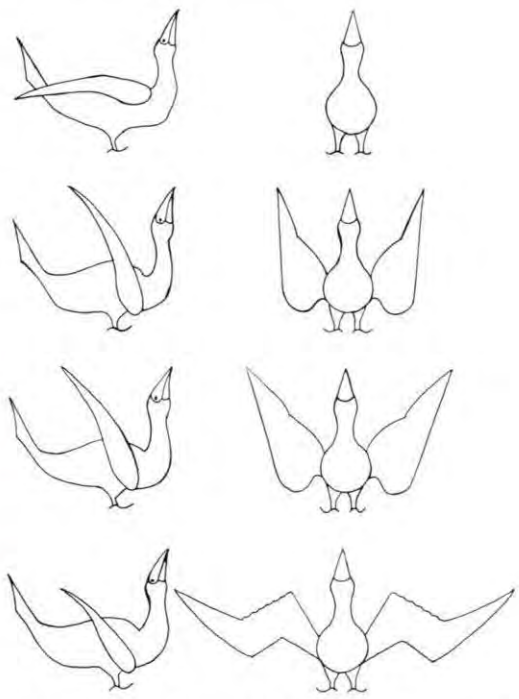

Fig. 1. Male advertising of boobies, as seen from the side and the front. From top to bottom: Brown, Masked, Red-footed and Blue-footed Booby.

Male-advertising Displays

The males of many species use male-advertising displays to indicate that they are male, own a nest or territory and are single. The male-advertising displays serve to attract females as potential mates and to space males according to the resources available in the habitat. The postures of the male-advertising display of peacocks and turkeys are familiar to most people.

Closely related and morphologically similar birds often appear to use postural differences for species recognition. The various species of boobies differ in their male-advertising displays by the extent to which they raise and spread their wings (Fig. 1). Some cormorant species can be recognized in flight by the way in which they hold their heads and necks. These flight postures may serve to hold species flocks of cormorants together in the same manner

Fig. 2. Crest postures of the Black Cormorant in and outside the nest.

as colourful wing patches help to keep species flocks of ducks together during migration.

Guarding Of Nests

Boobies, darters and cormorants often nest in dense colonies with their conspicuous nests only pecking distance apart. In such colonies the pair must take turns guarding the nest site and its contents, otherwise conspecifics will remove the nest material and claim the nest site, and predators will take the eggs and chicks. In order to avoid any confusion between the pair as to who is guarding the nest, the nest guard in these species holds its body in a horizontal position while its mate holds its body upright. In the Black Cormorant, *Phalacrocorax carbo*, this positional dicotomy is further emphasized by the bird on the nest having its crest down and the bird outside the nest having its crest up (Fig. 2).

Like other birds of the order Pelecaniformes, Black Cormorants lack alarm calls. When outside the nest they signal danger by raising their heads and lowering their crests. The sudden departure of a cormorant outside its nest will cause its mate to leave also, thus exposing the nest to molestation. When there is no danger the departure of the bird outside the nest is slow and deliberate and usually this departure is preceded by a pre-take-off posture. The pre-take-off posture serves to encourage the bird on the nest to stay put. Very elaborate pre-take-off postures have been observed in gannets, boobies, darters and cormorants (Fig. 3).

Signal Postures

Signals, like other biological entities, are subject to the forces of natural selection. In general, the explicitness and effectiveness of a signal depend on its distinctiveness. Signal postures should, therefore, differ markedly from each other and from the postures associated with feeding, preening

Fig. 3. Pre-take-off postures of (from the top) Black Cormorant, Red-footed Booby, male Anhinga (= North American Darter), Northern Gannet.

and resting. Consequently signal postures tend to be stereotyped and spectacular with relatively little intra-specific variation. Some students of comparative ethology are analysing the signals of closely related species in order to deduce from them the phylogenetic origins of both the signal patterns and the birds. Homologous signal postures can be demonstrated in species, genera, families, and even orders, of birds which, according to the fossil record, diverged many millions of years ago. The origin of the male-advertising displays of boobies, darters and cormorants has been traced back to the pre-take-off posture of gannets (van Tets, in press, *Ornithological Monographs No.* 3). The open-mouthed food-begging of passerine chicks can also be observed in the chicks of several non-passerine orders. In several other orders where the feeding of chicks probably evolved independently the chicks beg for food either with closed bills as in cormorants or with opening and closing bills as in gulls.

Like anatomical features, behaviour patterns can change in form and function during an animal's maturation. The pelecaniform birds announce their arrival at their nests with signals derived from the food-begging of chicks. Gulls use signal patterns derived from the food-begging of chicks prior to mating.

As has been outlined above, posture plays an important role in avian communication. The signal patterns of many common bird species have still not been adequately described and compared. This gap in our knowledge of the world around us is one which many amateur and professional ornithologists can help in closing. All that is required is a keen sense of observation and patience.

[*The drawings with this article are by the author.*]

Dr. E. P. Hodgkin, of the University of Western Australia, spent a day photographing and examining the Australian Museum's collection of echinoderms. Recent collecting along the coast and offshore dredgings have resulted in several new records of starfishes for Australia, and also some new species.

SHORT-WINGED GRASSHOPPER

The grasshopper pictured above, *Monistria ligata*, is one of quite a number of Australian species in which the wings are very short and useless for flight. Its general colouring is yellowish-grey with bright-yellow spots and lateral stripes. The hind wings, which are usually concealed under the fore wings, are bright red. This insect lives in eucalypt forest or in open treeless country and is restricted to a small area of New South Wales bounded by Port Stephens in the north, Katoomba in the west and the Illawarra Range in the south. Related species are found in other parts of Australia. The female (shown here) measures $1\frac{1}{8}$ inches, the male five-eighths of an inch long. (Photo: Anthony Healy.)

FOREST DRAGON LIZARD

The Forest Dragon Lizard, *Gonyocephalus spinipes*, is found in rain-forest and associated areas in many parts of New South Wales and south-eastern Queensland. It averages 12 inches in length, and feeds largely on insects. [Photo: Howard Hughes.]

Men of the emu totem clan, Aranda tribe, with their tjuringa ilpintira design, in which black, red and yellow solid circles represent all stages in the development of eggs from the ovary to the matured eggs from which the young birds have emerged; the heart is shown by two large yellow patches, the intestines by meandering lines, the excrement by black dots and the feathers by white dots. Ground designs of this kind were erased after the ceremonies with which they were associated. [Photo: Sir W. Baldwin Spencer; by courtesy of the National Museum of Victoria.]

The Emu and the Aborigines

By FREDERICK D. McCARTHY
Principal of the Australian Institute of Aboriginal Studies, Canberra

THE emu, *Dromaius novae-hollandiae*, being the largest bird in Australia, is an important source of food and other things for the Aborigines, and the inspiration for unusually interesting artistic designs, rituals and mythology.

The Aborigines devised methods of hunting the emu from an intimate knowledge of the habits of these great birds. The emus were skilfully stalked by hunters who hid behind a leafy branch, or donned an emu's skin, the head of which was held up with a stick. The spears were sometimes dragged along the ground with the toes to arouse less suspicion. As the emus were approached their actions were imitated perfectly by the hunters until the birds responded with ruffled feathers and guttural calls, only to be speared when they perceived the hoax and wheeled to escape. Sometimes a group of men, women and children surrounded emus on a plain and as they closed in the men killed some of the birds with spears and clubs. Plant poisons, including the narcotic pitjuri, were put into quiet pools at which emus drank to stupefy the birds and render them easy victims for the hunters. Pits were dug under a tree to trap them when they came to feed on the fruit, or a man waited in the tree and thrust a heavy spear into the back of an emu.

Innate curiosity enticed emus to investigate a bunch of feathers waved above a rock or low bush, enabling the hunters to spear them at close range. In central Australia the bird's call was made through a short, hollow bough by a man in a pit to draw an emu within spear range or cause it to fall into one of a circle of pits around him. Brush fences were built to form alleyways along which emus walked into a pit dug in a narrow opening. In western Queensland and New South Wales cord nets 60 feet long and seven feet high, with a mesh about a foot square, were secured to poles and trees to make a V-shaped corral into which the emus were driven and killed. While emus were drinking at a pool, a net was set across their pad; as they returned the hunters appeared suddenly behind them, and in the resulting panic one usually became entangled in the net. After lighting a ring of fires around a waterhole, the hunters threw "emu's eyes" (australites or tektites of meteoric origin) at the birds to confuse them and cause them to run into the water, where they were easily killed. The australites were believed to be the eyes of ancestral emus which lost them while searching for food, but imbued them with a magical control over the living birds.

Emus Had Many Uses

The emu was carefully prepared for cooking. Some of the feathers were plucked for ornaments, intestines and leg sinews withdrawn, the body singed over the fire, the legs cut off at the knee, and the head skewered to the body. Ashes were then scraped out of the fire-pit, the carcass placed therein and covered with feathers, over which hot ashes and sand were strewn, and left to cook. The meat was shared either among the families of the hunter's local group or his relatives.

The emu was not only prized for its flesh and eggs, but for many other purposes. Lumps of fat from its body were valued as a salve to protect people's skin from the sun, cold and insects, and in some tribes the fat was reserved for use by the older men. Ornaments such as chignons, head circlets and hair plumes were fashioned out of the feathers, which in western Queensland were wrapped in fur-twine or netting as amulets for the cure of ailments, or sent as an invitation to an ally to assist in warfare. Among the central Australian tribes the Kurdaitja shoes worn by a sorcerer and the avenger of a crime were made of emu feathers stuck together with human blood. The strong sinews of the legs made excellent bindings for spear joints and spear-thrower barbs. In the Lake Eyre district the tribal rainmakers pushed emu bone skewers through folds of their skin and drank the blood that flowed from the wounds. The bones also served as pointing bones in sorcery, nose styles, shoulder pins for skin cloaks, and as drills for boring holes in skins and wood.

In a popular game among young and old a man or boy playing the part of an emu was stalked by the other males in the group. In gesture language, the emu was denoted by the shape of its track, the motion of its head, or by its wobbly motion when running.

Mythology And Ceremonies

South-eastern Australian legends relate that the emu, in common with other animals, had its origin in the Dreamtime when the earth was inhabited by spirit people. One of these was a composite creature, half emu and half human, and the two were separated by an ancestral spirit of the emu clan. The emu was the totem of Ngalalbal, the mother of Daramulun, the pre-eminent sky hero on the south coast of New South Wales. In central Australia Spencer and Gillen stated that the ancestors of the emu (Erlia) clan originated at Erliunpa (100 miles east of Alice Springs). Their bodies were covered with feathers, and they wore sacred symbols (Nurtunja) on their heads. As they journeyed westward along the Macdonell Ranges they camped and went into the ground at Oniara, came up again at Ulpiral and went on to Kirrikura and Soda Creek, where some of the men remained. They created totem centres on the way, and shed the last of the feathers from their bodies at a place 50 miles west of Alice Springs, where they again went into the ground until they reached Apaura in the Belt Range; here

they formed an important totem centre. At some of these places stocks of human and emu spirits were left to await incarnation in the emu clan, and at the principal centres were stored their Tjurunga, sacred stones and boards in which the spirits of dead people abide until they give life to a future baby of the clan.

Near Jessie Gap an emaciated emu died and turned into a stone which became a source of evil power. A mythical emu killed by wild dogs in the Flinders Ranges of South Australia formed the famous Parachilna red ochre deposit, from which ochre was traded widely, and tribesmen travelled hundreds of miles from Queensland to secure supplies of it from the deposits.

At the totem centres the clansmen performed ceremonies in which they portrayed the lives of their ancestral spirits, and other ceremonies through which they sought to increase the supply of food, raw materials and other things. An Aranda increase ceremony for emus witnessed by Spencer and Gillen was an elaborate one. A complex and colourful design, called the Tjurunga Ilpintira, was painted on several square

Stone tjuringa of the emu clan, Aranda tribe. The large circle represents a camp of the emu ancestral spirits, the half circles are the birds in a sitting posture, the dots the large sinews in their legs, and the tracks those of the bird itself. [Photo: Howard Hughes.]

A Waninga, representing the head and neck of an emu, worn by a member of the emu totem clan in the Aranda tribe during a ceremony intended to increase the number of emus in the countryside. [Photo: Sir W. Baldwin Spencer; by courtesy of the National Museum of Victoria.]

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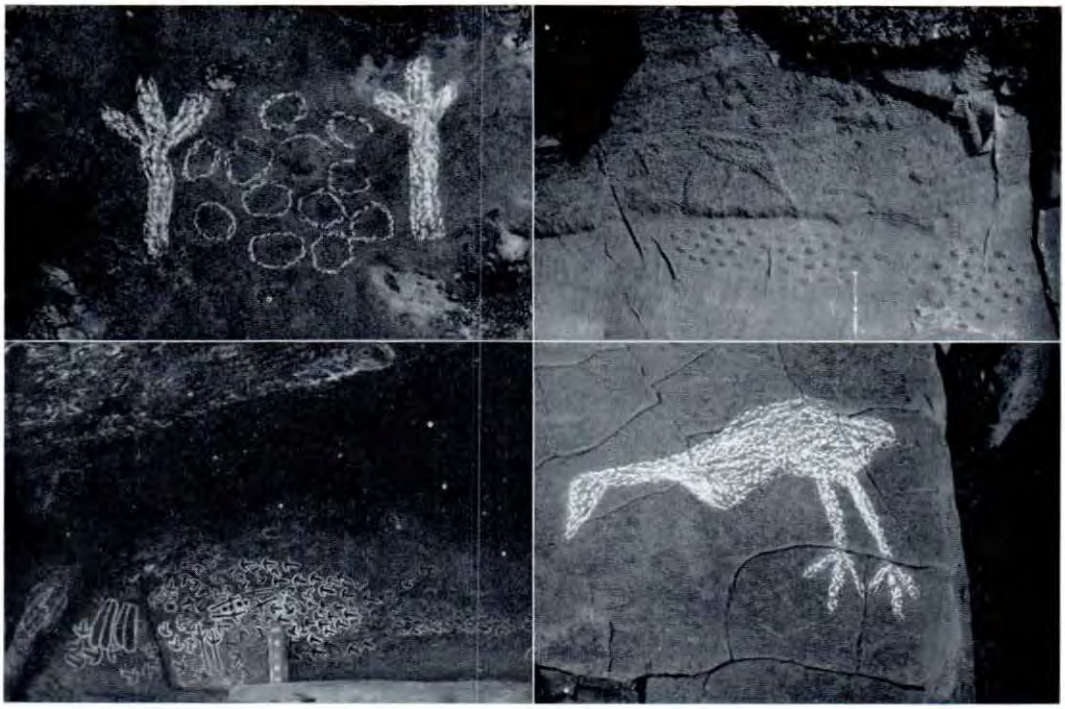


Top left: rock engraving of a clutch of eggs between the legs and feet of a sitting emu, Port Hedland, Western Australia. Top right: pecked engraving of an emu rearranging its clutch of eggs among a number of other clutches, Mootwingee, New South Wales. Bottom left: emu tracks painted on a cave wall, around a sacred stone, at a totem centre of the emu clan, Rogudi, Northern Territory. Bottom right: pecked engraving of an emu, Mootwingee. [Photos: Author and I. H. Murray.]

yards of sandy soil saturated with human blood to form a crust. A long Tjurunga, crowned with tufts of emu and black cockatoo feathers, was worn on the head of each of three older men who acted the part of the Inniakwa ancestors of the clan. Some younger men took the part of their descendants, the Illiaura; black bands painted on their bodies stood for the dark breast of the emu, and sticks in their hair for its legs. The women were allowed to see from a distance the Inniakwa imitating the movements of the emu, but were then driven back to their camp. The Inniakwa ran over a hill and stuck their Tjurunga head-dresses in the ground, and the men present gathered round the Ilpintira to hear its meaning explained in a chant by their leader. The appeal for a plentiful supply of emus was made to the ancestral spirits. The emu was identified with various constellations of stars in the night sky by many tribes.

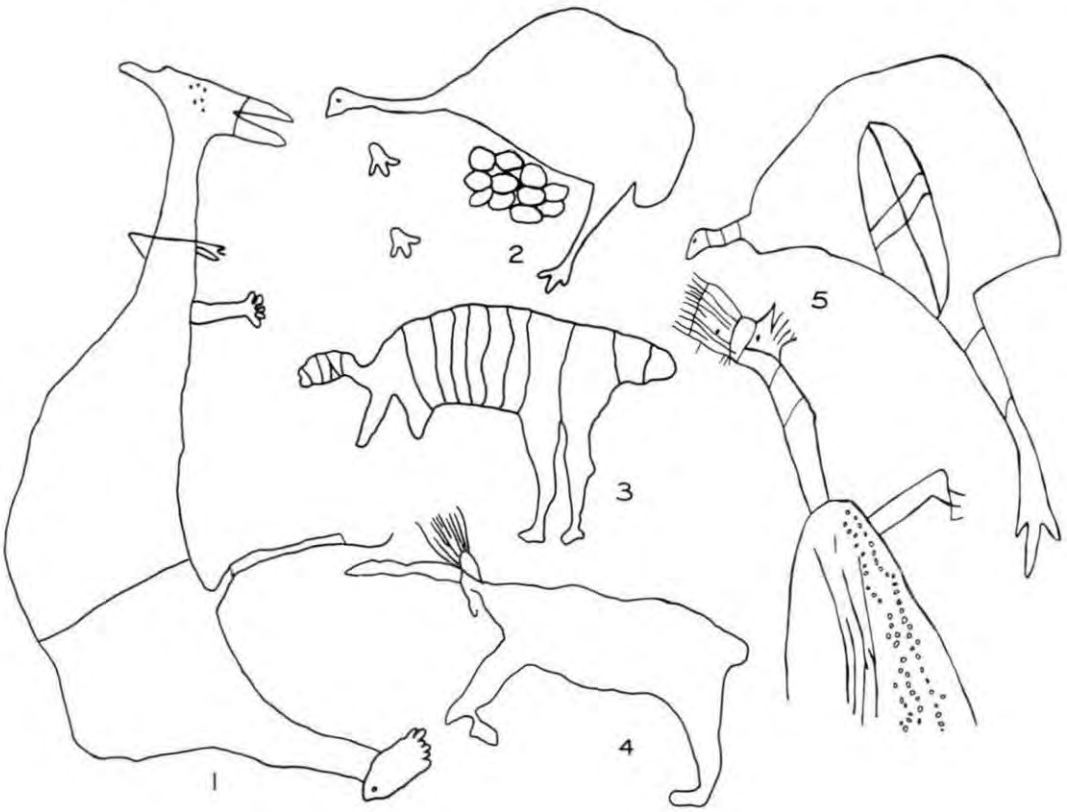
One of the most widespread legends about the emu is its conflict with the brolga. Thus the Minwula tribe of Cape York relate that after the emu had laid her eggs in a big nest the brolga stole all but two eggs. The emu looked everywhere for them, and then realised that the brolga had taken them. She told everyone in the camp what had happened. In a fight with the brolga, the emu hit her over the head with a stick which caused her hair to turn white and then rubbed red berries on the brolga's head in anger. An Arnhem Land legend says that an emu was attacked by two men, who held him by the head and neck to try to kill him, unaware that he was Gurugadji, a mythical emu man. He escaped, jumped into a waterhole, where he became a Rainbow serpent, and swallowed the hunters. He now lives in the sky as a rainbow and the natives believe that he can swallow any human beings if he wishes.

The Emu As An Art Motif

The emu is the commonest bird motif in Aboriginal art because of its size and economic and ritual importance. It is usually shown in profile, with one or two legs and a three-toed foot, and usually lacks the wings and the droop of the feathers. From one to eight or so birds, or an adult with striped chicks, are shown in groups. The figures may be stiff, like a child's drawing, but many capture the subtle grace of a standing or walking bird on the alert, feeding, or following others in file. Some are obviously figures of dead birds.

Among the hundred-odd outline engravings of emus in the Sydney-Hawkesbury district of New South Wales are groups of seven large birds in a circle with their heads in the middle, a pair courting, and one standing beside its eggs. In this area, too, are composite mythical ancestral figures with human and emu characteristics. Emus up to two feet high or long occur among the pecked engravings in western New South Wales and South Australia, but in Depuch Island and other north-western Australian galleries these figures range from miniatures to life-size.

Single and flocks of emus are painted in caves all over the continent with the exception of south-western Australia. At Glen Isla, in Victoria, and in central western New South Wales, graceful little groups of stickmen hunt emus with spears and boomerangs, and medicine-men are shown singing magic into an emu to render it easy to kill.



Outline engravings in the Sydney-Hawkesbury district of New South Wales: Nos. 1 and 4, composite human and emu ancestral spirit figures, about 19 feet long, in Ku-ring-gai Chase National Park; 2, life-sized engraving of an emu, with tracks and clutch of eggs, Maroota; 3, emu effigy (wrapped in twine) 13 feet long, used in totemic ceremonies, Narrabeen; 5, ancestral spirit figure, with emu and shield, Maroota.

The emu is not a very prominent subject in the great series of Wondjina cave paintings in the Kimberleys, nor is it as common as the kangaroo and other animals among the X-ray paintings in rock shelters and on the bark paintings of Arnhem Land. There are some interesting bark pictures of emus near water-holes, grouped with kangaroos and other animals at a favoured hunting ground, or beside its nest of eggs.

Emu figures are cut into the bark of the baobab tree in the Kimberleys, and incised and painted on weapons and sacred objects in the Northern Territory and Arnhem Land. In eastern Australia the emu was modelled in low mounds of earth or sand on the Bora initiation grounds among culture heroes and other designs.

The eggs of the emu were relished by young and old, and were represented by round stones at sacred sites. A cave painting at Delamere, Northern Territory, illustrates an emu sitting on its nest by showing a clutch of eggs between the legs while short strokes indicate the feathers. Sets of eggs in outline or hammered over the whole surface, often between the legs and feet, are a common motif in rock engravings from north-western Australia, through central and South Australia to western New South Wales.

The track of the emu is painted on cave walls, weapons and sacred objects, engraved on stone artifacts (cylcons, Tjurunga, axes, slate knives), and is a prominent motif in rock engravings. It may denote the tracks of an emu to a nest or water-hole, or those of an ancestral being. On Mt. Tomah in New South Wales many hundreds of them are engraved on the walls of a rock shelter.

The changes that took place in Aboriginal art from naturalism to linear designs had an interesting effect upon the compositions. Thus, from life-size groups of hunters spearing emus, or of emus and their eggs and tracks, the artists reduced their pictures to the tracks of the hunter and emu, or to the tracks of the game around a water-hole.

Thus, the emu illustrates perfectly the manner in which Aboriginal economy is interwoven with their social customs, totemism, religious beliefs and rites and forms an important inspiration for art and mythology.

The name emu is from a Portuguese name, Ema, for the crane and afterwards the ostrich. Each Aboriginal tribe had its own name for the bird, a few of which are as follows: Erlia, Dinnawan, Marayong, Koondooloo, Oorin, Boggabri, Kongkorong, Baraimal, Pukuna, Noorine, Miowera, Gaumaran, Guraan Guggurmin, Murui, Uringah, Rakana, Pettabang, Warree, Karawingi, Biddibang, Oorooba, Wittakit, Koolbori, Kulya, Widji, Kari, Kewora, Pinyali, Warrachi.

NOTES AND NEWS

SUNFISH

A large sunfish was recently caught alive at Port Hacking, New South Wales, and taken to Marineland, in Manly, where it died. It measured 7 feet long and 10 feet from the tip of the dorsal to the tip of the ventral fin, and weighed 1,075 pounds. It was donated to the Australian Museum by Dr. J. Thomson, Manager of Marineland. A plaster mould has been made of the specimen and a fibre-glass cast is being made for display in the Museum.

VISITOR TO MUSEUM

Mr. Hobart Van Deusen, of the Archbold Expeditions, American Museum of Natural History, visited the Museum on his way back to New York after a seven months' collecting trip in New Guinea. While at the Museum he examined the collection of New Guinea mammals and recorded on tape his impressions of the galleries.

MALACOLOGICAL SOCIETY

Dr. D. F. McMichael, the Museum's Curator of Molluscs, was recently elected honorary secretary-treasurer of the Malacological Society of Australia. Mr. T. Garrard, an Honorary Associate of the Museum, was elected president.

MUSEUM PREPARATORS

A recent conference of museum preparators held at the National Museum of Victoria, Melbourne, was most successful, and it was found that the interchange of views on the many techniques involved in the preparation of museum exhibits was very helpful. Two visitors to the Australian Museum after the conference were Mr. Eric Carr, preparator at the Western Australian Museum, Perth, and Mr. Roy Vogelpoel, senior preparator at the Queen Victoria Museum, Launceston, Tasmania. Both studied the Australian Museum's display techniques.

The view southward from Hargraves Lookout, Stanwell Park, New South Wales, is a good example of topographic aids to stratigraphy. Each sandstone unit is cliff-forming and each shale unit forms the intervening slope. [Photo: D. Rogers.]

Triassic Rocks of the Sydney District

By G. ROSE
Of the Geological Survey of New South Wales

FOR the purposes of geological mapping the rocks of the earth's crust are subdivided into units of similar lithology or similar age. Within the Sydney district the main units exposed are of the Triassic Period. This period ranges in time between 180 and 225 million years before present. For the determination of such an age, a standard time-scale has been established by using the rate of decay of radio-active minerals in rock units and then extending the units on a world-wide basis by use of fossils. Fossils are one of the most important tools used by the geologist in establishing the relative ages of the various disconnected rock units.

Towards the end of the Carboniferous Period (270 million years ago), a flexure in the earth's crust developed in an area approximating to the present position of the Hunter River Valley. The depression developed by the flexure allowed an embayment of the sea to develop and the Sydney Basin began to form. During the Permian

Period (270-225 million years ago) the southern margin of this basin migrated southward until in Upper Permian time the sea covered an area extending from Newcastle to just north of Bateman's Bay and westward to Lithgow. An open channel in the Murrurundi-Mudgee area connected the Sydney Basin to the Great Australian Basin through the Oxley Basin. Toward the close of the Permian Period the basin became estuarine or possibly completely closed to the sea and began to contract toward the north and north-east. At this stage the greater part of our coal-bearing strata was laid down. The top of this coal-bearing sequence, the Newcastle or Illawarra Coal Measures, is taken as an arbitrary base of the Triassic Period.

The basin continued contracting away from all margins during the Triassic and the uppermost rock units are localized in a small area in the Camden region. Thus the basin which was originally formed in the Hunter Valley region as a relatively small trough expanded to a large continental sea covering many hundreds of square miles and finally contracted to a relatively small lake in the Camden area where it finally became filled and sedimentation ceased.

The rocks of the Triassic Period have been subdivided into three major units which, in order of decreasing age, are the Narrabeen Group, Hawkesbury Sandstone and Wianamatta Group. The Narrabeen and Wianamatta Groups have been subdivided into a number of smaller units, each of which has particular characteristics and occupies a particular position within the sequence. The recognition, mapping and determination of the relative position of such rock units is termed stratigraphy. The table at the end of this article is a stratigraphic table showing the Triassic units which may be observed within a radius of 50 miles from Sydney in their correct vertical position.

In geological mapping it is important that each unit should be recognizable in the field. The recognition of the unit may be aided by its surface expression. The view southward from Hargraves Lookout, Stanwell Park, is one of the best examples in New South Wales of topographic aids to stratigraphy. Each sandstone unit is cliff-forming and each shale unit forms the intervening slope. On closer examination each unit has particular characteristics. Using the information obtained from these cliff sections, a basic stratigraphic sequence for the Narrabeen Group in the area has been defined.

If the sequence is examined vertically from the old Coal Cliff Colliery entrance just north of Scarborough, to the top of the cliff line, a total of eight stratigraphic units may be recognized in the Narrabeen Group. The Coal Cliff Sandstone, which is the basal unit of the Narrabeen Group, is a lithic (i.e., composed of rock fragments) quartz sandstone with sporadic iron oxide concretions and lenses, and overlies the Bulli (coal) Seam. This sandstone is overlain by a grey shaly unit, containing numerous sandstone bands and siliceous iron oxide lenses and concretions, termed the Wombarra Shale. It has been the cause of the trouble in maintaining the road to the north of Scarborough. When wet it becomes greasy and unstable and in places will slump or slide under its own weight. The concrete wall just above road level between Stanwell Park and Scarborough demonstrates the measures which must be taken to control fretting of the shale and subsequent falling of the overlying sandstone. The Otford Sandstone Member which is developed within the Wombarra Shale is a small, cliff-forming, greenish, lithic sandstone containing multi-coloured pebbles and occasional iron oxide concretions. The upper section of the Wombarra Shale, which corresponds to the concrete wall mentioned above, separates the Otford Sandstone Member from the Scarborough Sandstone. This unit is cliff-forming, conglomeratic at the base but grades upward into a medium to coarse sandstone. Multi-coloured fine to coarse pebbles are very abundant. The Stanwell Park Claystone overlies the Scarborough Sandstone and is a red-brown, green and grey mottled claystone with thin greenish-grey sandstone bands. The rich red-brown colouring which can be seen in the railway cuttings near Scarborough led the original workers to term this unit the "Lower Chocolate Shales". By far the thickest unit in the Narrabeen Group in this area is the Bulgo Sandstone. This is an

alternating sequence of shales and sandstones, some 400 feet thick. Good exposures may be observed in the road cuttings between Hargraves Lookout and Stanwell Park. The Bald Hill Claystone, previously termed the "Top Chocolate Shales" because of its colour and relative stratigraphic position, overlies the Bulgo Sandstone. Its reddish-brown appearance is extremely characteristic and many good exposures may be seen in the area around Bald Hill and along Lady Carrington Drive. In some of the quarries in this region, a thin whitish band occurs at the top of the reddish claystones; this is a clay-pellet claystone called a "tonstein". The uppermost unit of the Narrabeen Group in the South Coast area is the Gosford Formation. As it is a shaly unit and weathers very readily, exposures are poor. Outcrops may be observed in a few of the road cuttings in the area, perhaps the best examples being along McKell Avenue from Waterfall to the Upper Causeway (Port Hacking River).

The above eight stratigraphic units make up the Narrabeen Group in the South Coast area.

From this it can be seen that by observation of the characteristics of the rocks cropping out on the surface it is possible to build up an ordered stratigraphic sequence called a stratigraphic column. In recent years drilling for coal in the Appin-Bargo-Heathcote region has shown that the above basic sequence may be extended subsurface for many miles.

From the north of Stanwell Park to Long Reef the Narrabeen Group lies below sea level and coastal outcrops are of the Hawkesbury Sandstone.

The uppermost observable rocks of the Narrabeen Group in the Long Reef area, the Gosford Formation, are underlain by the reddish brown Collaroy Claystone, which has been equated to the Bald Hill Claystone. It is of interest to note that an attempt was once made to extract copper from the claystones in this area. Small pieces of native copper have been found and some of the very early workers used the term "cupriferous shales" for this unit.

To the north, in the Gosford-Lake Macquarie Region, the Tuggerah Formation (corresponding to the Bulgo Sandstone and Stanwell Park Claystone) and the Munmorah Conglomerate (corresponding to the Scarborough Sandstone, Wombarra Shale and Coal Cliff Sandstone) are developed. It is in this region that the Narrabeen Group attains its maximum thickness of 2,300 feet.

Modifications to the mapping of units, new techniques and more detailed appraisal of information are almost continually changing the face of geological maps. This applies equally to the Sydney district, and in recent years more detailed work in the Blue Mountains area, in particular, has

A cliff of Hawkesbury Sandstone at The Gap, Watson's Bay, Sydney. [Photo: M. R. Bunny.]

Cross-bedding in Hawkesbury Sandstone at The Gap, Watson's Bay. [Photo: M. R. Bunny.]

modified the mapping previously presented. It is almost standard practice to use the cliff lines around Echo Point, Kings Tablelands and Govetts Leap as fine examples of the Hawkesbury Sandstone. However, recent work has shown that without exception all these cliff lines are rocks of the Narrabeen Group.

It has been possible to propose three major units within the Narrabeen Group in the Blue Mountains area. The Burralow Formation consists mainly of sandstone and grey and red-brown shales and claystones and has been equated to the Gosford Formation and Bald Hill Claystone. The equivalent of the Bulgo Sandstone and the Stanwell Park Claystone is the Grose Sandstone. This is the main cliff-forming unit in the Blue Mountains. The Caley Formation which underlies the Grose Sandstone may be equated to the remainder of the Narrabeen Group on the South Coast.

The Hawkesbury Sandstone is possibly one of the best-known rock units in Australia, not only because it is used as a superb building stone but also because approximately one-eight of the continent's population lives within its limits. The name was originally applied as the "Hawkesbury Series" to embrace both the Narrabeen Group and the Hawkesbury Sandstone but was later modified to apply only to the massive sandstones, composed almost entirely of quartz, overlying the more shaly lower part of the Triassic sequence. The type area for the Hawkesbury Sandstone is in the Cowan-Hawkesbury River area, where it is seen as an almost unbroken profile of sandstone.

There are some localized thin shale lenses and partings but these are of minor importance compared to the Narrabeen Group. Some larger shale lenses are developed toward the top of the unit. The best examples of these lenses may be seen at the old brick pit at Brookvale (now being developed for a residential area) and the operative brick pits at Turramurra and Asquith. The recent excavations along the new express-way north of Hawkesbury River have exposed some fine examples of these shales.

One of the most interesting features of the Hawkesbury Sandstone is the occurrence of cross-bedded units in the formation. The sandstones were all laid down under freshwater conditions and as they were deposited by streams small deltaic areas were formed which gradually progressed in the direction of stream flow. These deposits now appear as parallel laminae oblique to the normal strata. This generally means that they lie at an angle of greater than 15 degrees to the horizontal. On close examination of these units, it has been found that almost without exception all streams carrying sediment which ultimately became the Hawkesbury Sandstones flowed from the south.

The best exposures of these sandstones may be seen in the Hawkesbury River area, the coastal cliffs between Dee Why and Stanwell Park, building excavations in the

inner city area and in the gorges along the eastern section of the Blue Mountains. The most westerly outcrops of the Hawkesbury Sandstone along the western roads occur at the water tower just west of Woodford Railway Station and on the western flanks of Mt. Tomah. West of these points a few isolated residuals occur capping the more prominent hills.

The Wianamatta Group is the uppermost Triassic unit in the Sydney Basin. It consists of an alternating suite of shales and sandstones with shales occupying by far the greater percentages of the sequence. It may be divided into two major units, the lower Liverpool Subgroup and the upper Camden Subgroup. The Ashfield Shale, Minchinbury Sandstone and Bringelly Shale (in ascending order) make up the Liverpool Subgroup. The Ashfield Shale crops out over the greater part of the area occupied by the Wianamatta Group. It has been prominent for many years in the brick shale industry in the Sydney district and it is indeed fortunate that such a supply of excellent raw material has been available. As the unit is shaly and easily weathered to clay, the best exposures are without exception man-made. The brick pits at St. Leonards, St. Peters, Heathcote and Bowral provide good examples of the Ashfield Shale sediments. The Minchinbury Sandstone and Bringelly Shale do not outcrop in the metropolitan area but are confined to Penrith-Camden districts.

The upper Camden Subgroup may be subdivided (in ascending order) into the Potts Hill Sandstone, Annan Shale, Razorback Sandstone, Picton Formation and Prudhoe Shale. These units occur only as isolated knolls in the Horsley Park, Bringelly and Camden areas. The best section of the Camden Subgroup is seen on the Hume Highway crossing of the Razorback Range north of Picton. The shales immediately north of Picton are referrable to the Bringelly Shale of the Liverpool Subgroup. On the southern side of Razorback Range at the beginning of the ascent, the Potts Hill Sandstone is well exposed in an old quarry. The Annan Shale is dark green to black in colour, with thin sandstone lenses, and is overlain by the Razorback Sandstone. On the southern side of the range this sandstone is not clearly discernible but at the beginning of the descent on the northern side of the range it is clearly seen in outcrop as a cliff some 30 feet thick. The Picton Formation is very variable and consists of an alterating sequence of shale and sandstone. The last existing formation of the Triassic Period is the Prudhoe Shale which, with one very small exception in the Bringelly area, is confined to the very top of the Razorback Range.

Fossils, as previously mentioned, are one of the most important tools used by the geologist in correlation of rock units. They become more important in the Triassic rocks in the Sydney district because of the very limited occurrence of good index types.

The Wianamatta Group at Razorback Mountain, near Picton, N.S.W. [Photo: M. R. Bunny.]

R. Etheridge, jun., in 1888, stated in relation to the Triassic Rocks: "The meagreness of this fauna renders the occurrence of any animal remains, however small or poorly preserved, of the highest importance, whether it be regarded as throwing light upon the age of the rocks in question, or their mode of occurrence". This statement is still applicable to-day. Numerous localities have been examined and several different types of fossils have been recorded, but it would be impracticable in this article to do more than mention them in summary form.

From the Narrabeen Group recorded fossils include the plants, similar to present-day tree and fern leaves, *Glossopteris browniana, Taeniopteris maclellandi, Dicroidium odontopteroides* (formerly known as *Thinnfeldia*), *D. lancifolia, D. crassinervis, D. narrabeenensis, Schizoneura gondwanensis, Alethoptera* sp. and *Phyllotheca* sp.; the fishes *Palaeoniscus antipodeus, Gosfordia truncata* and *Belorhynchus gigus*; the amphibian *Platyceps wilkinsoni*, and the small shell-like phyllopod *Estheria*.

These fossils occur at irregular intervals and no definite localities are, in most cases, recorded. Of special interest is the occurrence of the shell-like *Estheria* which is closely allied to the present-day crustaceans. This small fossil has been recorded from many areas toward the base of the Narrabeen Group and was, in fact, recovered in the core of an old bore at Narrabeen from a depth of 1,961 feet.

The old Railway Ballast Quarry at Gosford is of world renown because of the excellent specimens which were obtained of some 18 different species of fishes.

Specimens of the fern-like *Dicroidium* may be seen on the rock platform at North Narrabeen bathing pool.

The old brick shale pit at Brookvale, which was established in a shale lens in the Hawkesbury Sandstone, is also of world-wide interest and yielded an excellent array of species, including the plants *Dicroidium* sp. and *Phyllotheca* sp.; the fish *Cleithrolepis granulatus, Brookvalia gracilis, Macroaethes* sp. and *Semionotes* sp.; the amphibians *Mastodonosaurus* (*Capitosaurus*) cf. *robustus* and the insect *Mesotitan* sp. Specimens from this locality are still being obtained from the spoil along the roads now established in the area.

Fossil footprints left by Triassic animals when the sandstones had just been deposited as soft sand are reported from time to time and occasional references are found to sporadic occurrences of fossils in the Hawkesbury Sandstone. Early records report amphibian remains from Cockatoo Island; more recently the writer has been told of occurrences of fossil fish from a tunnel at Lane Cove and a brick pit at Turramurra.

The greatest diversity and most interesting fossils in the Sydney district have been recorded from the Wianamatta Group. Varying from large amphibians to plants to microscopic shells, they have provided a wealth of information. The fossils recorded are in most cases restricted to the Ashfield Shale. The plants *Dicroidium, Macrotaeniopteris, Taeniopteris* and *Podazamites;* the shells *Unionella wianamattensis, U. bowralensis, U. carnei* and *Unio dunstani;* the insects *Mesotitan giganteus* and *Notablattites subcostalis;* the fish *Myriolepis pectinata, Pleuracanthus parridens, Sagenodus laticeps, Platysonus* sp. and *Semionotus formosus;* the microscopic fossils *Globochaete alpina, Eothrix alpina* (Algae), *Trochammina, Spiroplectammina* (*Foraminifera*), and the amphibians *Platyceps wilkinsoni* and *Clyclotosaurus*. The latter is the most complete Triassic labyrinthodont skeleton known in the world.

The above specimens have been obtained from three main localities: the old brick pits at St. Peters, the brick pit at Bowral and the old Gibraltar Railway Tunnel north of Bowral. The microfossils were obtained from the Minchinbury Sandstone. There is no reason, on present knowledge, why similar specimens and perhaps new species may not be found in other localities.

The Triassic rocks of the Sydney district have given us some of the most beautiful scenery in the world. It is hoped that this article will provide the reader with a basis for a better appreciation of them from the geological viewpoint.

STRATIGRAPHIC TABLE

Period	Epoch	Group and Sub-group		Formation and Member	Maximum Thickness (in feet)	Lithology	Fossils	Economic
TRIASSIC	Upper (?)	Wianamatta Group	Camden Sub-group	Prudhoe Shale	120	Shale with sandstone lenses	.....	.....
				Picton Formation	160	Sandstone and shale	.....	.....
				Razorback Sandstone	70	Massive sandstone with shale lenses	.....	.....
				Annan Shale	40	Shale with sandstone lenses	.....	.....
				Pott's Hill Sandstone	40	Sandstone with shale lenses	.....	.....
			Liverpool Sub-group	Bringelly Shale	200	Shale, green and black	.....	Bricks and tiles.
				Minchinbury Sandstone	20	Calcareous sandstone with shale lenses	Ostracods, algae	Stoneware.
				Ashfield Shale	200	Mudstone and silty shale, dark grey	Plants, molluscs, insects, fishes, amphibians.	Bricks and stoneware, tiles.
	Middle (?)			Hawkesbury Sandstone	900	Massive quartz sandstone with pebbly or shaly lenses.	Fishes, insects, plants, amphibians.	Building stone, bricks, tiles, stoneware, road foundation, kerbing, builders' sand.
	Lower (?)	Narrabeen Group Narrabeen-Wyong Area		Gosford Formation	600	Shale, shaly sandstone and sandstone	Amphibian, fishes and plants.	.....
				Mangrove Sandstone Member	30	Sandstone, massive	.....	.....
				Ourimbah Sandstone Member	30	Sandstone, massive	.....	.....
				Wyong Sandstone Member	100	Sandstone, massive	.....	.....
			Clifton Sub-group	Collaroy Claystone	500	Red and green shale with claystone with sandstone bands.	.....	Road surfacing.
				Tuggerah Formation	400	Red and green shale, sandstone, and fine conglomerate.	Plants	.....
				Munmorah Conglomerate	800	Conglomerate, sandstone, red, green, blue and grey shales.	Plants, phyllopod	.....
		Narrabeen Group Grose River Area		Burralow Formation	450	Quartz sandstone with grey shale and red-brown claystone.	Plants	.....
				Tabarag Sandstone Member	80	Quartz sandstone, massive	.....	.....
				Grose Sandstone	700	Massive sub-labile sandstone with a little shale and siltstone.	.....	.....
				Caley Formation	150	Sub-labile sandstone, shale and siltstone	.....	.....
		Narrabeen Group South Coast Area and sub-surface Southern Tablelands		Gosford Formation	150	Shale with a few beds of sandstone	.....	.....
			Clifton Sub-group	Bald Hill Claystone	100	Reddish-brown claystone with few bands of sandstone.	.....	Road surfacing.
				Bulgo Sandstone	700	Sandstone with minor shales	Phyllopod	.....
				Stanwell Park Claystone	120	Reddish-brown and greenish claystone and sandstone.	.....	.....
				Scarborough Sandstone	120	Sandstone and conglomerate	.....	.....
				Wombarra Shale	120	Shale	.....	.....
				Otford Sandstone Member	25	Sandstone and conglomerate	.....	.....
				Coal Cliff Sandstone	30	Sandstone with a few shale lenses	.....	.....

Boys and girls enjoy painting and modelling the special exhibits in the Museum's Children's Room during school vacations. Some of their handiwork is displayed on the walls.

Children and the Museum

By PATRICIA M. McDONALD

IT is said by some that a person visits a museum twice in a lifetime: once as a child and again to bring his own children. Whatever truth may be in this, there can be no doubt that children of all ages do form a substantial proportion of the total number of museum visitors.

Museums are regarded as educational institutions, so the question naturally arises —what can children gain in educational experience from a museum visit? Through their gallery displays, museums present material objects of the natural and cultural world, both from the past and the present, striving to relate them in a meaningful way. It is hoped that these displays will further the educational process by creating interest in the objects and by presenting information about them in a readily understandable form. To this end, the Australian Museum is installing many new exhibits of the "intructional" type, that is, the objects are connected by a theme or story line, enlivened by diagrams, models, photographs and other explanatory materials. Exhibits of this kind at the Museum are, in the Australian Aboriginal gallery "How They Make Fire" and in the bird gallery, "Bird Migration".

"Walkabouts"

Using a similar idea, a system of questionnaires called "Museum Walkabouts" has been devised for the use of children at

week-ends and during school holidays, when most children come to the Museum. One object of these Walkabouts is to increase interest in the Museum by combining exhibits from various galleries into a single study. For example, in one Walkabout entitled "Animal Life in Fresh Water", children were asked to study certain exhibits in the mammal, bird, reptile, fish and invertebrate galleries in order to discover how these animals are adapted for life in this particular environment. Another Walkabout—"People"—required a study of the evolution of primitive man, an examination of the ways of life of various native races and a comparison of these with the development of the early civilizations of Mesopotamia and Egypt.

Another object of the Walkabouts is to encourage regular Museum visiting—to form the habit in children of coming to the Museum throughout the year. To assist in this, the Walkabouts have been designed as a progressive series, with certificates and booklet prizes to be won at the end of each stage. Three Walkabouts are prepared for each school term and each new series is commenced during the school holidays preceding it. In this way, a child who completes the first three Walkabouts becomes a "Museum Traveller" and receives a card indicating this. If he returns next term and completes a further series of three, his award is the certificate "Museum Adventurer" and so on through succeeding stages. Visits over a period of more than two years are required to reach the final award.

Each Walkabout is checked by the Education Officers; good work is commended and a poor effort receives some constructive criticism before the Walkabout is returned to its owner. In fact, the work of correction, correlation with previous efforts, and awarding of certificates and prizes is becoming an increasingly lengthy process as the volume of Walkabouts swells with each new series. This expansion and the comments of the children themselves indicate that the Walkabouts are very popular with young visitors.

Children's Room

During school holidays, further activities are available in the Children's Room. Each vacation, a theme is chosen and special exhibits are prepared to illustrate it. For instance, one theme was "Peoples of the Pacific" and children were asked to contrast tools and weapons, baskets and ornaments, made by native races living in different areas of the Pacific Basin. Another theme was "The Growth of Animals" and specimens from many of the major animal groups were shown at various stages of

Finding the answers to questions in a Museum "Walkabout". These children are hard at work in the Australian Aboriginal Gallery.

growth. Painting, modelling and drawing materials are made available and children may use the exhibits as models for their work. Some living animals, such as lizards, frogs and spiders, are also shown. During one January vacation, some Wanderer Butterfly pupae were on display and when these metamorphosed, they were banded by the children, who were thus made to feel that they were taking part in the butterfly migration studies organized by the Museum's entomology section.

The Children's Room was conceived as a place where those who were already interested in natural science could receive help and guidance in their chosen study. Whilst the room does fulfil this function to some extent, activities there are hampered by a lack of space for the numbers of children who attend. The Museum officer on duty must cope as best she can with the numerous inquiries and demands for assistance. It is hoped that special classes for children who are genuinely interested may be arranged in the future.

Film Screenings

For the three vacations of each school year—in January, May and September—free film programmes for children are shown on week-day afternoons. The films are chosen, as far as possible, to illustrate the exhibits in the Museum galleries so that the audience, having seen the films, may follow them with a study of the actual specimens. In this way, it is hoped not only to provide interest and entertainment in the theatre, but also to increase interest in the exhibits—to bring them to life, as it were —by showing them on film in their natural surroundings.

Great care is exercised in making up these programmes, for children can be quite severe critics. Compiling a programme to suit children of all ages is not easily accomplished, for a balance must be struck between those films suitable for the very young and those of interest to the teen-age group. However, thousands of children and adults do attend these film screenings every year and many return in successive vacations until they seem like old friends.

Programmes For School Groups

In addition to these vacation activities for children, special programmes are organized for those who visit the Museum in groups—particularly, of course, in school groups. Some of these come to the Museum once a month, each following an individual course arranged by their teacher in collaboration with the Museum education staff. Others may come only once or twice in a term, and many, of course, can manage only one visit in a year. Even so, there are many classes who cannot be assisted because of the lack of staff and facilities to cope with the numbers requiring attention.

Again, the main aim of these programmes is to create interest in the subjects shown in the exhibits and to widen the knowledge of the children. Following modern educational theories, didactic methods are avoided as far as possible and children are encouraged to participate actively in their lessons—to ask questions, to discuss problems and to discover facts for themselves by studying the exhibits and their labels.

The pupils are introduced to their studies in the lecture hall, where specimens illustrating the chosen topic are available for closer examination. Actually handling the specimens is considered of particular value: to stroke the soft feathers of an owl, to heft a primitive stone axe, to try hardness tests of minerals, or to use Aboriginal fire sticks means much to a child who previously may have seen these things only as pictures in a book. The education officer leads a discussion of this material, illustrating the main points by means of the specimens and with films showing the original surroundings whence they came.

Following this introductory period, the class continues its studies in the exhibition galleries. From the exhibits, the pupils are required to find the answers to a questionnaire which is designed to increase their knowledge and understanding of the subject they are studying. Thus the child is kept actively involved in his studies throughout the course of his visit to the Museum.

For Education Week of each year, an exhibition of the work completed as a result of these class visits is mounted in the

The exhibition of children's work during Education Week aroused great interest among Museum visitors. Book prizes, provided by the Museum Trustees, were awarded for the best work in the various sections.

main entrance to the Museum. Project books, posters, models, miniature dioramas, collections of specimens—a great variety of material, much of it of very high standard, is produced by the children and attracts considerable interest from Museum visitors. The children are delighted to have their work displayed in public and to have the opportunity of comparing it with that of their contemporaries.

However, for many reasons there are children who cannot participate in these organized programmes. For these children, information leaflets have been prepared to answer their questions, specimens are identified and Museum material is lent to schools for teaching purposes. Recently a technical officer was appointed to prepare special travelling cases of specimens and explanatory materials, so that teachers and pupils may be assisted in their studies of natural history. It is hoped to expand this work considerably in the future.

In these ways, the Museum is attempting to interest children, to widen their knowledge, and to encourage them in their study of the fascinating world of animal life.

[*Photos. in this article are by Howard Hughes.*]

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To teachers and pupils of schools and other educational organizations special facilities for study will be afforded if the Director is previously advised of intended visits. A trained teacher is available for advice and assistance.

Gifts of even the commonest specimens of natural history (if in good condition) and specimens of minerals, fossils and native handiwork are always welcome.

The office is open from 9.30 a.m. to 1 p.m. and 2 to 4.30 p.m. (Monday to Friday), and visitors applying for information there will receive every attention from Museum officials.

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