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An Inside Story
AURORA AUSTRALIS:
Lights of the South
Vincent Serventy
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Front Cover

Feathers make fascinating close-ups and more vibrant hues can be seen in Photoart on page 56. The cover features the iridescent feathers of the Superb Bird of Paradise. Photo: Kate Lowe.

EDITORIAL

Since European colonisation of this country, a number of introduced species have found conditions here so much to their liking that they've become pests. Traditional English hedgerow plants such as Privet, and the tropical lantana, have flourished so well that they are strangling our bushland. Many of our pests were brought to Australia on purpose, obviously without any idea they would fare as well as they have. In his article 'Raspberries, Blackberries and the Cultural Cringe' (p.50), Tim Low elaborates on how acclimatisation societies, established for the homesick colonist, were formed specifically to bring in species from their homelands. Can we blame them for their lack of insight? Even thorough research cannot guarantee an introduced species will serve its purpose. The Cane Toad (see article on p.69) was originally introduced as a form of biological control. Now it has become a pest itself and is advancing into the Northern Territory at a rate of 27 kilometres a year, leaving death and destruction in its wake.

To turn the tables, seemingly destructive occurrences can sometimes have positive benefits. For example, thousands of ships have been wrecked around Australia's coastline for nearly 400 years. Yet this maritime litter often provides a haven and refuge for a myriad of marine creatures. Likewise, old tyres can be seen as an eyesore or pollution when dumped on land–but when connected and sunk, these too can be made into artificial reefs (see article p.92). The thrifty dung beetles also utilise waste products, turning animal excrement into food or incubators for their young (see article p.62).

While our efforts to create can, unintentionally, end up being destructive, if we put our minds to it we can make something worthwhile out of something presumed 'useless'.

Fiona Doig, Editor

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Raspberries, blackbe

The brilliant scarlet Roseleaf Raspberry *(Rubus rosifolius)* has become a weed in cleared areas. Photo: E.A. Pratt, A.N.T.

...ries & the cultural cringe

By Tim Low

The early Australian botanist Joseph Maiden was scornful of our native raspberries, dismissing them in 1889 as "encouraging to look at, but extremely disappointing to taste". They were, he complained, insipid, mawkish, granular and astringent.

Maiden wrote from a time when Australian native fruits were still expected to attain a place in world agriculture. Unfortunately Maiden, like other writers of his time, measured Australia's wild plants against Europe's domesticated crops, the products of centuries of cultivation and improvement. Our wild foods could not compete, and our flora, like the fauna, came to be disparaged as part of the great Australian cultural cringe.

That cringe set in early. In 1843 in Tasmania the Quaker missionary James Backhouse, after praising the Mountain Raspberry (*Rubus gunnianus*) as the colony's best fruit, exclaimed that not one of Tasmania's edible plants was "of sufficient value to be worthy of the attention of the agriculturist or horticulturist".

In my view, Maiden, Backhouse and their ilk deserve a posthumous raspberry for their rudeness to Australian plants. I grew up in the thrall of that great cultural cringe, partly of their making, when nearly all nature programs and books in Australia were English and American imports. As a boy, how I longed to see wild primroses, squirrels and oaks! Raspberries I liked because they bridged both worlds, commanding the status of things English and American yet growing naturally in Australia. Australia's seven species, while not identical to those of Europe and America, were closely related and similar in looks.

Native raspberries (*Rubus* species) flourish in the moist forests of eastern Australia, especially in shaded gullies and along fringes of rainforests. The flavours of the berries vary enormously among species, from exquisitely sour-sweet to dry and insipid. A couple of the species would certainly be worth improving through cultivation.

Raspberry plants are prickly scrambling shrubs called brambles—except for the unusual Mountain Raspberry, which is a petite ground-hugging shrub of Tasmania's cold mountains. Raspberry leaves have saw-toothed edges and the flowers are pink or white with five rounded petals.

Raspberry flowers resemble those of strawberry plants, apple trees and wild roses, and all are members of the remarkable rose family (Rosaceae) to which so many of our fruit trees belong, including all the stone fruits and the pear, loquat, prune and almond.

Australia's brambles all bear red raspberries but overseas species may be yellow, orange, brown, white or black. For example, the Yellow Raspberry or Yellowberry (*R. ellipticus*) of China and India has juicy golden berries about a centimetre wide. It's become a nasty weed of rainforest edges near Brisbane. The various blackberries are also species of raspberry, belonging in the same genus *Rubus*—which means red!

The traditional cultivated raspberry is *R. idaeus* of Europe and Asia. Writers have suggested that *rasp*berry refers to its slightly bristly fruits. Wild plants have crimson or amber berries but gardeners have bred yellow, brown and almost white forms. As early as 1870 there were 35 cultivated varieties. The berries are used in jams, pies, sweets, vinegar, wines, brandies, liqueurs and medicines.

The Bush Lawyer *(Rubus moorei)* is a prickly climber. Photo: T.J. Hawkeswood.

Young leaves of the Molucca Raspberry, *Rubus moluccanus*, were used for medicinal purposes in Borneo, likewise the roots have been used in Malaysia. Photo: T.J. Hawkeswood.

Rubus idaeus is only one of many cultivated *Rubus* species. America's Loganberry (*R. loganobaccus*) is esteemed for its deliciously sour fruits, ideal for cooked dishes, preserves and yoghurts. The Boysenberry (of hybrid origin), Wineberry (*R. phoenicolasius*) and Dewberry (*R. roribaccus*) are also farmed. The last of these grows wild around Sydney and Canberra, having escaped from cultivation. It's easily recognised by its enormous (up to four centimetres long) black fruits.

More economically important in Australia than any of these cultivated berries are the weedy blackberries. These rank among our most invidious and uncontrollable pests.

No one can say with certainty how many kinds of blackberry there are; some botanists estimate 300 species world-wide and at least seven grow wild in Australia. These were once grouped under the name *R. fruticosus* agg., the 'agg.' being an abbreviation for 'aggregate', indicating that closely related species are grouped together.

Blackberries are south-eastern Australia's worst pest plant and in Victoria alone over 663,000 hectares are ensnared. The prickly brambles infest paddocks and creek banks, choking out native flora and providing refuge for Rabbits and other vermin. The introduction of the blackberry to Australia is one of the more sorrowful examples of cultural cringe. It implicates those most shameful of institutions, the colonial acclimatisation societies. In mid-nineteenth century Australia, the perceived inferiority of Australian plants and animals was a matter of public concern. Prominent citizens banded together into acclimatisation societies whose aim was to introduce superior organisms from elsewhere in the world. The Victorian governor, Sir Henry Barkly, wanted monkeys gamboling in the gum trees to amuse wayfarers. Others proposed to release Llamas into the Australian alps and Boa Constrictors into the scrubs where, supposedly, they would gobble up all the deadly snakes. The societies had their successes, and their legacy includes some of our worst problem pests—Rabbits, Foxes, Starlings and the like.

As a traditional English hedgerow plant, the blackberry was a prime choice for the homesick acclimatisers. It was grown in Australia as early as 1843, although it seems the acclimatisers cannot be blamed for that. In that year the settler James Fenton planted out three cuttings in Tasmania, which he said made wonderful headway, "throwing out long arms in every direction".

"Two or three years after that date the blackberry quite astonished the settlers (including myself)", Fenton later recalled. "Round the stumps and logs in every direction, young blackberry bushes grew up luxuriently and spread out violently. At first it seemed mysterious how they managed to spring up so far away from the parent bushes, but it was soon apparent that the birds were fond of blackberries and that they carried the seed far and near."

The spread of blackberries in Victoria, where they pose the worst problem, was more directly due to the acclimatisers and, in particular, to prominent member and Victorian Government botanist of the day, Baron von Mueller. Mueller proclaimed that the blackberry "deserves to be naturalised on the rivulets of any ranges". He led many expeditions into unexplored mountainous regions of Victoria and, it is believed, scattered the seeds on these trips. He posted blackberry and raspberry seeds all over Australia and, even 20 years after the blackberry was proclaimed a noxious weed, was still pronouncing its virtues. Although von Mueller stands pre-eminent among botanists of his time, having discovered an unbeatable 2,000 new species of Australian plant, it is difficult to reconcile his achievements with his irrational and unshakeable passion for the blackberry.

The acclimatisation societies' other link with the blackberry involves the curious Currasow, a turkey-sized bird from South America. Victoria's Acclimatisation Society had eight of them for release in Victoria. As the Currasow was known to favour blackberries, society members were urged in 1863 to spread the blackberry to wherever it had not yet established.

Appalled though I am by the antics of the acclimatisers, I do admit to a fondness for fresh blackberries. In summer and autumn it's a joy to gather the roadside berries for jams, tarts and pies. One sometimes encounters a Fox, for they also forage on the fruits.

I am also impressed by the blackberry plant's long history of use as a medicine. Almost 2,000 years ago the Roman historian Pliny asserted that the shoots "eaten by themselves like cabbage sprouts...check looseness of the

bowels and discharge of blood, and are good for dysentery."

Blackberry plants contain tannins, the astringent effects of which have an indisputable effect upon dysentery, diarrhoea and bleeding. Numerous cultures around the world have independently adopted raspberry plants as treatments for these ailments. The Zulus and white South Africans use the twigs and roots of various African raspberries, and the Molucca Bramble was used in Borneo (the young leaves) and Malaysia (the roots). Evidence from Aboriginal Australia survives in one obscure reference of 1901 to Aborigines in the Shoalhaven area of New South Wales using decoctions of the Roseleaf Raspberry, Queensland Raspberry and Small-leaf Bramble to treat diarrhoea. The latter was also used by white settlers. There is no reason to doubt that these simple treatments worked, although doctors nowadays advise us that diarrhoea usually requires no treatment—mere rest is best.

The European Raspberry's leaves contain not only tannins—hence their occasional use as tea substitute—but also an unidentified substance which relaxes uterine and intestinal muscles. Raspberry leaf tea was once prescribed by English doctors to treat painful and profuse menstruation, and the Australian Roseleaf Raspberry has been used the same way, apparently with satisfactory results.

The leaves of the Roseleaf Raspberry have also been boiled as a vegetable in Indonesia, but I find them too fibrous. The berries of course are much tastier and, like those of Australia's other brambles, are well worth harvesting. The berries are relished by Satin Bowerbirds, cassowaries and other birds, which spread the seeds about in their droppings.

For the interest of berry pickers and others, the Australian species are here described: the Small-leaf Bramble or Pink-flowered Native Raspberry (*R. parvifolius*, sometimes called *R. triphyllus*) is a widespread species, ranging from Rockhampton to lowland Tasmania. It is South Australia's only native bramble, occurring there in the Mount Lofty Ranges and the south-east. The common bramble of open forests, it often grows on hillsides and sandy soils by the sea, forming a low scrawny shrub. The flowers are pink and the pinnate leaves have three or five tough wrinkled leaflets with white undersides. The pretty berries, produced in summer and autumn, have a fine flavour and are well worth eating and perhaps cultivating. Aborigines ate them and used the leaves for diarrhoea. This species occurs beyond Australia as far north as Japan, where its fruits are rendered into wine.

The flowers of the Mountain Raspberry *(Rubus gunnianus)*. Photo: J. Simmons.

The Roseleaf Raspberry or Roseleaf Bramble (*R. rosifolius*), also called Forest Bramble and Thimbleberry, occurs from southern Queensland to eastern Victoria. Although mainly restricted to rainforest edges and very moist eucalypt forests, it's become a weed of paddocks and roadsides in areas of cleared jungle. The pinnate leaves are very soft, with slender leaflets coloured bright green on both sides. The white flowers are followed by distinctive berries which resemble strawberries but are hollow (hence 'Thimbleberry'). Although not strongly flavoured, they make excellent jams and tarts and are often borne prolifically. This species also occurs beyond Australia, as far away as Taiwan, Assam and the New Hebrides. A double-flowered variety is grown in Asia for ornamental purposes and the species has become a weed in Africa and Brazil. Introduced to Hawaii, it is now replacing the rare Hawaiian Raspberry, a delicate spineless species ill-adapted to introduced grazing animals. Aborigines ate the fruits, and the leaves were used for diarrhoea by Aborigines and South Africans.

The Queensland Raspberry (*R. fraxinifolius*) closely resembles the Roseleaf Raspberry but has broader and thicker leaves, and flowers and fruits borne in larger clusters. It sprouts along rainforest edges in eastern Queensland.

The Bush Lawyer (*R. moorei*) grows along tall rainforest margins in New South Wales and southern Queensland, where it forms a robust prickly climber. Its shiny, dark green leaflets are grouped in fives, the flowers are white, and the distinctive fruits are reddish-black and large (two to three centimetres long). Although exquisitely sour to taste, they contain numerous hard seeds. There are believed to be two species of very similar appearance, one of which is yet to be named.

The Molucca Bramble or Broad-leaf Bramble (*R. moluccanus* or *R. hillii*) is another species of rainforest edges, found from Victoria to northern Queensland and the Northern Territory. Its simple leaves are large and broad (mostly five to eight centimetres wide) with a crinkled surface and white underside. The pink or white flowers are followed by small sour berries of indifferent flavour. This is perhaps the least palatable of Australia's raspberries, and comes closest to Maiden's dour description.

The Mountain Raspberry or Alpine Raspberry (*R. gunnianus*) of Tasmania's mountains is an extraordinary dwarf species growing only 40 to 80 centimetres across. Its wiry stems creep beneath the soil, sprouting forth bunches of tiny leaves. The flowers have slender creamy petals and the fruits bear only a few large segments (called drupelets). Joseph Maiden, suffering from that inevitable cringe, described this as "the best native fruit in Tasmania...though that is perhaps not saying much". □

FROM THE JOURNAL

"A lake is the landscape's most beautiful and expressive feature. It is earth's eye; looking into which the beholder measures the depth of his own nature." So wrote nature philosopher Henry David Thoreau in 1854 when he made his beloved Walden Pond in Massachusetts known around the world.

Although Lake Eyre may not merit this same international acclaim, for Australians it has always been an important place. After overcoming the barrier of the Great Dividing Range, early explorers just took it for granted that there was an inland sea, as all the rivers ran to the west. However, this 'inland sea' was found to be a huge salt pan—Australia's largest and one of the largest in the world. Edward John Eyre, after whom the lake was later named, called it "one vast low and dreary waste" after reaching its southern limit in 1840.

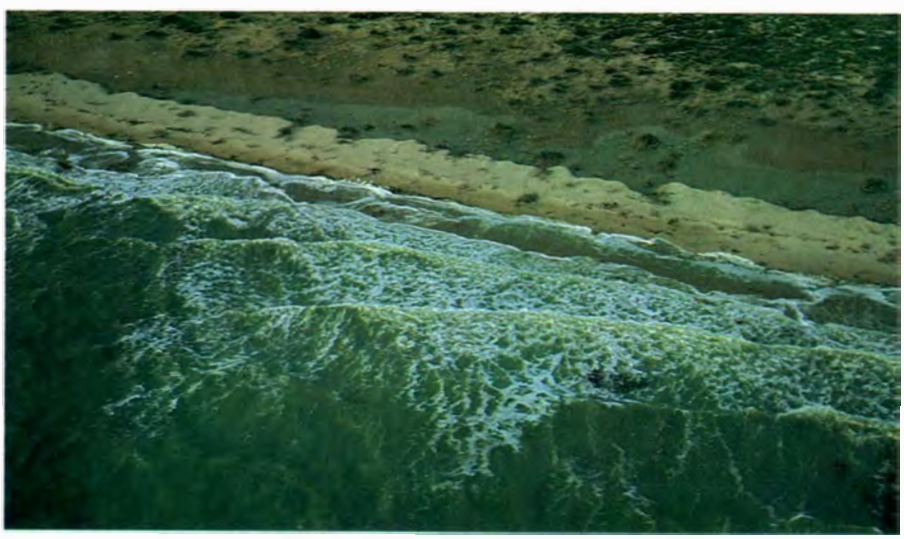
Yet at certain times this great salt pan—in an area of Australia where the annual rainfall averages 150 millimetres and the evaporation rate is 20 times as much—can become a lake. It is part of a vast, closed drainage system that taps 1,300,000 square kilometres. Heavy, widespread rainfall in this region causes the lake to fill, although this may happen only twice every hundred years.

The first recorded complete fill took place in 1949-52. An even greater inpouring occurred in 1974, when it was estimated that the area of the lake totalled about 9,700 square kilometres. The maximum depth in 1974 was only 5.7 metres but this expanse of warm, shallow water provided ideal conditions for an explosion of water life. In the dried, salty mud of the lake bed were the eggs of non-biting midges, the chironomids, as well as other insects. And fish were flushed into the lake from permanent billabongs along Cooper Creek, the Warburton, the Diamantina and the other rivers that stretch like fingers in every direction from the lake.

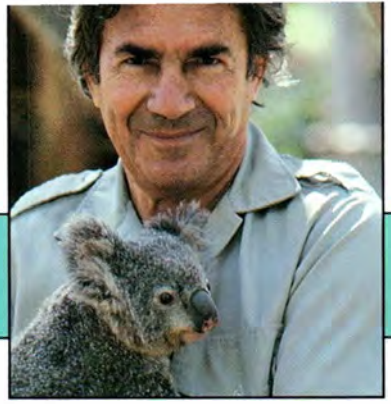
A young Pelican uses its wings for balance as it walks away from the author.

In March 1974 when I first crossed the lake by boat from north to south, the waters were almost fresh. A year later salinity had risen to that of the sea, and by 1978 the area of water had dropped by half and salinity was above that of the sea.

The speed with which water life took advantage of the warm water and abundant food was staggering. On our second visit in 1975, I found lines of dead fish, with Hairback Herrings numbering approximately 20 million and the same of Hardyheads, along the shorelines. The bodies were estimated to weigh 2.08 million kilograms. The combination of rising salinity, changes in temperature with the chill of winter sending surface layers almost to freezing point, muddy upper layers cutting light from the lower levels, and possibly some poisoning from



A surf breaking on the inland sea of Lake Eyre.



OF VINCENT SERVENTY

water blooms, would have caused the death of these fish.

Huge though these kills were, the waters still contained living fish—those that had managed to adjust to the changing conditions in a pattern found in most creatures that live the chancy life of inland lakes and pools.

The explosion of life under water was paralleled by the above-water animals which made Lake Eyre their home during these 'fat' years. Dense clouds of midges rose in the air as we walked through the bushes along the shore. Feeding on them were myriads of Long-jawed Spiders whose silken nets enshrouded countless kilometres of the shoreline shrubbery. Nesting Silver Gulls crowded the islands in the lake. Usually laying two eggs every four months when conditions are good, under these ideal conditions most nests contained four or five eggs.

Naturalists estimated that there were between 40,000 and 50,000 Pelicans and the same number of Pied Cormorants feeding in the lake. Many had begun to nest when we first came in 1974 and by 1977 the colonies were huge.

The strong sun and drying winds, however, were dropping the water levels rapidly and by the end of 1977 the exodus had begun. Thousands of Pelicans were seen searching for food along the Murray River, and Centennial Park in Sydney had its first recorded Pelican visitors, competing with the Coots and Black Ducks for food handouts. Some Pelicans reached Indonesia, causing a sensation in villages where they were a novel occurrence and 150 reached the Palau Islands, in the Carolines of Micronesia, making it the first record of our Pelicans north of the equator.

The animal that remained freshest in my memory, however, was a Long-haired Rat (*Rattus villosissimus*). This species is also known as the Plague Rat, as in good conditions when plants are green its numbers may increase so much and so fast that it sweeps over the inland plains in ravening hordes and may even attack campers. As I watched this particular animal plunge into the water and begin to swim south, a Black Kite dropped onto the creature and lifted it into the air. But just as quickly as it was snatched up it was let go, when the rat twisted and bit the bird on the foot. I waded out to rescue the swimmer, placing it in the shade of a bush. A few seconds later the rat returned to the water and began its southward swim once more. Again the bird swooped, the rat bit, and I waded out and placed it back in the shade. The rat looked at me in what seemed a reproachful manner, then turned back to the water.

I let it go as even rats are entitled to their dreams, and like its northern lemming relatives, it was not committing suicide but looking for pastures new. Water, to both lemmings and Long-haired Rats, is a barrier to be crossed. How was the rat to know this was no Cooper Creek but a desert sea whose shoreline lay 140 kilometres to the south? Later I was to find hundreds of dead Long-haired Rats on the southern shoreline.

What is the future of this fascinating region of desert and salt pans, which at times explodes into vigorous life? The South Australian Government has dedicated the bed of Lake Eyre North and much of the Tirari Desert to the east as a huge new conservation park. The South Australian Conservation Council has suggested the whole desert region, with Lake Eyre as its magical centre, should be nominated as the Lake Eyre World Heritage Area. It would be a fitting tribute to our most extraordinary desert wilderness. □

A fish kill on the shores of Lake Eyre. Millions of Hairback Herring were washed onto the shores after dying in the lake. Photos: Vincent Serventy.

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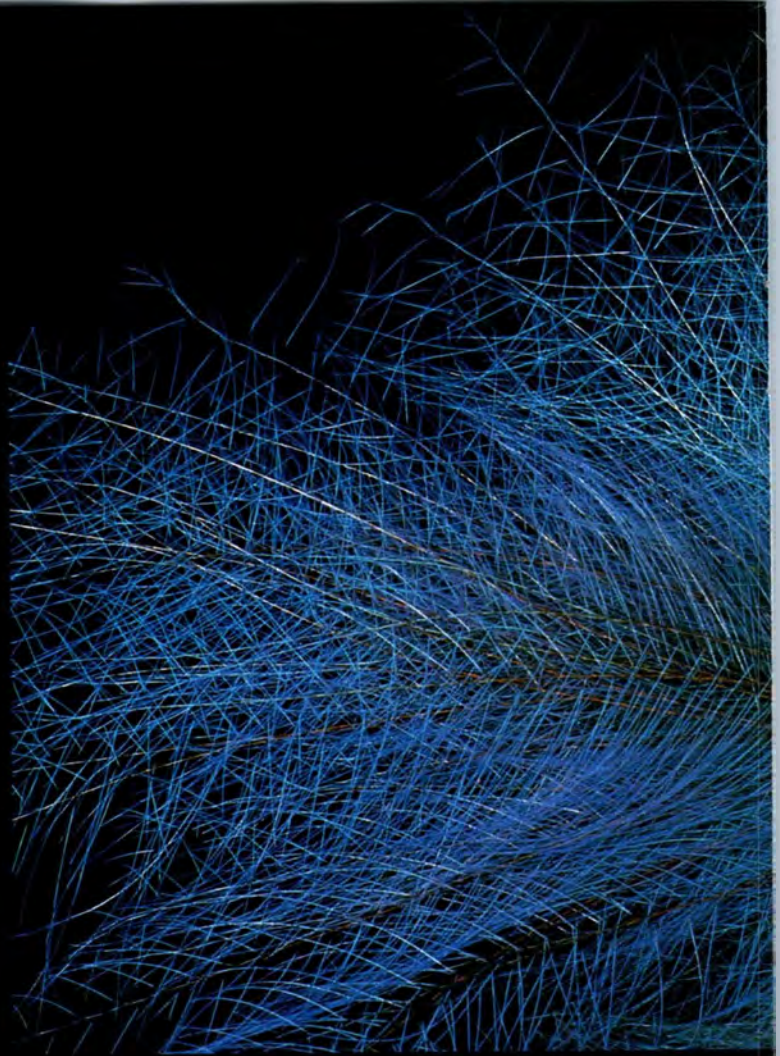

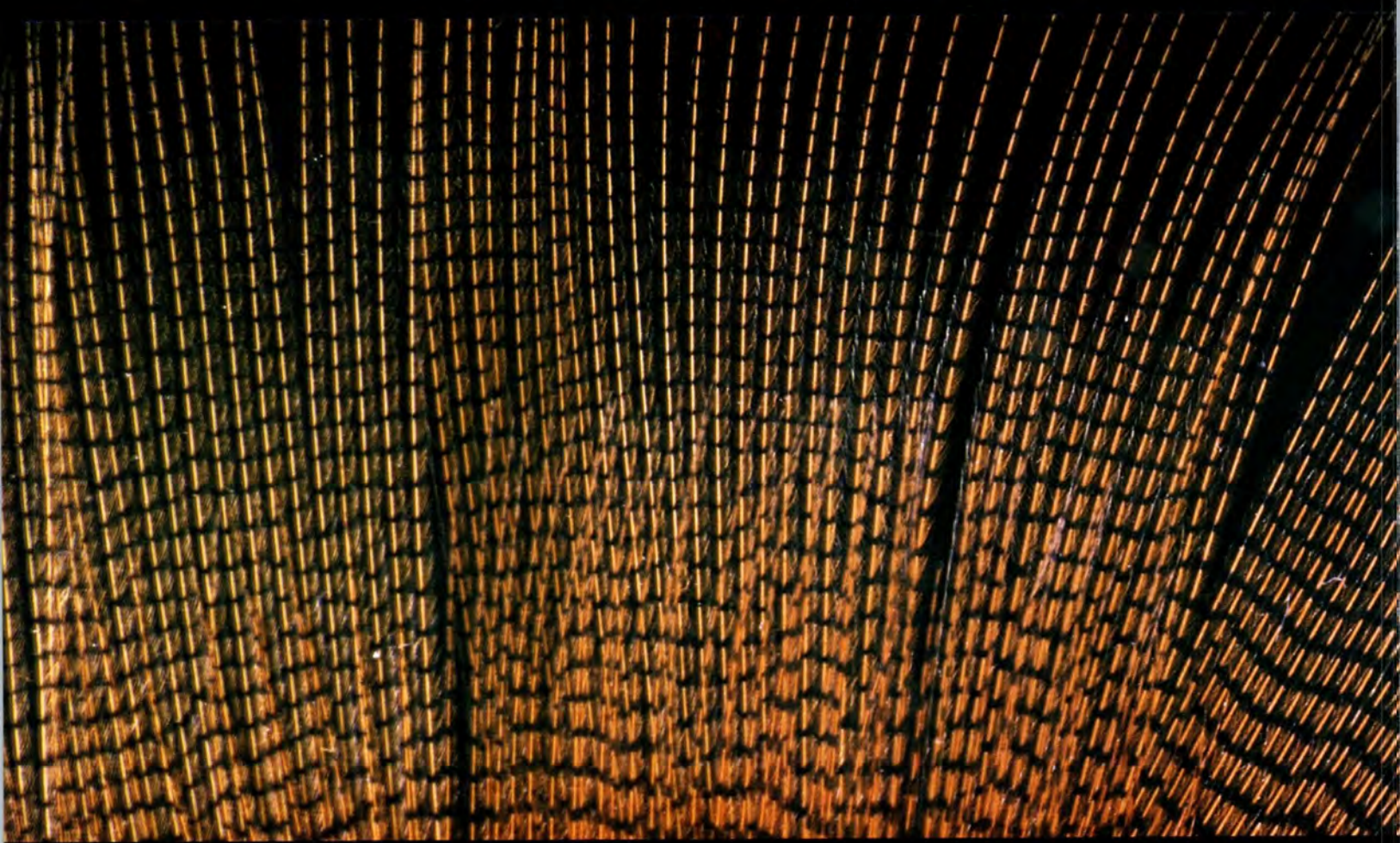

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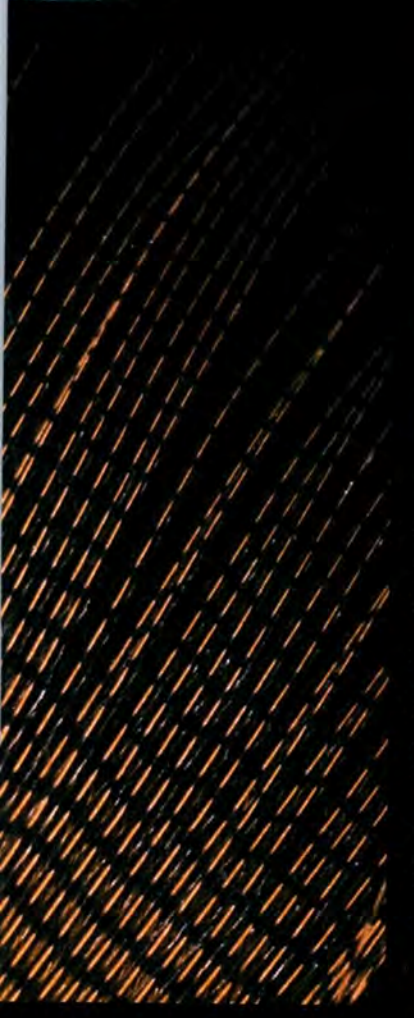
A regular gallery of portfolios by talented Australian photographers on a subject relating to natural history.



FEATHERS IN PERSPECTIVE

PHOTOGRAPHY
BY KATE LOWE

AUSTRALIAN MUSEUM

Constructed almost entirely of keratin and arranged in tile-like overlapping formations, feathers are a marvel of aerodynamic engineering. Keratin, an animal protein, is the chief constituent of hair, horns, hoofs and nails, and its lightweight, resilient properties, combined with its strength, make it ideal for flight design.

Besides being essential for flight, feathers are also important in maintaining body heat. Although light, they are extremely warm, as sales of down quilts and sleeping bags attest! The thick feather coating also protects the bird against possible injury–feathers comprise, on average, about a third of a bird's total body weight.

Along the rachis (shaft) of the feather are rows of processes called barbs, set out in an arrangement somewhat resembling the teeth of a comb. If you separate the barbs on a contour feather (those used for flight) and smooth them out again, you will notice how miraculously they all link up. This is because alternate sides of each barb have hooked barbules that link up with corresponding curled barbules in zipper-like fashion. This ingenious function means that birds can 'repair' minor damage to plumage (providing barbs are not broken) simply by preening, which relinks the barbules. However, feathers eventually become damaged beyond repair and they do wear out through use. Since overly-damaged feathers impair flight, old feathers must be discarded and replaced with new ones. This

The bright blue ornamental flank feathers on the Blue Bird of Paradise, *Paradisea rudolphi*.

◀The tiny barbules can be seen in this close-up of feathers on the Mandarin Duck, native to China. Caged pairs were given at Chinese weddings as a symbol of marital fertility.

▲A splash of vibrant blues highlights the wing feathers on the Rainbow Pitta, *Pitta iris*, a tropical northern Australian species.

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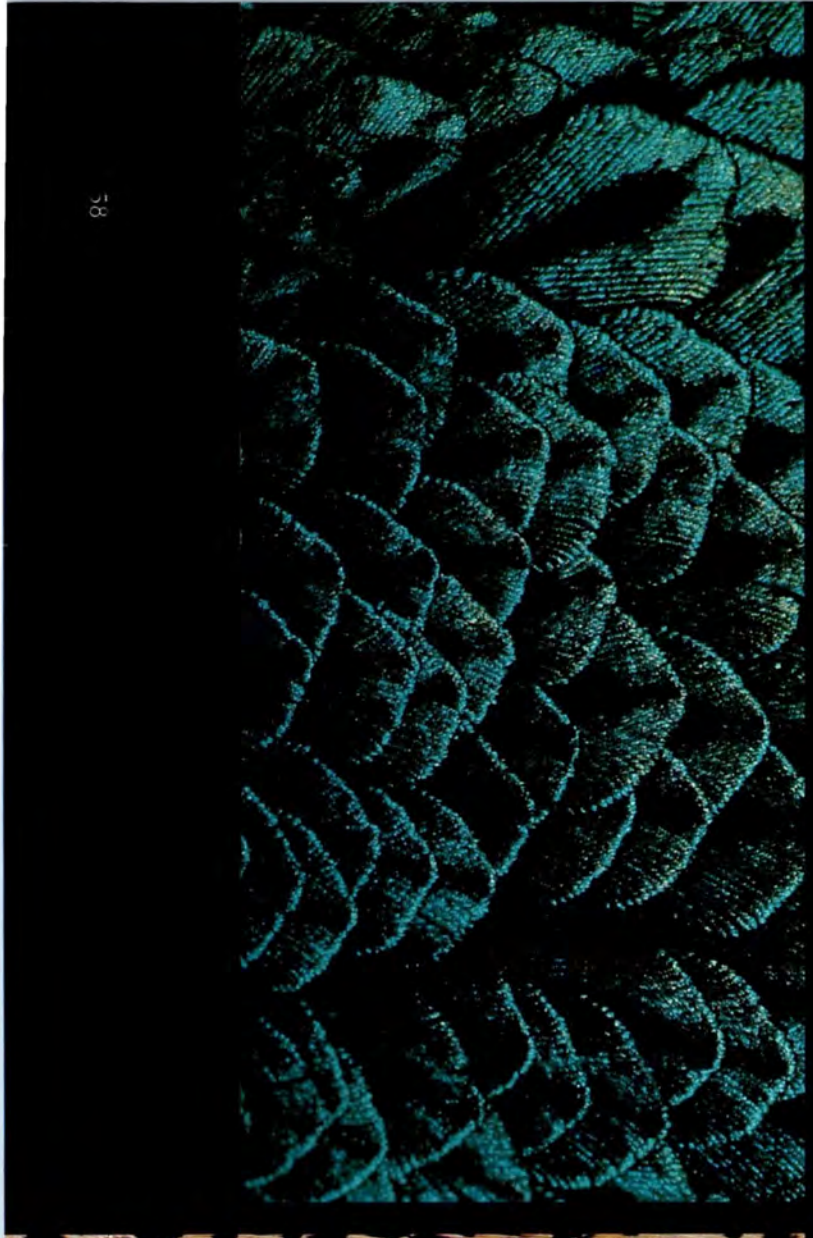
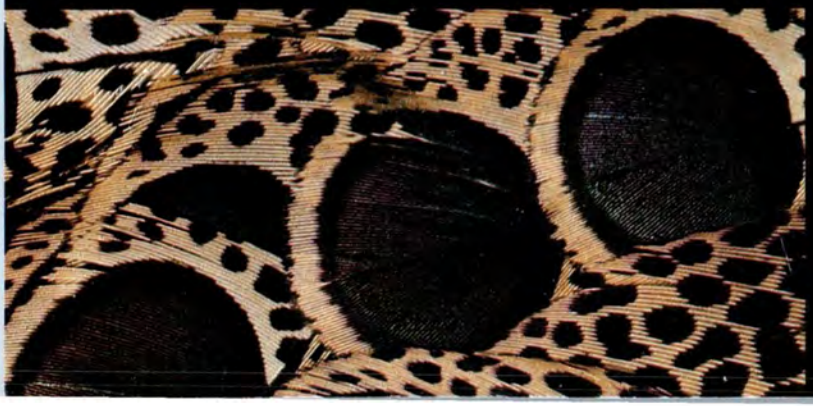
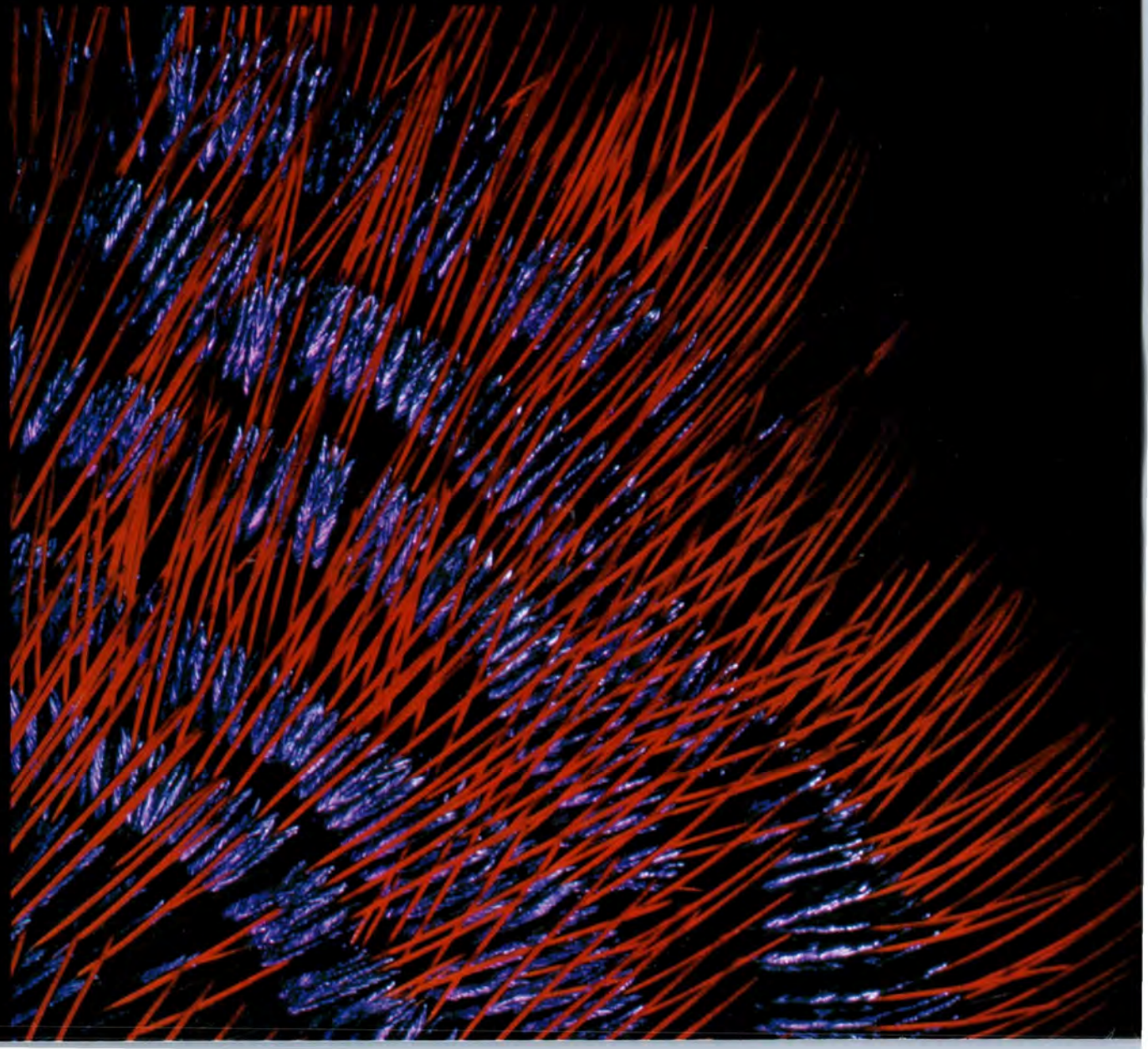
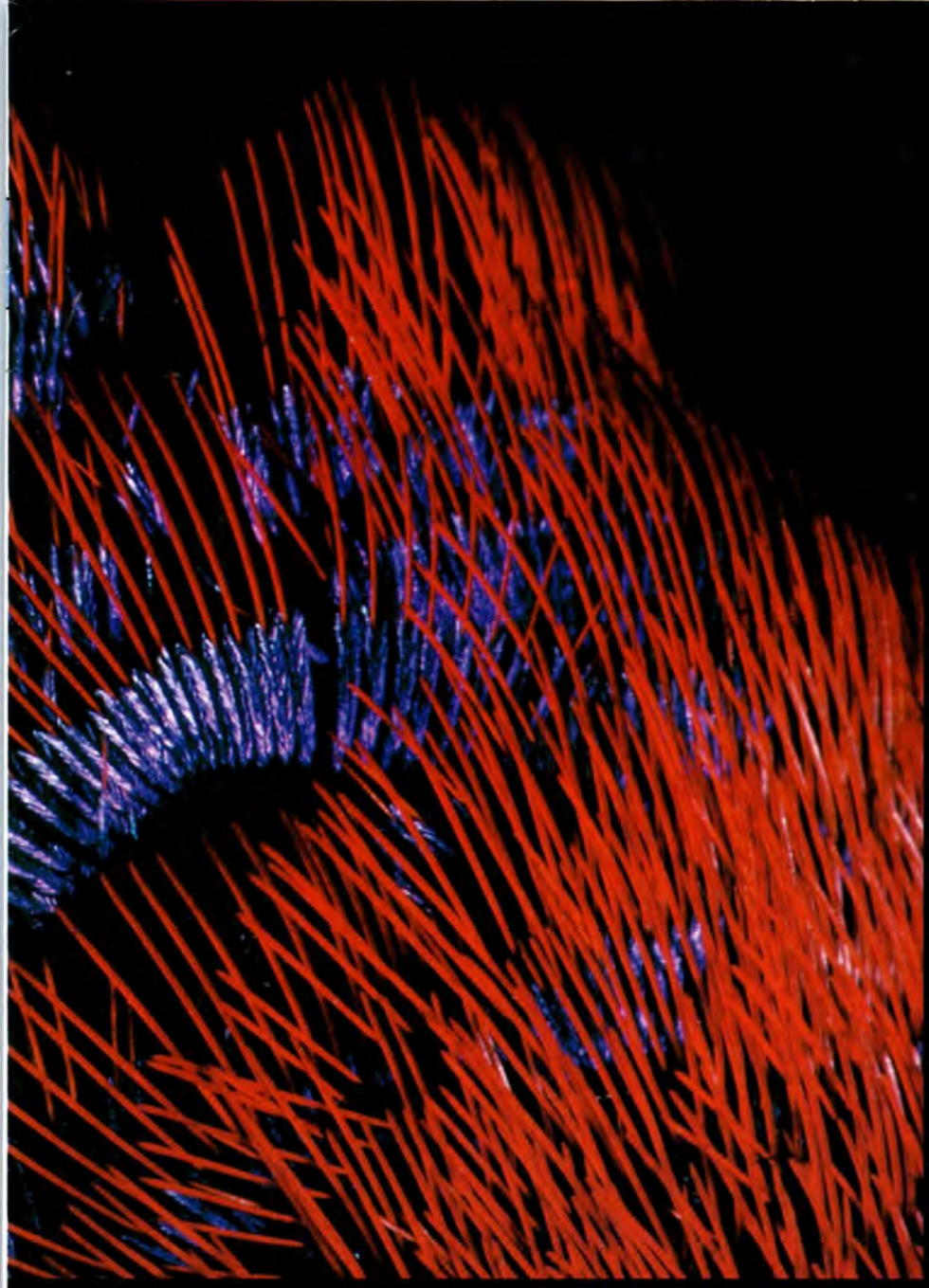








▲ These stunning red and purple feathers form the chest plaque of the tiny, colourful sunbird *Cinnyrus senegalensis*, sometimes placed in the genus *Nectarinia*.

◀◀ Iridescent chest plaque feathers of the Superb Bird of Paradise, *Lophorina superba*.

◀ Complex patterning on the wings of the Malay Peacock Pheasant, *Polyplectron bicalcaratum*.

process, known as moulting, occurs in all bird species at least once a year.

The colours we see in feathers are created by pigments, the actual structure of the feather itself, the refraction of light, or a combination of these. Melanin, the pigment that colours our hair and skin, gives feathers their black, brown, reddish-brown and dull yellow hues. The brighter scarlets and yellows are produced by fatty pigments called lipochromes.

Blues are not created by pigments at all; they are produced by the same optical process that is responsible for making the sky blue, known as Tyndall scattering. Minute bubbles in the keratin that are shorter than the wavelength of visible light absorb colours of longer wavelength, notably all reds and yellows. Blue has the shortest wavelength, hence it is the only colour reflected. Greens and purples are created by the visual combination of the effects of Tyndall scattering and either yellow or red pigments.

The iridescence found in some feathers is also created optically, involving both the structure of the feather and the refraction of light. When moving an iridescent feather, the bright, shiny colours can only be seen at certain angles. This is because some barbules are rotated 90° relative to neighbouring barbules, breaking up the incidence of light into diffraction patterns, the same way oil floating on water produces its scattered colours. Because the barbules are rotated in this manner, they cannot link up to produce a flat surface. This is why iridescent colours are very seldom found in flight feathers – they usually only occur in non-functional, ornamental feathers. Barbs can be covered with a number of transparent membranes; the visible colour depends on the thickness and number of these membranes as well as the angle of light and its refraction. Hence the multi-tone effect found in the iridescent feathers.

All bird specimens photographed here come from the Australian Museum's extensive bird collection.

– Fiona Doig

Australian WILD FOODS

Text and Photos by Tim Low

A nondescript plant, this Bungwall Fern has underground stems packed with slimy, tasteless but, nevertheless, nutritional starch.

Edible Eyesores

Contemporary Australians and traditional Aborigines view nature in different ways. To the urban Australian wilderness is seldom more than a playground for recreation or aesthetic pleasure; to Aborigines it was the provider of all foods and needs.

The Water Ribbons plant (*Triglochin procera*) illustrates this difference. Urban eyes see only a weedy reed with greenish spindly seed spikes. Aborigines, however, saw this as a means to a full stomach. Hidden in the mud beneath each plant lie as many as 200 pale oblong tubers, two to five centimetres long, filled with nourishing starch. Aboriginal women dug these up with sticks and ate them roasted or raw. On Groote Eylandt in the Northern Territory, roasted and pounded tubers were a popular food for teething ba-

Beneath this rather uninspiring Water Ribbons plant lie starch-rich tubers, which when roasted or raw would have provided a nourishing meal for many Aborigines.

Storksbill, although more attractive, was probably not such an important food plant. The edibility of its red taproots is debatable.

bies and elderly folk. Eaten raw, they share the texture and taste of raw potato.

Water Ribbons are found throughout Australia except in the central arid outback. Several varieties occur, some with flimsy floating leaves as illustrated, and others with thick erect leaves that sprout above the water. Although usually found in sluggish waters of swamps, billabongs and creeks, Water Ribbons sometimes grow in swift streams, usually in the shallower stretches.

In swampy coastal districts of eastern and northern Australia, as far south as Sydney, Water Ribbons often grow in the vicinity of another former Aboriginal staple, the Bungwall Fern (*Blechnum indicum*). Like Water Ribbons, this is a nondescript plant unlikely to be noticed by the casual observer. To the Aborigines around Brisbane, however, it was the staff of life. This coarse fern has fronds one or two metres tall and black underground stems packed with starch.

Several early observers wrote of how the fern's starch-filled underground stems were used as food. "It was mostly the gins who dug this up and put it in their dillies to carry to camp," Constance Petrie, daughter of early Queensland settler Tom Petrie, wrote in 1904, "great loads there would be at times, for the root was highly esteemed." In 1894 a Dr Bancroft recorded that "it is first dug out with a sharpened stick, dried in the sun for a short time, roasted and afterwards bruised, when it is eaten in conjunction with fish, crabs and oysters." Special bungwall stones were used to soften the stems, and the 'chop-chop' of the stones was apparently a familiar campsite sound.

Bungwall must have been an easily gathered staple when the long stems were trailing freely in water, and a day's supply was probably gathered in an hour or two. The shipwrecked convicts Pamphlet, Flinigan and Parsons were able to subsist on the starch while crossing Moreton Bay and, when staying with the Aborigines, were liberally supplied with the fern. Bungwall starch is slimy and almost tasteless. It must be eaten with seafood or meat to supply flavour and satisfaction.

The third plant illustrated here, the Storksbill (*Pelargonium australe*), is more attractive. It is closely related to garden Geraniums and has similar flowers and leaves. The flowers are pink or white, always in clusters, and the seed-pods are shaped like storks' bills.

Aborigines reputedly ate the red taproots, although samples I have tried were appallingly astringent and almost impossible to eat. However, its once-only record as an Aboriginal food in 1898 was possibly in error. As it grows only on coastal dunes, inland plains and rock outcrops in southern Australia, in areas where Aboriginal culture was long ago destroyed, its use as an Aboriginal food is unlikely ever to be corroborated. Did Aborigines see in the pretty flowers and leaves a signpost to a tasty snack? Or was Storksbill disregarded as useless rubbish? We may never know for sure. □

DUNG BEETLES

BY GEOFF WILLIAMS

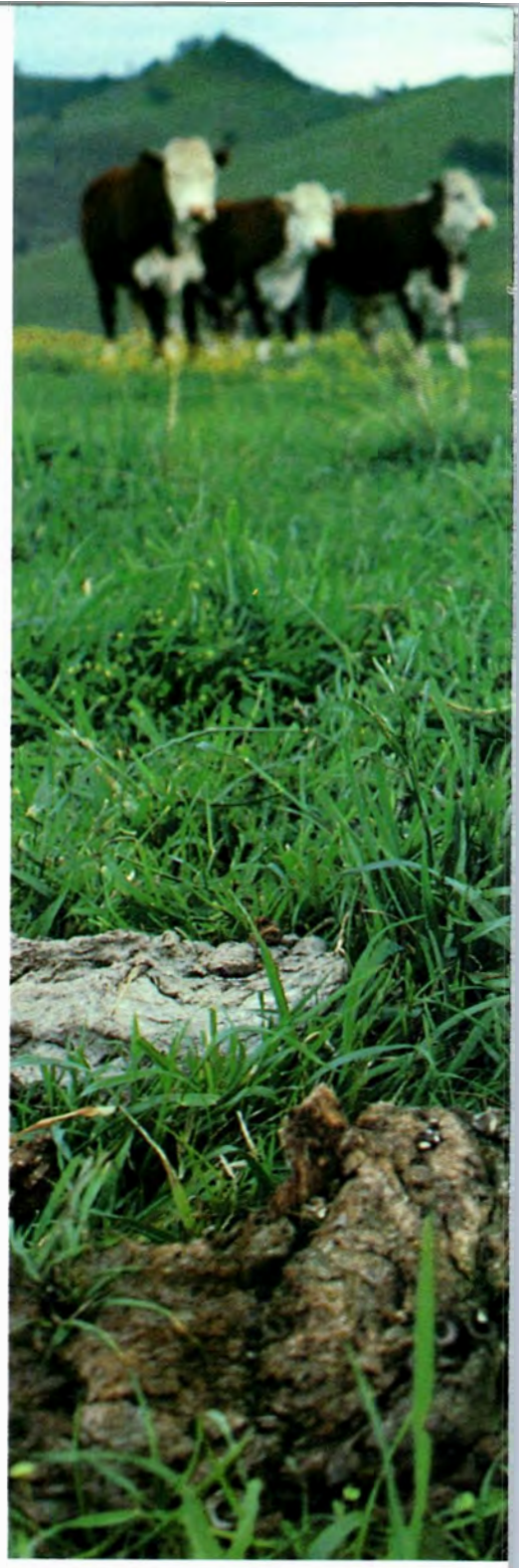
***Cephalodesmius armiger* is one of the few native dung beetles of no agricultural significance that has been relatively well studied. The species 'synthesises' dung from plant material. This is then used to fashion brood balls in which the young will develop. Photo: G. Williams.**

Dung– an almost anti-social subject but one of particular importance in the natural environment–occupies the singular attention of a whole suite of insects and other organisms.

Of these organisms one of the most popularly associated with dung are the dung beetles. Although generally overlooked in Australia, in such continents as Africa their presence is difficult not to notice, especially on the plains and savannahs where grassland herds and grazing animals are found. Here a wealth of scurrying dung beetles, both large and small, occur.

Many of these beetles simply bury portions of animal manure wherever they find it. Other species fashion the manure into spherical balls which they then roll away to preferred sites and bury to provide food for their young. These beetles, and in particular the large, green *Scarabaeus aegyptorium* and the similar *S. sacer,* were thought by the ancient Egyptians to be only males (the females being superficially indistinguishable), and the eventual emergence of the new generation of dung beetles from the manure balls was seen as self-propagation and symbolised rebirth.

Interestingly, the Egyptian word meaning to 'become' or 'make' also translates to 'roll', and the biological phenomenon of ball manufacture, ball rolling and eventual 're-emergence' of an adult dung beetle was reflected in the Egyptian Sun god cosmogony by Khepri, the rising or new Sun aspect of the god Ra-Atum, a great scarab bee-



Not all dung beetles encountered in Australia are native. Some species, such as *Onthophagus nigriventris* (near right, photo: G. Williams), were introduced to disperse cow manure and help combat associated insect pests such as the bush-fly. However, most native species find little enticement in the droppings of domestic stock and, in the absence of specially introduced exotic dung beetles, cow pats can persist for lengthy periods in pasture before being broken down. Thus the cow pats and the rank grass that grows around them reduce pasture area available to livestock. Photo: Kathie Atkinson, A.N.T.

This tiny native dung beetle, member of the genus *Demarziella*, is only four millimetres long. Photo: G. Williams.

Aridacopris maximus, a native dung beetle, constructing brood balls. Photo: G. Williams.

tle pushing before him the Sun disc of his own creation. What the ancient Egyptians considered an act of self-recreation and resurrection is, in fact, one of several feeding and reproductive strategies employed by dung beetles throughout the world.

Dung beetles are members of a single large family (Scarabaeidae) commonly called scarabs. Although the term 'dung beetle' loosely applies to several groups within that family, the term is usually specifically coined for just one subfamily, the Scarabaeinae. A diverse group containing some 4,500 species, the dung beetles are most widely distributed throughout the forests and savannahs of the world's tropical and warm temperate zones. With the exception of some brilliantly coloured and metallic species that occur primarily in the Americas, most dung beetles are plainly coloured black.

In size they range from the 5.5 centimetre-long African *Heliocopris gigas,* a veritable armoured giant of the invertebrate world, to minute forms little more than two millimetres in length. Despite their drab colouration, the males of many species carry head and thoracic horns of fantastic size and shape. What role these male adornments play is still not completely understood. An early hypothesis about a combative use may well be correct, however, for their use by males allows a competitive edge over other individuals for scarce or favoured resources and reproduction.

Although Australia today does not have any large native herbivores that form grazing herds, as in Africa, it is interesting to contemplate the impact of the geologically recent extinction of Australia's mammalian megafauna—*Diprotodon* and the like—on the Australian native dung beetle fauna. What now-extinct six-legged beasts may have attended to the waste products of our once giant wombats and kangaroos, for example?

The scattered populations of today's macropod grazers produce pelleted droppings rather than the massed pat by-products of African grassland herds, so the amount of food available and the physical size of that food resource must have a limiting and modifying effect on the diversity of the dung beetle fauna, the size of the populations and the ability of individual species to occupy various habitats.

Yet Australia possesses a rich dung beetle fauna which goes largely unnoticed in our surrounding environment. Nearly 300 species are known and the fauna extends across northern Australia and down the eastern and western coasts. Few species, however, occur in Tasmania and the arid interior. The factors that appear to limit overall distribution appear to be rainfall and temperature. Areas with low rainfall, at cool high altitudes or in southern latitudes, can be expected to possess relatively few or no species at all. The distribution of individual species is also dictated by suitable habitat. Species found in rainforest, for

example, are unlikely to occur in drier types of vegetation.

The fauna has its highest diversity along the eastern seaboard from northern Queensland to New South Wales. Virtually none of our native species is found outside Australia. The fauna is divided into three tribes. The largest, known as the Onthophagini, has nearly 200 Australian species, which are found from high, cold mountain woodlands to lowland forests, heaths and grasslands. They all belong in the one genus, *Onthophagus,* which with its more than 1,500 described species in the world, is the largest genus of organisms known to man.

With less than 100 species, members of Scarabaeini form the second largest Australian dung beetle tribe but, unlike the former group, its many genera are often restricted to the wetter forests of the eastern coast. Beetles in this tribe are the only ones that roll balls of dung. It is felt that Scarabaeini represents an ancient Gondwanaland element, possibly originating in the Jurassic period some 136 million years ago. Their nearest relatives are found in New Caledonia and New Guinea.

Nearly half of Scarabaeini is restricted to the rainforests of the eastern coast. These rainforests occur as scattered islands within surrounding seas of eucalypt forests and woodlands. This 'island-like' nature of our rainforests results in the restriction of many beetle species to single areas. The tribe Scarabaeini is also unusual because many species are flightless. This imposes difficulties, not least of all mobility, in the ability of individuals to locate food and one another.

The last of the three dung beetle tribes occurring in Australia is Coprini. It comprises the smallest dung beetles and ones that we know very little about.

As a group both larval and adult dung beetles are specially adapted to use animal manure as food. They play an important role in the breakdown of organic matter and its recycling as plant nutrients.

Dung as a source of food quickly breaks down and dries out, becoming unsuitable. The beetles have a number of highly efficient morphological and behavioural adaptations that allow them to quickly locate food and then bury it to provide sustenance for the developing next generation. The initial location is generally by smell and most species are strong fliers. In Africa this is important because many dung beetles are intrinsically reliant upon the vast moving herds of grazing animals. In the case of the large *Heliocopris* beetles, the enormous quantities of food required tie them irrevocably to an association with elephants. No elephants–no beetles, although most other species are far less choosey.

Because the dung dries out quickly and is also competed for by other insects, dung beetles are equipped with structures that increase the speed with which they can disperse and bury their food. The overall body shape is strongly compact and the head and thorax are strengthened to lessen the abrasive effects of digging. The head is modified along its front to act as a shovel and scraper when digging, and the forelegs are widened as an adaptation to excavating soil. The characteristically enlarged thorax of dung beetles also allows greater muscle development and attachment. In some species both sexes actively collect dung and construct nest burrows. This behavioural strategy further enhances their ability to utilise the food source before its nutritional value is lessened by environmental factors and before competitors can monopolise the dung.

During summer the small pellets of dung produced by macropods (wallabies and kangaroos) quickly dry out and become useless to native beetles. However, one small group of dung beetles in the genus *Onthophagus* has modified feet that allow them to cling to the fine hair of their hosts. The beetles, if in the right place, can catch hold of individual dung pellets as they are produced. The beetle falls with the pellet to the ground, rolls the pellet away and buries it before it dries out. An egg is laid with the dung pellet upon which the larva feeds.

Dung beetles are not all tied to large mammalian hosts as one might assume. In rainforests alternative dung sources include the droppings from small lizards, frogs, large terrestrial snails, birds and small nocturnal mammals such as possums, native rodents and marsupial mice. And, although the larvae of most dung beetles are dependent on animal dung for food, some adults can utilise non-dung food sources such as rotting fruit, mushrooms and dead animals. *Onthophagus dunningi* is a species which grows to nine millimetres in length and occurs along the eastern coast of Australia. It may be found at dung and occasionally fallen fruit but more commonly attacks various types of mushrooms. Adult beetles burrow into the soil alongside the mushroom, entering the underground bulb. The beetles feed on the mushroom and fashion brood balls from the mushroom pulp upon which the larvae will feed and develop. As a result of this activity, the mushrooms often collapse and are rendered useless.

Other dung beetles that utilise non-dung food sources belong to the native genus *Cephalodesmius,* which contains three species that occur in rainforest between south-eastern Queenland and southern New South Wales. One species, *C. armiger,* has been extensively studied.

Although animal dung may also be gathered, *Cephalodesmius* beetles literally synthesise 'dung' from plant matter collected on the rainforest floor. Adults, mainly males, forage actively for fallen leaves, fruit and flowers and even fresh plant shoots and leaves.

The plant material is dragged into their burrows where the females compress it. After some weeks the material becomes mushy, and is then suitable for the construction of brood balls into which the females lay an egg. As the larvae develop within the balls of manufactured dung, the adults remain in attendance, although most of the work of adding additional material to the ball, to provide for the increasing needs of the growing larvae, is undertaken by the females. Eventually, after the adults have died, each larva pupates within the hollowed brood ball and emerges after a pupal phase of two to three weeks. In emerging to the surface, the young bypasses the remains of the dead female which nurtured it. Of the male, which remained inactive in the nest while the female laboured, the researchers studying the beetles' life history could find no trace.

Unfortunately, few of our native dung beetles have been so well studied and we frequently know little more than their distribution and habitat requirements. For the majority of dung beetles that have no known economic or agricultural importance, our understanding of their life history has advanced little from that of the ancient Egyptians some 4,000 years ago. □

books books books books books books

Kakadu Man Bill Neidjie

By Bill Neidjie, Stephen Davis and Allan Fox. Allan Fox and Associates, Sydney, 1985, 92pp. $19.95.

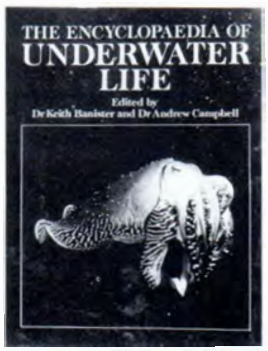
This is a beautiful book. Its imaginative layout, superb colour photographs and pleasant printing make it a delight to look at. It celebrates the wisdom of an Aboriginal elder, Big Bill Neidjie, a traditional owner of land on the East Alligator River in the Northern Territory. Bill lives with his family on his own land. The Banitj people of the Gagudju language group, of which Bill is a member, were awarded title to this land as a result of the Alligator Rivers Stage 2 land claim. In the foreword to the book, the Federal Minister for Aboriginal Affairs, Mr Clyde Holding, justifiably praises Bill and the Banitj people for agreeing to lease their land back to the Commonwealth so that it could be included in Kakadu National Park for all Australians to enjoy.

The focal chapter, "I Give You This Story", in Bill's poetry-like prose, discusses topics such as ecological practices, contact history, law, land ownership and death. His tolerance and understanding of human society, both black and white, is evident. Fox, in his chapter "Australian Dreamtime", sketches a general prehistoric and ecological background for the occupation of Australia, and Davis' "Bill Neidjie of the Gagudju" deals specifically with the East Alligator River region—its prehistory being unfolded by the results of archaeological research, and its history from the time of Leichhardt's arrival there in the 1840s to the present.

Despite the aesthetic qualities of the publication and the power of Bill Neidjie's words, the way that Aborigines are depicted—as immaculate conservationists—disturbs me. There is no doubt that Bill Neidjie and other Aborigines possess formidable ecological knowledge, which is reinforced by a complex system of beliefs about the creation and maintenance of Aboriginal society, and that the rest of Australian society has much to learn from them. Unfortunately, in our attempt to atone for the last 200 years of European injustices, we have dramatically altered our view of Aboriginal society from that of the wretched savages (recorded by Dampier in Western Australia in 1688) to the 'neo noble' people of Fox and Davis presented in this book. Both positions are unacceptable: the first denied Aboriginal humanity; the last renders them so perfect that observation of the slightest blemish may cause the uncharitable amongst us to relegate them once again to the ranks of the outsiders.

I am also less pessimistic than the authors about the future of the Banitj people. On the front fly cover they write: "If sometimes the pathos gets you, just remember that Bill may be the last of his line and with him goes some of the wisdom of 50,000 years!" Western Arnhem Landers have survived the last 100 years of often destructive contact with the external world with remarkable cultural resilience. I am confident that they will survive another 100 years of freehold tenure of land and acceptance by the broader Australian society of their cultural values and right to pursue them.

—Betty Mehan



The Encyclopaedia of Underwater Life

Ed. by Keith Banister and Andrew Campbell. George Allen and Unwin, London, Sydney, 1985, xxxii + 287pp. $59.95.

The Encyclopaedia of Underwater Life is a general reference book covering a great variety of aquatic life. Intended for use by the layperson, the language is light and anecdotal, using common names where available.

The book is divided into two main parts: fish and marine invertebrates. The first section on fish discusses variety, evolution, history of fishes in captivity, endangered fishes and commercial fisheries; and representatives from all four classes of fishes living today are covered in the following 16 subsections. This massive undertaking has been done very well although some of the larger groups, most notably the spiny finned fishes, cannot be covered in detail. There is also an anecdotal subsection titled "Fishy Tales".

Marine invertebrates are dealt with in five subsections covering the protozoans, sedentary and free-swimming invertebrates (such as sponges and jellyfishes), worm-like invertebrates, jointed-limbed invertebrates (such as crabs), molluscs, echinoderms and sea squirts.

A bibliography, acknowledgements, glossary and index conclude the text. The glossary is confusing because it is split into two sections (fish and marine invertebrates). Most limiting, also, is the glossary's small type—some readers may need a magnifying glass.

There are many fascinating snippets throughout the book, often highlighted in 'fact boxes'. Examples include a male angler fish that parasitises the female; the pores on a shark's snout, which can detect one millionth of a volt of electricity; a freshwater fish that grows to three metres in length; and carp that float on the surface hopelessly drunk after eating fermenting fruit.

The work has a strong slant to the north as only one of the 16 authors works in the Southern Hemisphere. Occasionally the fish distribution information is incomplete: beardfishes, cusk eels, grenadiers, the Band Fish, the Goblin Shark and others occur in Australian waters but are not listed as such.

The photographs and artwork are generally quite good with the exception of the shoddy illustration of pelagic crustaceans on pp. 224-225. Here an arrow worm, sea spider and salps are referred to as crustaceans (which they are not). They are, however, all listed under their individual and correct taxa elsewhere in the book. Also, beware the jumbled figure captions on pages 203 and 276!

In spite of its shortcomings, it is a very useful general reference for people interested in aquatic life. At $59.95, however, it is somewhat overpriced.

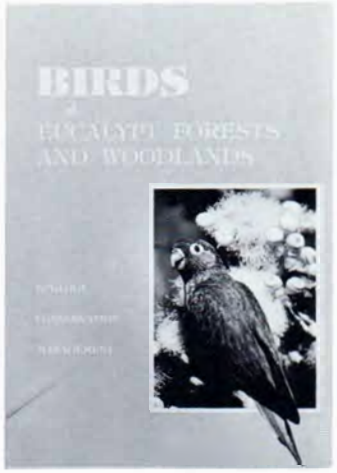
–Mark McGrouther

Birds of Eucalypt Forests and Woodlands: Ecology, Conservation and Management

Ed. by A. Keast, H.F. Recher, H. Ford and D. Saunders. Surrey Beatty & Sons, Sydney and The Royal Australasian Ornithologists Union, 1985. 384 pp. $47.00.

I find it difficult to discipline my enthusiasm for this book and even more difficult to explain concisely why. There are many bird books around but, regardless of their quality in other respects, most of them deal systematically with one species at a time. One consequence of this rigid, linear format is that it is often difficult to convey to the reader any impression of the significance and implications of the data presented. This book is a welcome departure: it approaches directly those questions that are, to me, among the most fascinating of all–the relationship of one bird species to another, and to its environment. This book offers a wealth of insight into the structure and mechanics of the avian community in eucalypt woodland.

About a third of the land area of Australia is (or was) covered in woodland or forest. Over much of the arid interior, acacias and other plants dominate these woodlands, and along the eastern coast there are substantial areas of rainforest. Otherwise, broadly speaking, woodlands in Australia are dominated by eucalypts. About 230 of the 720-odd species of birds in Australia depend on these woodlands, in one way or another, during at least part of their life cycles. Birds in eucalypt woodland occur at a density of around 10 individuals per hectare in dry open woodland to about 30 or more in wet unlogged forest (compared with a figure of about 70 individuals per hectare suggested for undisturbed tropical lowland rainforest in New Guinea, one of the richest avian environments anywhere). Eucalypt woodlands are, in short, one of the most significant of Australian natural environments, and large numbers of our common birds live in them.



The fact that those discussed in this book are among our most common and familiar birds does not mean that their biology is well understood. Far from it: little is known of some. This book explores the relationship between the eucalypt woodland environment and the birds that inhabit it. It is essentially the record of a symposium on the subject held at the University of New England in November 1982, but it has been fleshed out with several additional studies and with a number of 'summing-up' essays, discussing the point and import of the various papers presented. But it is also much more than this. Surprisingly little work had been done in this area before the studies discussed at this forum began, with the result that the present book represents a good and comprehensive summary of what is known on the topic. It has already become my own first point of reference for any question relating to birds in eucalypt woodland.

Organised into three main sections dealing respectively with the structure of bird communities in eucalypt forests, their relationships with their environment, and the impact of human activities upon these communities, the work consists essentially of 26 studies, each focused upon a particular and specific problem within these areas. The various studies seek answers to the questions: just how many birds are there in an average patch of woodland; how does one species of bird co-exist with another; and how are their numbers influenced by bushfires, logging, clearing and various other changes in land management practices. A number of studies explore the life histories of a particular species or group of species of birds within the eucalypt community–these include such common and characteristic groups as the thornbills, treecreepers, rosellas, pardalotes, fantails and honeyeaters.

This is the very stuff of current ecological research into birds, and some of it may be difficult going for the average layman. Nevertheless, the material is well edited and presented, and the threads of all the varied studies are gathered together in a series of introductory and 'summing-up' chapters organised around each section, as well as in two lucid preliminary essays by H. Recher and A. Keast, all of which contributes to a coherent perspective.

After reading it, I spent an enjoyable hour or so indulging in the noble and traditional reviewer's sport of hunting for typographical or editorial errors; I found these few and trivial. The index is good, and the illustrations attractive and well-chosen. All in all, this is an excellent book, the latest in a series of similar works on Australian fauna from the publisher, Surrey Beatty, who deserves a special accolade for producing yet another worthwhile, well-produced and well-designed volume at a competitive price.

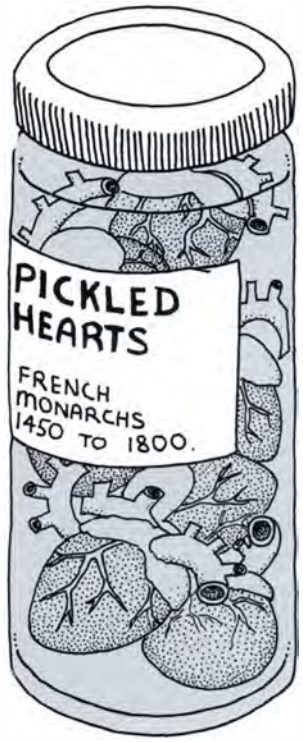
–Terence Lindsey

letters

Pickled Hearts

In her interesting article on Frank Buckland's predilection for rather bizarre gastronomic delights, Georgina Hickey mentioned Frank's illustrious father, the Reverend William Buckland (Professor of Geology and Mineralogy at Oxford University) who claimed to have eaten King Louis XIV's pickled heart. While there seems little doubt that Buckland did indeed gobble up this tasty royal morsel, there are conflicting accounts of whether or not he realised just what, in fact, he was eating.

The Viscount Harcourt, in a letter to *The Times*, recounts that in 1848, at a dinner party at his house in Nuneham, Buckland was shown a silver locket containing a substance similar to pumice stone. Buckland had always maintained that he could tell any mineral by its taste, so, according to Harcourt, he popped it into his mouth and inadvertently swallowed it. Although tradition has it that Buckland died the same night (presumably of a heart attack!), this was not so. He lingered on for another eight years.



Another version of the events at that dinner appears in E.T. Cook's *Life of Ruskin* (who studied geology under Buckland at Oxford and who was once invited by Buckland to share "a delicate toast of mice"). Buckland had always boasted that he had eaten his way through the entire Animal Kingdom and that the worst tasting was a mole (although at other times he claimed that it was a blue-bottle fly). At the fateful dinner Buckland is reported as saying, whilst looking at the preserved King's heart, "I have eaten many strange things, but have never eaten the heart of a king"—whereupon he gobbled it up and added to his menu the heart of 'le Roi Soleil'.

One epitaph written on Buckland after his death ends:

"Here lies a Very Reverend
shade,
A man of parts,
Who holds, till the Last
Trump be played
An Ace of Hearts."

—Dr Ken J. McNamara
Western Australian Museum

Conservation *vs* Animal Rights

The battle to *stop* the Canadian seal cull (see Flannery's "Animal rights: a conservation dilemma", ANH Autumn 1986) was not a conservation issue at all: it was only an animal rights issue. The conservation issue—conservation meaning an attempt to manage the Harp Seal population to the maximum mutual advantage of the seals themselves and those who depend on them for a living—had been going on for far longer—ever since scientists have tried to understand the population dynamics and implement sound harvesting levels.

It is important that conservation and conservationists are not confused with animal welfare and animal liberationists. The former are concerned with species in the biological sense; the latter are concerned with individual animals in an ethical sense. However, the two are not mutually exclusive. Flannery does not quite make this clear. He is right, however, to point out the flow-on effects of stopping the harvest of seals. It had to be reduced if the population was to remain at a viable or even slowly increasing level, but stopping it altogether could have dire consequences for the Harp Seals themselves and those who depend on them (although the three eskimos in the photo did not look exactly like subsistence hunters).

Harp Seals feed on capelin —small, seasonally abundant fish off the Newfoundland and Labrador coast—which are being exploited commercially to the point where there are now grave fears for the future of that fishery. Where are the animal liberationists on that issue? What will happen when the seal populations increase again and compete even more strongly either with humans or other Harp Seals for a diminishing supply of capelin? There will be pressure to cull the seal (*sensu stricto*) or the seal population itself may suffer a dramatic crash from starvation.

Conservation and animal rights issues certainly are complex as Flannery notes. Rarely if ever can they be pursued on a single-species, simple cause-and-effect basis. Rather, the whole ecosystem has to be considered. Otherwise some delicate strand or another of the socio-biological web will be broken. Individual animal rights will then count for nothing.

—Dr John K. Ling
South Australian Museum

Obsessed with Death and O.S.

On Sir Alister Hardy, Robyn Williams writes "Sir Alister died earlier this year at the age of 89" (A.N.H. Vol. 21, No. 10); on Sir Macfarlane Burnet "...he died last winter, just before his 86th birthday..." (Vol. 21, No. 11); on Professor Frank Oppenheimer "The old man died, not long ago, of cancer. The Exploratorium lives on" (Vol. 21, No. 12); and Professor Steven Jay Gould is described as "Short, carrying a huge briefcase, and wearing clothes as does someone with cancer..." (Vol. 22, No. 1). Mr Williams, who I noticed is now President of the Australian Museum Trust, seems to be obsessed with death. Perhaps you could call his regular contribution "Robyn Williams' Obituary Column".

If you don't like that idea, how about "Robyn Williams Goes Overseas" based on the following vainglorious lines: "I first arrived in Australia 20 years ago, fresh, innocent and extremely European" (Vol. 21, No. 7); "I went there [University of London] having just been around the world..." (Vol. 21, No. 8); "So I did what any experienced 24-year-old world-traveller might do..." (Vol. 21, No. 8); "It was the very last day of our trip overseas" (Vol. 21, No. 12); and "On my last trip to New York..." (Vol. 22, No. 1).

I look forward to reading more of Mr Williams' contributions to *Australian Natural History* but hope he will lighten his tone by steering away from death and his tedious worldly connections.

—Janet Thompson
Killara, N.S.W.

Aggregations of Cand Toads are a common sight in Queensland. Photo: Photo: A. Mostead.

Photo: D. Maitland

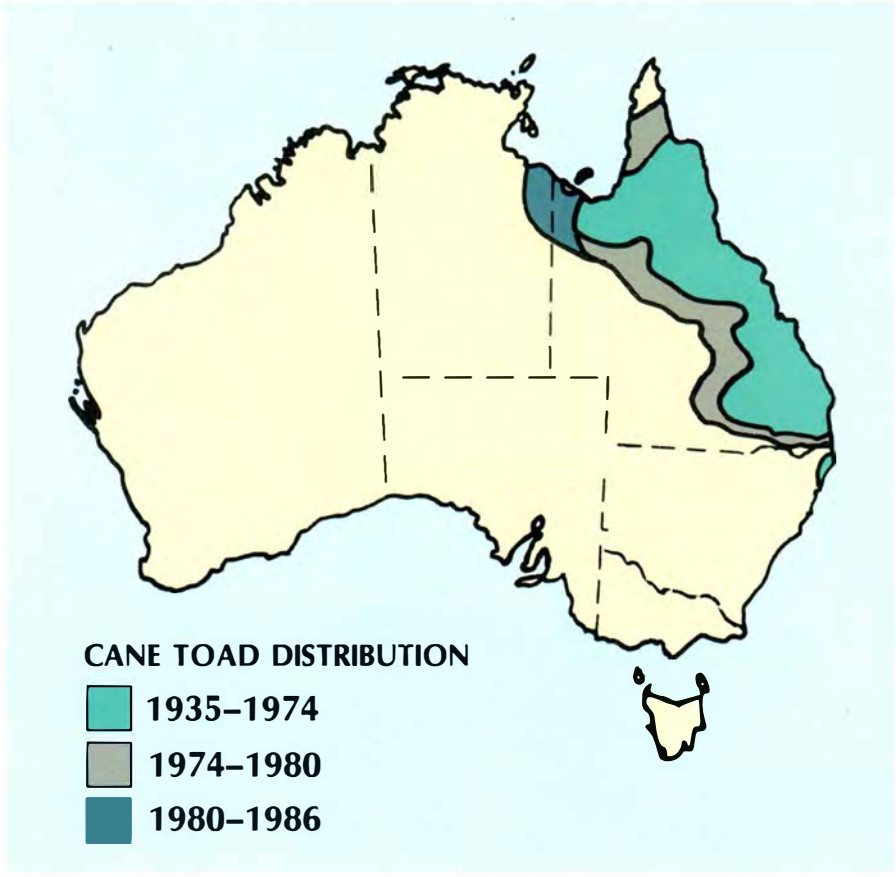
INVASION NORTH

Successful Conquest by the Cane Toad

The Cane Toad (*Bufo marinus*) arrived in Australia in 1935 as a consignment of 101 individuals. Initially bred in captivity, this central and South American toad was dispersed to several localities in coastal Queensland in order to control the Grey-backed Cane Beetle, a pest of sugar cane. Since then they have managed to conquer over 50 per cent of Queensland and parts of northern New South Wales, and have recently penetrated the Northern Territory. The rate of unassisted spread in northern Australia averages as much as 27 kilometres per year.

Although confined to relatively open habitats, Cane Toads live in areas with climates ranging from warm-temperate to semi-arid and the wet and seasonally dry tropics. They live on low flat plains, rocky escarpments, around tropical rain-

by William J. Freeland (C.C.N.T.)



Distribution of the Cane Toad. Originally introduced into Queensland, it is now spreading into the Northern Territory.

Poison secreted from glands behind the tympanum. Photo: David Maitland.

forests, in wet and dry eucalypt forests, saline flats behind mangrove forests, and do extremely well in urban situations. Clearing of forests, as well as mowing, grazing and burning activities, create additional habitats well suited to Cane Toads.

Not only is their spread rapid and the area conquered huge—their population densities can also be high. Estimates from the tropical dry season indicate there are as many as 5,000 Cane Toads per hectare around waterholes. The massive area conquered and the large numbers of these animals are likely to cause great costs to humanity and the conservation of Australia's native fauna. Costs to humans must be balanced against any potential economic benefits. Costs to conservation can only be evaluated from an examination of the toad's biology and an understanding of what makes a successful invasion.

Biology of an Invader

Ecologists have developed a series of hypotheses as to why some organisms succeed as invaders and others fail. Factors thought to contribute to successful invasion include physiological tolerance of the new physical environment, availability of appropriate food in the new environment, competitive superiority of the introduced organism over native species, and resistance to native predators and parasites.

Cane Toads are indeed tolerant of a wide range of physical environments. Adult toads can withstand temperatures from 0ºC to approximately 41ºC, although activity occurs over a smaller temperature range. This tolerance is enhanced by their ability to control body temperature by moving to warmer or cooler parts of the environment.

Although we think of frogs and toads as organisms tied to permanent sources of water, Cane Toads are remarkably resistant to desiccation. They can withstand loss of up to 52.6 per cent of body water and can resorb water from moist soil or the atmosphere. They have been observed laying eggs in brackish water and successful development of tadpoles

can take place in up to 15 per cent sea water.

Australian habitats provide the Cane Toad with a wide array of potential food items. Unlike most frogs, Cane Toads exploit stationary food sources, which include items such as plates of dog food. However, they feed on virtually anything that moves which is small enough to be swallowed—with ants, beetles and termites making up the bulk of the diet. Moths, bugs, centipedes, millipedes, scorpions, spiders, flies, insect larvae, frogs, other Cane Toads and even small mammals may also be eaten. Depending on the particular location and abundance of prey items, toads at one site may feed predominantly on, say, beetles, while at another, ants or termites.

The Cane Toad is an extremely large (often 150 or more millimetres long) and aggressive amphibian, and would at first glance be regarded a devastating competitor for Australian frogs. Yet the sparse data available indicate that native frogs have suffered little from the Cane Toad's invasion. Dry season frog communities around waterholes in the Queensland and Northern Territory Gulf country are just as species-rich, and the individual species' populations and rates of population growth just as large, regardless of Cane Toad populations. In addition, the native frog species' patterns of habitat use, activity rhythms and foods consumed, although broadly overlapping those of Cane Toads, are little affected by the toads' presence. Why this lack of competition? Perhaps because the severity of these environments results in individual frog species' populations rarely reaching carrying capacity. Put simply, there are never as many frogs as could be accommodated by available food and shelter. However, the situation may differ in more benign environments or with other frog species.

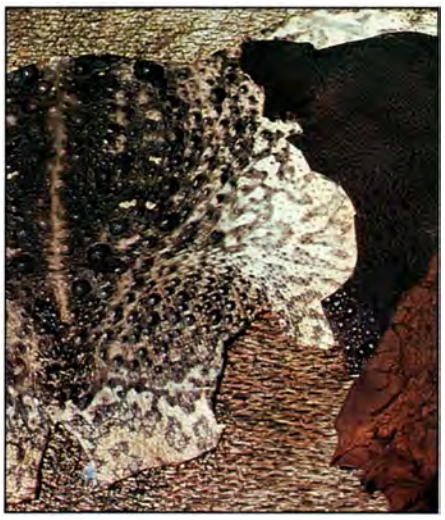
Cane Toads are resistant to many of Australia's predatory organisms. A pair of large toxin-secreting glands (just behind the head) is their most potent defence. This toxin is a lethal mixture of digitalis-like steroids, bufotenine, and epinephrine. A dog may die within 15 minutes from a single mouthing of a Cane Toad. Two cases of human fatality have been recorded. One involved the death of two South American Indians following ingestion of Cane Toad egg soup; and

Despite the Cane Toad's toxicity, this girl can't resist giving her clammy pet a hug. You never know—if she could give the toad a kiss without it poisoning her, it might just turn into a handsome prince...but then she's a little young for that. Photo: A. Mostead.

the other a Philippino Inspector of Detectives who requested that his cook provide frog legs for dinner.

Australian predators vulnerable to the toads' toxin include goannas, King Brown Snakes, Blue-tongue Lizards and native quolls among others. These animals have disappeared or exhibited major reductions in population density following Cane Toad expansion into new areas. Not all Australian predators, however, are so vulnerable. The Keel-backed Snake, frogmouths, a short-necked turtle (*Elseya latisternum*), crayfish (*Euastacus* spp.), Bustards and others feed on Cane Toads with apparent immunity. I have seen a Cane Toad between 60 and 70 millimetres long being dragged off by a large centipede, having first fallen prey to it. Other predators such as Water Rats, crows, Black Kites and Koels either open Cane Toads from the ventral side, thereby avoiding the toxin glands, or feed on already opened, road-killed individuals. The eggs and tadpoles of Cane Toads also have a toxin defence system and so are mostly avoided by Australian predators.

On arrival in Australia, the Cane Toad carried with it relatively few of its own parasites and it now lacks the blood protozoa, gall bladder sporozoans and helminths that it harboured in central and South America. Since the toad has been in Australia, it seems to have shown a degree of resistance to the parasites of Australian frogs, having acquired relatively few of their flukes and round worms, and no blood protozoans.



Raw and tanned (right) skins of Cane Toads. Photo: Margit Cianelli, A.N.T.

The Cane Toad has a relatively rapid rate of reproduction. It breeds in shallow water and can deposit as many as 50,000 eggs in one clutch, at least twice in a summer's breeding season. The tadpole can develop in only 16 days, although a month is more usual. The toads become sexually mature by the breeding season following their hatching and, in the wild, have been recorded remaining sexually active for at least five or six years. One toad was kept alive in captivity for almost 15 years.

At this stage, no single feature seems responsible for the Cane Toad's successful invasion. All that can be said is that it entered an environment in which low rates of parasitism, possibly low rates of predation and a large, underexploited food supply occur. The physical environment is well within the toad's tolerance limits and its life history enables it to become abundant and widely dispersed.

Costs and Benefits

As mentioned previously, Cane Toads were brought to Australia to control the Grey-backed Cane Beetle, a pest of sugar cane. However, at the time of introduction, there were enough data to suggest that the Cane Toad was unlikely to be effective in controlling cane beetles. In fact, there were *no* conclusive data to suggest that Cane Toads were ever effective agents for the biological control of agricultural pests. Introduction took place in the hope that control *might* be achieved, despite opposition from Australian conservationists.

Since their introduction, Cane Toads have, nevertheless, made some significant contributions to Australians. Not only have they provided many students with their first experience of amphibian dissection, but their mothers may well have had first definite evidence of the future Cane Toad-dissector's existence from a now-outdated, toad-based pregnancy test. When injected into a toad, urine from pregnant women causes maturation of the toad's gonad. This test has been replaced by faster and more specific tests.

As laboratory animals, Cane Toads have made significant contributions to scientific research and now form the basis for a small specialist leather industry. Students, researchers and the leather industry will continue to need Cane Toads but these can be bred and raised in captive situations (as was done during the introduction of Cane Toads to Australia). Large populations of wild toads are unnecessary for such purposes. The economics of captive toad breeding and raising has never been examined.

It is difficult to evaluate costs resulting from the Cane Toad invasion. Toads were once a problem for the bee industry: they would sit outside hives eating large quantities of bees. But the unexplained decline of Cane Toad populations in many areas of eastern Queensland has reduced this problem. Costs associated with toad pollution of bores, water holes, drinking troughs and swimming pools cannot be quantified. Loss of dogs is another cost. Cane Toads feed on human faeces and can act as disseminators of human worm eggs and bacterial cysts. No one has ever investigated the scale of the problem in areas with limited sanitation.

The Cane Toad has also had a significant negative impact on Aboriginal culture. Throughout the Queensland and Northern Territory Gulf country, Aborigines refer to the Cane Toad as the 'poison frog'. They are familiar with the toad's devastating impact on the goanna, which is both a food source and a major totemic animal.

While benefits to Australia from having Cane Toads are certainly measurable and of value, the economic, social and conservation costs make a 'do nothing' strategy inappropriate. What we need from Cane Toads could be provided by Cane Toad farms. At the same time, reduction of the toad's rate of spread and size of its wild population must be a target for research and, hopefully, future management action.

The need for action has been recognised. Under the auspices of the Council of Nature Conservation Ministers (C.O.N.C.O.M.), a detailed investigation is being launched into the demography and pathology of Australian Cane Toad populations by the Conservation Commission of the Northern Territory and Queensland's James Cook University. These studies will provide insight into the practicality of controlling Cane Toads and the unexplained declines of Cane Toad populations in parts of eastern Queensland. Hopefully something can be done prior to the Cane Toad's invasion of the vast wetlands at the Top End of the Northern Territory.□

AUSTRALIAN NATURAL HISTORY MAGAZINE

POSTER

A cuttlefish (*Sepia* sp.), seeing and deceiving. Photo: W. Gladstone.

Millions of years of evolution separate the cephalopods (octopus, squid and cuttlefish) from humans. Yet, in one of the most graphic examples of convergence, each group has evolved similar eye structures to see their surroundings. Cephalopods (apart from *Nautilus*) are also exceptional amongst their fellow molluscs by their loss of a protective outer shell. This has been compensated by a wide ranging mobility, high intelligence, superior eye structure and a legendary ability to change colour.

The oceans are complex and diverse theatres of visual images. Light coming through the water's surface is disrupted by waves and scattered by sediment. The survival of each individual within this environment depends upon its success in capturing food, avoiding predators and attracting mates.

The cephalopods were among the first marine animals to evolve a single chambered eye. Early cephalopods shared the oceans with animals that possessed compound eyes, such as trilobites and crustaceans. Compound eyes have limited resolving power which restricts the range of feeding strategies that can be exploited. As such, cephalopods became active, hunting carnivores and flourished.

The eyes of cuttlefish and mammals are remarkably similar. Both evolved in complex visual environments and are governed by a single lens. The amount of light entering the cuttlefish eye is controlled by a valve-like iris. Cuttlefish can look forwards and upwards and have stereoscopic, binocular vision in both planes. The eyes distinguish polarised light (useful for navigation) and the high density of retinal cells suggests that cuttlefish eyes may resolve finer details than those of humans.

Cephalopods have lost the protective outer shell common to their molluscan relatives. Nevertheless, their soft bodies are well protected. All spray dense clouds of black ink in the face of attackers and flee in the ensuing confusion. The octopus, in addition, can squeeze itself into tight crevices. However, the most striking trick in the defensive repertoire of cephalopods is their ability to change colour and blend into their surroundings; the cuttlefish is the master mimic.

Cuttlefish are armed with almost two million colour cells, called chromatophores, over their bodies. Chromatophores contain colour pigments, either brown, black, red, yellow or orange. The colours appear when the walls of the chromatophore cells are stretched and expanded by small muscle fibres. Nerves control the activity of these muscle fibres, so the chromatophores can be activated almost instantaneously. Waves of colour flow across the body of the cuttlefish as it threatens opponents, attracts a mate, or takes on the shades and patterns of the sea floor. □

–Dr William Gladstone
University of New South Wales

LIMITED OFFER

Limited copies of this poster (only) are available laminated on heavy art paper. Send cheque or money order for $10, with name and address of recipient, post-free, to The Australian Museum, Poster Offer, Freepost 10, P.O. Box A285, Sydney South, 2000. Offer expires 30 November 1986 and applies only to the poster in this issue.

A Thylacine from the Museum's collection. Photo: John Fields.

CONFESSIONS·OF·A TAXIDERMIST

BY LISA WHAITE

Visiting a natural history museum is a fascinating introduction to the world of taxidermy, but it is by no means the only outlet for this unusual science. While museums keep taxidermists busy with 'run-of-the-mill' requests such as the preservation of a Thylacine specimen or the preparation of countless mammal and bird skins for the scientific collections, there is always a bit of spare time for satisfying some weird requests—as Lisa Whaite, former Publicity Officer for the Australian Museum, explains.

The word taxidermy has a Greek origin and means literally "the arrangement of skins'. It is as much an art as a science and calls for a variety of skills—not the least of which is a good imagination.

At the Australian Museum, the Prep Shop is headed by George Hangay who, as Chief Preparator, is responsible for allocating and overseeing all work done by the department. This mainly involves preparing specimens for display or preservation in museum collections. Although not all new galleries or exhibitions require the taxidermist's skill, some do rely quite heavily on it. The Mammals in Australia gallery is a prime example of the immense talent and dedication required by the craftsman to achieve the ultimate result—that is, the appearance of an animal frozen in time.

There are several new galleries in the pipeline at the Australian Museum which will also depend largely on the skill of the Prep Shop. Australia 88 is the flagship gallery for the bicentennial celebrations and will trace our beginnings, right through to the present day. Many of the displays will be modified models of prehistoric animals covered with fur to add to the realism. The Human Evolution gallery is also scheduled for opening in 1988. This gallery, with its Darwinian basis, is bound to be a controversial one and will feature more than one stuffed simian—of course the Gorilla will be there!

A museum is definitely the place for a taxidermist whose main aim is high quality. The importance of accuracy and realism means that the craftsman has the luxury of more time to perfect a specimen. And he has a better chance of perfecting a specimen with the backup of a large scientific staff that can offer up-to-the-minute useful criticism and facts.

However, the drawback with this type of work is the almost unavoidable deterioration of the specimen. While there is no such thing as ideal exhibition conditions, there are ways to prolong the 'life' of a specimen. Certainly quality work will last longer than a hurried or imperfect job and, within certain environmental parameters, should survive indefinitely—which is obviously longer than the animal in its living state could hope for! An example of this is the Thylacine specimen held by the Australian Museum. While it is acknowledged that the animal is extinct, this particular specimen is over 100 years old and, with care, should survive for many more.

The temperature of the exhibits must be regulated to 20°C (plus or minus 2°) and relative humidity, which is one of the taxidermist's major enemies, should remain between 53 and

One of the more unsavoury aspects of the taxidermist's lot is to work with human-like creatures. This Gorilla (called George!) died in Taronga Park Zoo and is now being prepared for the 1988 Human Evolution gallery in the Australian Museum. Photo: Heather McLennan.

Cartoons by George Hangay.

"Do you think we should offer him a cup of tea?"

57 per cent. When too high, humidity provides conditions ideal for fungal growth, and when too low, the specimen becomes brittle and easily damaged. Should it fall below 40 per cent, chemical changes take place and the creature rapidly deteriorates.

Among the several enemies to taxidermic specimens, sadly, light is one of them. This is why many museum displays use low light. The Insect gallery employs push-button light switches that turn off automatically after several seconds. Equally, dust, moths and other insects are a problem

The eyes have it! Glass eyes are important and expensive accessories of the taxidermist. Good quality eyes are the products of master craftsmen. Photo: Kate Lowe.

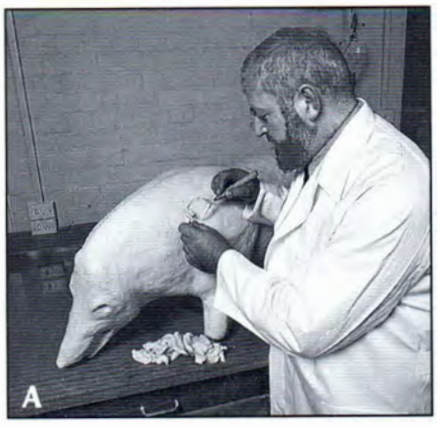
and so display cases should be as close to airtight as possible.

But not all people who brief taxidermists require the unfailing accuracy and immortality associated with a museum. Many are people who have lost a beloved pet or spouse and who want a reminder of the object of their affections. Although it is not normally museum policy to cater for the taxidermic needs of private individuals, preparators *are* sometimes approached to perform some very strange tasks—not the least of which was from Jeremy Bentham. Sometime in the 1830s, this English gentleman, wanting to keep an eye (so to speak) on his colleagues after his death, left a vast sum of money to the London University College, on the proviso that he be present at every board meeting. The recipients of this unusual request certainly fulfilled its conditions, for the late Mr Bentham was embalmed, placed in a glass case, and wheeled in and out of future meetings.

Another extraordinary request was from the widow of a violin player who wanted her dead husband's hand severed, stuffed...and mounted. In this case the taxidermist was able to convince his client that a cast of the hand, made with dental alginate, would fulfil her desire for a 'life'-long memento of her husband, without risking possible

The brilliant colours of this mounted Golden Pheasant only remain life-like under carefully controlled conditions. Too much light, high humidity or dust fade and dull the vibrant hues. Photo: George Hangay.

Sorting and preserving insects can prove to be an arduous although interesting task. Thousands of specimens are being sorted here after a successful night-collecting trip by The Australian Museum Society. Photo: John Fields.



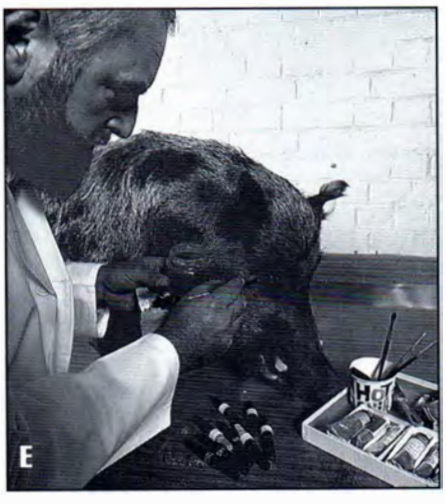
prosecution for the mutilation of a corpse. The cast shows superb detail, right down to the indentations in the fingers from the strings, and the finished product was tastefully mounted on a marble stand.

Most of the stranger requests directed to George Hangay and his team, however, are centred around animals. One particularly unusual brief was to create a lampstand from a sausage dog (or dachshund)! The poor creature was to be immortalised with a shade on its head and lights burning from its eyes! No less unconventional was the plea for a beloved cat to be turned into mittens! However, it seems that no matter how strange the request, one thing is usually standard. The majority of clients request that their pet be portrayed in an attitude of sleep—perhaps so they don't see the reproach in their eyes for this final indignity? Some people are so attached to their pets that they ask for glass coffins with handles, sized to fit into a suitcase, so they can accompany them on family holidays.

Of course, it is easier for the taxidermist to portray the animal in sleep. Eyes are still one of the most difficult aspects of taxidermy to perfect. They require a lot of experience before realism can be achieved, although modern techniques have assisted here. For over a century the Germans dominated in the manufacture of artificial eyes, but American techniques now lead the field. These days a set of fake human eyes costs approximately $25–35.

No matter what advances modern technology has made, there are certain basic procedures which must be followed. This usually begins with the maceration of the carcass. Once it has been skinned, the meat is carved off, the bones cooked and then either left to a colony of dermestid beetles to clean up or put in cold water until the remnants of meat rot away. The bones are then scrubbed and...but let's preserve some of the magic and mystique of this fascinating profession—as they say, a little knowledge is a dangerous thing! □

The serious business of large mammal taxidermy is demonstrated here by George Hangay. From the initial clay model (A) a fibreglass mould is prepared (B). Liquid polyurethane foam is poured into the mould (C). After the foam expands and hardens, it is released from the mould (D) and the tanned skin is then mounted on it. Finally, the specimen receives a little cosmetic treatment (E) before embarking on its career of "public life" in one of the exhibitions. Photos: John Fields.



THE MYTH OF EVOLUTIONARY PROGRESS

"Evolution is not synonymous with improvement... it is clear that evolution is more frequently degenerative than progressive."

Just about everybody understands the basic idea of evolution to mean that if they were to trace their family lineage through parents, grandparents, great-grandparents and so on, they would eventually come to ancestors that were more like apes than people. Extending the genealogy, we would find that these ape-like creatures were descended from more primitive mammals and these, in turn, from reptiles, amphibians and fishes. Things get rather fuzzy beyond about five hundred million years, but details don't matter. What most of us learned in high school or in introductory university zoology courses is that evolution is a matter of progress and improvement: from fishes via frogs and lizards, shrews and apes, to the crowning glory—humanity. While this simplified history is essentially correct, the lesson we have learned from it is wrong. Evolution is *not* synonymous with improvement.

It follows from all that we know of evolution and animals that every species alive today has an equally long evolutionary history back to the first living organisms. If we reconstruct the probable ancestry of, say a Kiwi, a legless lizard, a blind cave-fish, a louse, a liver-fluke, or a barnacle, we get a picture of loss and degradation. Indeed, since the number of parasitic species vastly exceeds the number of free-living ones, it is clear that evolution is more frequently degenerative than progressive. But this is still not the point.

If we reconstruct the evolution of any successful animal group, the picture we get is neither one of progress nor degenerative change, but of opportunistic spread: put another way, the 'direction' of evolution is sideways rather than upwards or downwards. Take for example, kangaroos. There are large ones, small ones and omnivorous ones; some that subsist largely on fungi, others that eat the subterranean parts of plants, or leaves, or grasses. Some kangaroos live in rainforest, others in the desert, some make nests, burrows, or spend their lives in trees. We cannot say that any one species of kangaroo is superior to another. We can only say that each species differs from the others and that these differences enable them to

exploit different resources within the same environment. Such evolutionary radiations—the exploitation of a wide variety of opportunities by closely related species—is by far the commonest situation observed by students of evolution.

The concept of 'survival of the fittest' has been ridiculed as tautological or circular (fitness being defined by the ability to survive). This misses the point. 'Fitness' in the evolutionary sense does not necessarily imply size, strength, vigour or 'progressiveness' but simply the possession of an advantage over competitors in surviving and reproducing. Birds on small oceanic islands are in danger of being swept out to sea by gales and, in this situation, 'fitness' could involve either very strong powers of flight or giving up flight altogether. Both possibilities have been exploited.

Many evolutionary changes are almost certainly random and have no bearing on fitness. Some have arisen out of competition for mates (such as the adornments of male birds of paradise, peafowl and some deer) and are probably an unnecessary burden on the species. Whatever the causes or results of evolution, Darwin's principle of natural selection applies. Put very simply in terms of modern biology, if the carriers of certain genes produce more offspring, on the whole, than other members of the population, then these genes will increase their representation in successive generations. The carriers of these genes can be said (in the particular circumstances operating at the time) to be fitter than other members of this species and they will prevail under the same circumstances. Rapidly changing circumstances may render *all* members of a species unfit.

In the light of these sketchy observations, what can we predict of the future for our own species? Over the past few millions of years our evolutionary lineage has passed through apes, australopithecines and several species of *Homo* to *Homo sapiens*. It has been marked by an overall increase in the size of the brain. But can we expect this trend to continue? The answer is *no*, unless parents whose brains are larger because of their genetic constitution leave more offspring than parents with brains of normal size. Similarly, *Homo sapiens* is less hairy than apes: will our descendants have even less hair? They will not—unless smooth-skinned parents rear more children than hirsute parents. Will our ill-organised vertebral column improve? Will varicose veins vanish from our legs or our abdominal musculature become better adapted to our upright posture? Will we become more sociable, less aggressive? All these improvements are unlikely because they are not related to reproductive efficiency.

I do not deny that evolution can involve progress. Indeed, I could cite the evolution of mammals from fishes as comprising about half a dozen instances of what can be defined as significant biological 'improvements'. One of the many successes arising from this branch of the total evolutionary tree is *Homo sapiens* but there is no indication of a continuing evolutionary impetus that will lead this species to further improvement. The impasse arises from the very factors that made us the dominant species on this planet.

Humans are the animals that *talk*. We are unique in communicating by means of a vast vocabulary of symbols which we *learn* from one another and pass from generation to generation. Whereas the behavioural possibilities of other animals are limited by their inherited instincts and what each is able to learn in its lifetime, humans can rapidly draw upon the experiences of all members of a community and, through tradition, their forebears. This system of information transfer has proved so effective that individual survival and reproduction is no longer totally dependent upon the genes carried by those individuals and, under these circumstances, evolutionary processes are deprived of the controls under which they normally operate.

Workers in the field of evolutionary biology are divided on the question of whether or not there is such a phenomenon as an evolutionary 'dead-end'. I would suggest that *Homo sapiens* is one such instance. □

—Ronald Strahan
Australian Museum

ROBYN WILLIAMS — The Riddance of Rut

A.B.C. RADIO SCIENCE SHOW

Imagine how demeaning it would be for women if they went on heat like dogs or cats. Every few weeks their 'parts' would swell, significant smells would be given off and an unequivocal willingness to have sex would be inferred by every man around. Not nice at all.

Yet humans are the only primate in which oestrus or a rutting period is absent. Long ago in the evolution of hominids, females stopped going on heat. Perhaps it was because they stood up and their genitals could no longer be seen in technicolour boldness. Perhaps it was because language came to be and people no longer needed to signal by means of odours. Some imaginative sociobiologists propose that women took to self-adornment to make up for this sudden lack of bodily display. Can we really claim that necklaces and make-up compensate for a spectacular posterior? In the realm of human sociobiology, wild imagination often reigns supreme.

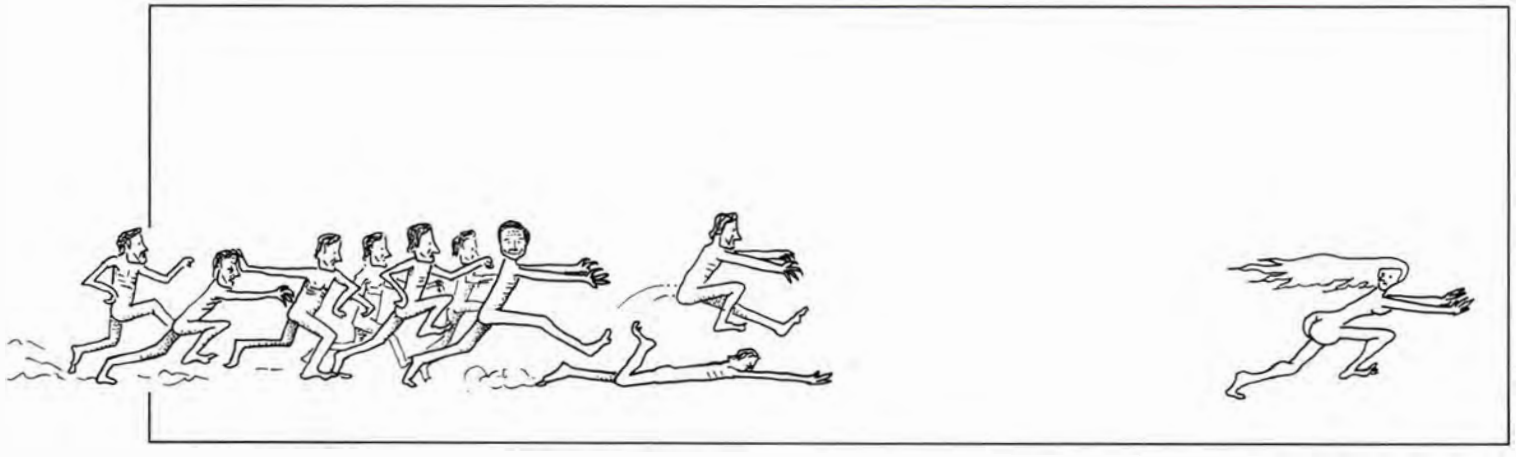
There is no question that the end of oestrus was a turning point. Desmond Morris remarked that human females became sexually receptive (at least in theory) at all times so that males would stick around to help look after the family during the long time it takes kids to grow up. Constant sex was the reward. Bouts once a quarter would hardly be sufficient inducement.

But the question of what the family was like remains. I had assumed that it resembled something traditionally tribal with a kind of nuclear family as its core. But there is no evidence that this need be so. Professor Adrienne Zihlmann from the University of California at Santa Cruz has studied Chimpanzees' relationships and concludes that our closest relatives certainly do not have a mummy-daddy-and-the-kids organisation. Such is also unlikely in other primates. With human beings all things are possible and indeed there have been all manner of variations in family patterns throughout our history, perhaps even, as some scientists claim, extensive matriarchal episodes where women are in charge of tribes and families, and men occupy roles quite unlike our modern image of the head of the family.

Professor Zihlmann and her colleagues suggest that the 'family' may have been without a father figure as such. This is not as unlikely as it may seem; after all, there is no hard evidence showing what social life was like 20, 30 or even 100,000 years ago, certainly no clues about relationships within a family. Shere Hite, author of the 1976 *Hite Report* on female sexuality, says we have been deluded–by what she calls the 'Judeao-Christian model'–into thinking that cave life was much the same as that in the average dwelling in Toorak or Vaucluse. Well, it may be in some respects, but I believe Ms Hite implies that ancient women, despite their 'primitive' circumstances, were much more in control than we would think. Having rid themselves of rut, they could dictate sexual terms more effectively. They could also draw on the general services of the male in ways that don't necessarily require him to be on the spot at all times. In some Papua New Guinean villages, for example, there are male houses and female houses, and clandestine visits are made between the two in the darkness of night. Shere Hite's prehistoric families could have acted similarly.

One puzzle about those times long ago is whether folk actually connected coitus with offspring. Afterall, why should one make such a leap of faith? If they did not see the link between sex and kids, then what would convince a male that his children were his own? And if they had no obvious reason to assume the coitus–birth connection, would they then think in terms of 'the family'?

All these questions are ultimately unanswerable. But that doesn't stop scientists and everyone else providing various answers. I shall offer only two thoughts about this speculation. One is that we must hesitate before ascribing the word 'natural' to any type of human family life. We do not know what our ancestors did and, most likely, it may not be what we think it was. My second thought is to applaud the riddance of rut. Just imagine what life would be like with it! □



RARE & ENDANGERED

Pedra Branca Skink

The skink *Pseudemoia palfreymani* is one of Australia's rarest and most geographically restricted lizards. The only known population occurs on a small 2.5 hectare island, called Pedra Branca, 26 kilometres south of the Tasmanian coast. The total number of individuals in the population has been roughly estimated at 250. Although the skink is numerically common, given the small area of land it occupies, it is considered one of only five endangered lizards currently recognised in Australia.

Pedra Branca is a barren sandstone island. The only terrestrial plant is the perrenial saltmarsh herb *Sarcocornia blackiana*, which is widespread on the island. Also inhabiting the island are fur seals, nesting sea birds (albatrosses and gannets) and a few invertebrates. The skinks are heavily dependent on the sea birds for their food. Skinks have been observed eating flesh from dead fish which nesting birds bring to the island to feed their young, and the birds' spilt regurgitated stomach contents. They may also feed on invertebrates. The birds nest on the island from October to May when the skinks are active. The skinks presumably hibernate during the other months of the year.

Pseudemoia palfreymani individuals seem to be associated with specific sheltered burrows in rock crevices and retreat to these when disturbed and probably to hibernate. The distribution of these burrows appears to determine the local distribution of these skinks.

As is the case for many other skinks from cool climates, the young of *P. palfreymani* are born live during late summer. Mating has been observed only once (in March 1984 in the wild) and involved the male holding the female's neck in his jaws.

The species was first sighted in 1947 but not collected until 1956 when the skinks' namesake, A.E. Palfreyman, captured six live specimens. Three went to the Tasmanian Museum and three to the Museum of Victoria. It was described in 1974 on the basis of four (of the original six) dead specimens. The other two had been lost. Since then two specimens were collected in 1978 and seven in 1984. An additional five were collected in 1986 (two of which are alive in the Australian Museum). □

—Georgina Hickey

***Pseudemoia palfreymani*—one of Australia's rarest and most geographically restricted lizards. Photo: R. Jenkins, N.P.I.A.W.**

Pedra Branca. Photo: R. Jenkins.

A Garden of inclusions ('jardin') in a Colombian emerald. Photo: B. Sechos.

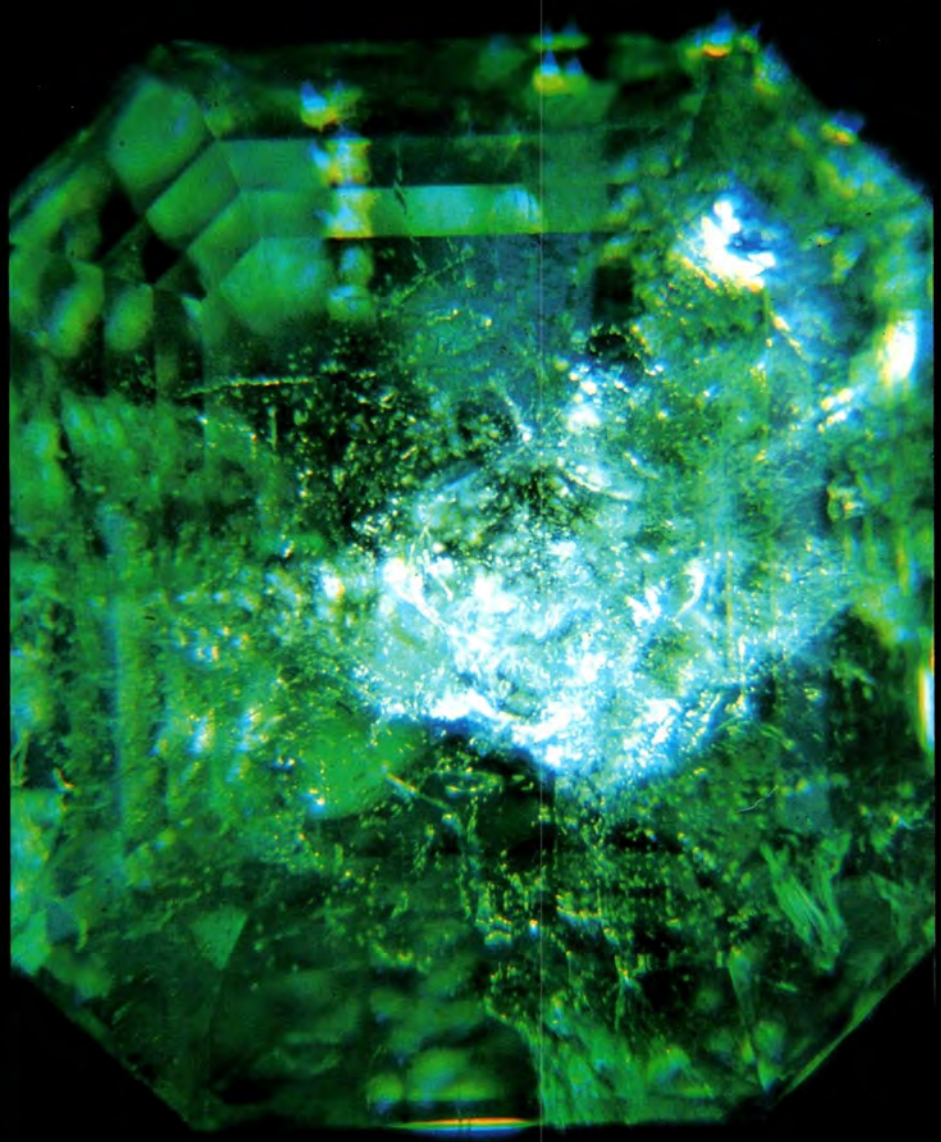
Three-phase (liquid, gas and solid) inclusion in the same emerald. Such inclusions are typical of emeralds from that locality. Photo: B. Sechos.

B A 'zebra stripe' inclusion unique to amethyst. Photo: B. Sechos.

Amethyst from Brazil. Photo: R. Weber.

C Aquamarine crystal and cut stone from Mt Surprise, Queensland. Photo: R. Weber.

Two-phase (liquid and gas) inclusions in the same uncut aquamarine, Mt Surprise, Queensland. Photo: B. Sechos.



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There is a fascinating array of gemstones of all shapes, structures and colours from all over the world in the Australian Museum's new mineral gallery, 'Planet of Minerals'. In this article Gayle Webb, from the Museum, takes us beyond the displays by exploring the inside story of gemstones.

GEMSTONES

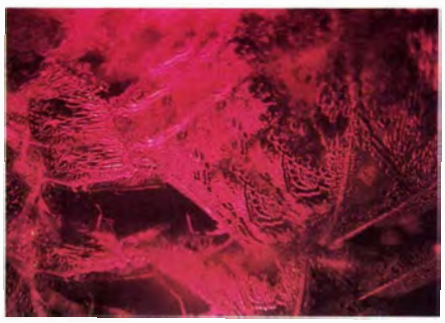
BY GAYLE WEBB

C

The greatest fascination of a gemstone lies in a paradox. This highly sophisticated product of the modern cutter's art is at the same time a piece of primal material, witness to incredible events which we may only deduce and imagine. Gems are the flowers of the geological process. They are the rarest of minerals for the qualities that give them their beauty—the qualities of colour, fire, brilliance, transparency and hardness.

A mineral is a naturally occurring, inorganic chemical element or compound, with a definite crystal structure and a composition that varies within defined limits. Minerals are the fundamental building blocks of the Earth. Of the 2,400 or so mineral species only about 100 are cut into gemstones and, of these, only about 15 circulate widely in the gem trade. Some gemstones are too soft for wear, some are even too rare to be mined, but collectors prize these for their beauty and rarity and they live their lives in boxes

A collection of rubies from Thailand. Photo: B. Sechos.



Liquid 'feathers' in a ruby from Thailand. Photo: B. Sechos.

or museums. When one considers the qualities that make a mineral worthy of being cut as a gemstone, such as colour (or complete lack of it), lustre, fire, hardness, clarity, and ability to grow both in crystals large enough to be cut and quantities worth the effort of mining, it becomes obvious why the group of gem minerals is so small.

Having fulfilled all the necessary criteria, gemstones today may still be downgraded by a lack of complete clarity, for current fashion dictates that stones be 'flawless'. The truly 'flawless' stone, that is, the stone without any inclusions, is so rare as to be almost impossible to find and would be very expensive indeed if it were. Emeralds, for instance, are almost never flawless and are valued more for their wonderful colour than their clarity. Their array of inclusions is affectionately referred to as a 'jardin', French for garden. Most stones, even when cut from carefully selected material, contain inclusions—traces of their origin in the Earth. Some inclusions may be obvious to the naked eye and, if there were a number of these, may dull the brilliance or colour of a stone. Many, however, are visible only under magnification. These magnified gemstone interiors reveal an unsuspected world of beauty and interest.

Gemstones are cut from crystals. Crystals are solid and have a regular internal arrangement of atoms. Growing unimpeded on a surface or on the walls of an open cavity, crystals will form plane faces and angles, typical of their particular crystal system. Crystals that develop in cramped circumstances may have few or no plane faces, although their atoms will still obey the same regular internal arrangement for that system. They are formed by the same processes that formed the rocks in whose interiors they grew, and their formation may have taken many thousands of years.

Rock and Mineral Formation

There are no minerals in the Earth's inner core. This is an area of enormous pressure and heat, possibly consisting of iron and nickel, and being somewhat similar in composition to iron meteorites. The next outer layer, which is about 3,000 kilometres thick, is the Earth's mantle. In the upper mantle, up to 200 kilometres beneath our feet, high pressure minerals are formed which may be conveyed to the Earth's surface by volcanic eruption. Diamond, which is highly compressed carbon, pyrope garnet and peridot (gem quality olivine) originate from this upper mantle zone.

The outermost layer of the Earth is called the crust and covers the mantle like a thin skin, sometimes as little as ten kilometres in depth. This is the site of the rock cycle in which most gemstones originate and are exposed at the surface by erosion or mining.

The formation of new rocks begins inside the Earth with molten magma solidifying as it cools and crystallises. The magma accumulates into huge, igneous rock bodies of granite, diorite and gabbro, and a portion of it may be forced to the Earth's surface, erupting from volcanoes as molten lava. In the coagulation of this lava, peridots may be found in small crystals.

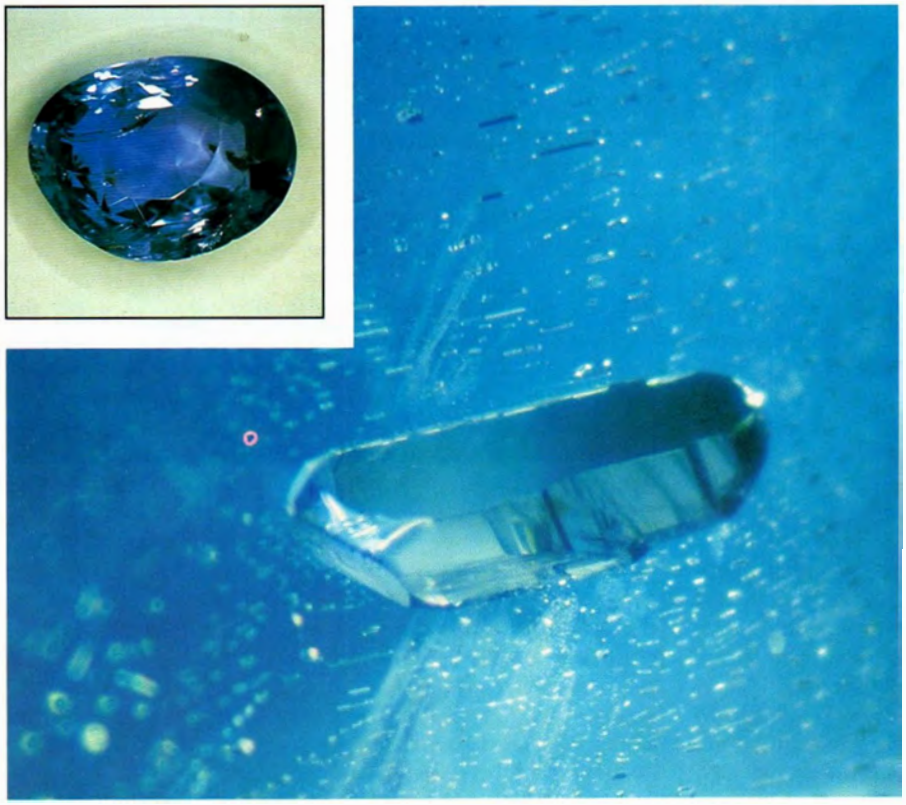
After the main crystallisation in the Earth's interior, a highly volatile residual melt remains, rich in boron, fluorine, chlorine, carbon dioxide, water and easily-volatised metals such as tin. This melt also contains many rare chemical elements and is extremely mobile and chemically active. It presses into fissures and cavities of the host rock and solidifies slowly into very coarse-textured rocks called pegmatites. Pegmatites often contain unusually large and beautiful gem crystals such as aquamarine, morganite, golden beryl, alexandrite, kunzite, moonstone, topaz, tourmaline and apatite. Other minerals from residual melts may include ruby, sapphire, zircon, spinel, gem quartz, some emeralds and fluorite.

Metamorphic rocks are pre-existing rocks that have undergone recrystallisation by heat, pressure or chemical alteration due to deep-seated disturbances in the Earth's crust. Minerals in the original rock may also be recrystallised and disseminated through the newly-changed rock. The beautiful rubies and sapphires of Burma were formed in this way, by metamorphic action on the limestone country rock. Other gem minerals that are formed by this process are almandine garnet, some emeralds, aventurine quartz, jadeite, lapis lazuli, iolite and kyanite.

Sedimentary rocks may form gem materials in veins and nodules, as solutions seep into fissures and build up within them. Opal, turquoise, agate, chrysoprase and malachite may occur in this way. Sedimentary rocks are formed by the weathering of other rocks and the deposition of the weathered particles into layered sediments. Although not originating there, many gemstones hard enough to survive the weathering process are found embedded in sedimentary rocks, and alluvial deposits may be rich sources of diamond, sapphire, ruby, spinel, zircon and topaz.

Against this background of geological processes, it is possible to see how

Internal graining (caused by strain in the crystal) and crystals in a diamond from Argyle, Western Australia. Photo: B. Sechos.



Sapphire from Sri Lanka with visible inclusions. Photo: R. Weber. Negative crystal in a sapphire from Sri Lanka. Photo: B. Sechos.

types of rock and minerals become concentrated in definite areas. This may lead to large concentrations of gem minerals in various parts of the world. Famous gem areas are the Mogok area of upper Burma, which supplies the finest rubies, sapphires and spinels from its metamorphosed limestones; the Minas Gerais and Minas Novas pegmatite areas of Brazil, which supply magnificent beryl and tourmaline; the diamond-bearing kimberlite pipes of South Africa and Botswana; and the rich alluvial gem gravels of Sri Lanka.

What are Inclusions?

Using the association of rocks and minerals as a guide, experts can build a picture of the conditions under which these minerals were formed, namely the pressure, temperature, chemical environment and type of rock from which they came. In the same way the interior of a gemstone provides its own associations which may help identify it and provide a clue to its formation. Gemstone inclusions are a tiny but vital part of the information geologists require to solve the mystery of the Earth's past.

The word 'inclusion' refers to all optically detectable irregularities in the interior of a mineral or gemstone. These include mineral inclusions different from—or the same as—the host crystal, twinning lines (changes in orientation of the crystal during growth), structural defects or damage, cleavage cracks, colour zoning and growth marks.

As the gem crystal formed in its rock cavity, it absorbed surrounding minerals into its own structure, perhaps even enveloping smaller, earlier crystals of its own kind. These are known as solid inclusions. In this way we may find tiny diamond crystals within a diamond. The crystal may also have absorbed chemical elements with which to form other inclusions as it grew.

Internal cavities of a crystal may contain trapped liquid from which the gem was formed and the outlines of these cavities often obey the crystallographic laws of the host crystal. These are called negative crystals. Cavities may, in addition, contain a bubble of gas, forming what is known as two-phase inclusions (two phases of matter). If they contain a solid as well they are known as three-phase inclusions. Cracks or fissures within the stone may be penetrated by liquid or gas to form mesh-like patterns, called feathers. These feathers are made up of tiny liquid droplets which may show a gas bubble under magnification. Growth phenomena are also apparent in many stones. They may be represented by the parallel lines of repeated twinning, jagged growth lines in, for example, a diamond, or colour zoning (common in sapphires and amethysts). Interrupted growth causes straight or angular striations in natural stones. Even after growth is complete, the crystal, if subject to other forces such as chemical attack, strain and radioactivity, may form additional inclusions.

Each process leaves traces in the internal pattern of the crystal, and particular types of gem minerals develop their own pattern of inclusions. Such inclusions may be diagnostic of their host and thus be used to establish the species of an unknown gem mineral. Also, since each gemstone's internal structure is unique, an inclusion picture of a particular stone may be used to identify it. This is called 'fingerprinting'. De Beers uses this method of fingerprinting diamonds. Inclusions may also be used to distinguish between a natural and a synthetic stone; or to establish the geographic area from which the stone originates, particularly in the case of rubies, emeralds and sapphires whose locations can often be accurately pinpointed, for example, Burmese rubies and Colombian emeralds.

As scientific methods become increasingly precise, it is possible to see even more inside a gemstone or crystal. The crystal structure of included minerals may be ascertained by X-rays and their chemical composition by X-ray fluorescence. These techniques permit examination of the smallest inclusions without destruction of the host gem or crystal. The electron microscope also greatly increases the scope of observation by allowing perusal of an object with dimensions as small as one hundred thousandth of a millimetre. If the inclusion is near the surface, an exact chemical analysis can be achieved by first grinding down the surface and then probing it with the newly-available electron microprobe.

Such refinements, available to the scientist, will clarify immeasurably the relationship between gemstones and the history of the Earth. Like fossils, gems may provide a reliable guide to the past and enlarge our understanding of events previously beyond our imagination. □

QUIPS, QUOTES & CURIOS

Garlic and the Black Speckled Doll

Garlic (*Allium sativum*), a perennial herb and member of the lily family Liliaceae, is one of the oldest cultivated plants in existence. Considered a general tonic stimulating energy and longevity, it has also been used to cure intestinal worms, fever, consumption, the plague, leprosy, cholera, whooping cough, asthma, bronchitis, high blood pressure, rheumatism, venomous bites and stings, constipation, the common cold, toothache, sore throats, nosebleeds and pimples. Its juice was used as an antiseptic during both world wars to prevent septic poisoning and gangrene. To the superstitious, garlic acts as a prophylactic against witches and the devil (six bulbs, which were apparently found in the tomb of Tutankhamon, were probably put there to ward off evil spirits); and against vampires (in 1973 a Pole, who had a phobia about being attacked by vampires, actually died from accidently inhaling a whole clove of garlic in his sleep). Garlic is a carminative (aids expulsion of air), an aphrodisiac (somewhat contradictory to the former attribute but nevertheless responsible for its often-used synonym 'the food of love'), and, if rubbed into the skin, is a good insect repellent (if you can stand the smell!). The advantages of garlic are so numerous that the first recorded industrial strike occurred when slaves, building the Great Pyramid in Egypt, refused to work when their garlic ration was withdrawn! In fact, until recent publication of a paper by Professor C.M. Harris *et al.* (*The Lancet*, March 1, 1986, vol. i, p. 492), it seemed that the only disadvantage of garlic was its foul smell. In this article, garlic is held responsible for the black speckles sometimes seen on antique china dolls. This extraordinary attribute of garlic, the authors point out, is an occupational hazard where the product is affected,not the producer.

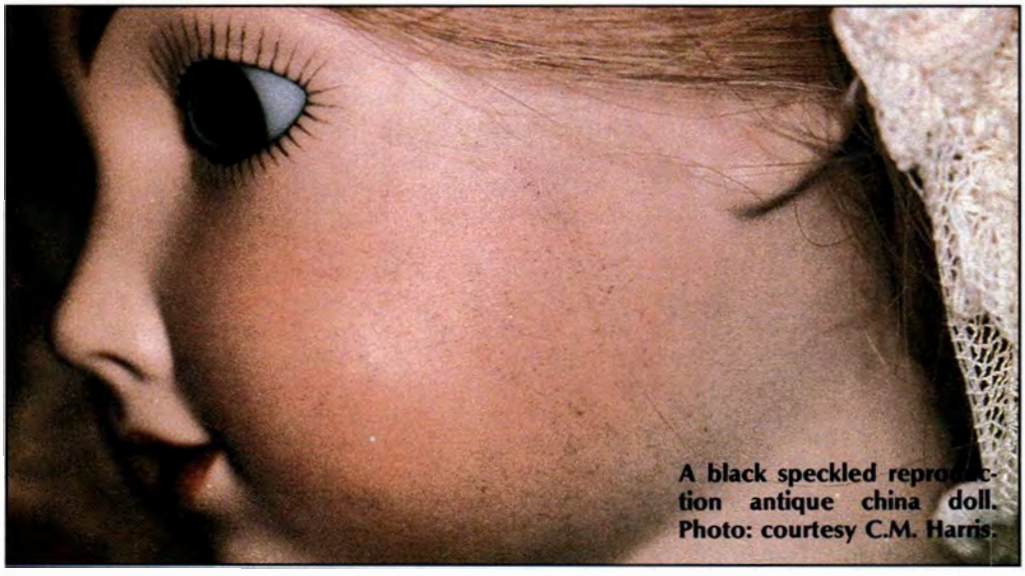
A young girl, who was employed by a British company to make reproduction antique china dolls, noticed that whenever she painted a doll's head, black speckles would appear after its subsequent firing. When the girl wore gloves, no speckles appeared. This seemed to indicate that the problem was in her sweat.

Analysis by mass spectrometry and X-ray fluorescence showed the speckles to consist of iron and sulphur, the sweat from the girl's hands to contain sulphides, and the clay to be rich in iron. A discussion of the girl's diet revealed that she ate large amounts of garlic, a food containing several organic sulphides. Abstinence from garlic for a week prevented further formation of black speckles.

In normal individuals, the sulphur compounds found in garlic are broken down and excreted in the urine. This particular girl, however, was proven to be a poor sulphide metaboliser and was excreting virtually unchanged garlic sulphides in her sweat. These garlic-derived organic sulphides, it seemed, were reacting with the iron in the clay to form the black speckles on the dolls.

Black speckling is apparently not uncommon and, until now, had usually been ascribed to dust in the mould or kiln. So if you come across a black speckled china doll, you can bet that its maker also had a peculiar metabolic deficiency and, most probably, an inordinate love for garlic.

Also mentioned in the same article was another occupational hazard where the product is affected. Apparently, cabinet makers with red hair leave fingerprints on oak that show up blue when it is fumed. (It appears that red heads aren't called 'Blue' for nothing!) The authors, however, offer no explanation for this phenomenon.



A black speckled reproduction antique china doll. Photo: courtesy C.M. Harris.

Caffeine—a Natural Insecticide

Plants such as coffee, tea and cocoa contain high levels of caffeine and caffeine-like substances called methylxanthines. According to Dr James Nathanson (*Science*, 12 October 1984, Vol. 226), these substances act as natural insecticides and, because of their low toxicity to humans, may be used in developing more potent pesticides that are relatively harmless to humans.

Dr Nathanson, working with tobacco hornworm larvae (*Manduca sexta*), added finely-powdered tea leaves and coffee beans to their laboratory food. At 0.3-10% coffee or 0.1-3% tea (by weight), the larvae exhibited decrease in appetite, hyperactivity, tremors and stunted growth. At higher concen-

trations, the larvae died. Concentrations of caffeine found naturally in undried leaves (0.68-2.1%) or coffee beans (0.8-1.8%) are sufficient to kill most tobacco hornworm larvae.

The methylxanthines work by affecting the insects' co-ordination, particularly when trying to moult, by blocking action of an essential enzyme, phosphodiesterase. Cells use the enzyme to break down cyclic-AMP, a compound necessary for neurotransmitter action. If cyclic-AMP levels build up, cell metabolism becomes unbalanced and can result in death.

Methylxanthines were also found to affect mealworm larvae, butterfly larvae, milkweed bug nymphs and mosquito larvae.

Dr Nathanson showed that low concentrations of methylxanthines, when mixed with octopamine-based pesticides (octopamine is an insect hormone that increases production of cyclic-AMP), increase the toxicity of the pesticide by 10 to 50 times. Because humans lack cell receptors for this hormone, the combination may prove to be extremely potent to insects but remaining relatively harmless to humans.

So next time you have a cup of coffee and relax back with a sigh, give a thought to the humble insects that have been shunned by that 'foul brew'.

First the Pill, Now the Bullet

A contraceptive, enclosed in a bullet and administered by airgun, has been designed to reduce libido and sexual development in male and female kangaroos, and to thereby enable populations to be reduced using birth control, rather than culling.

Dr Ted Stelmasiak from the Victorian Department of Agriculture, and Dr Simone van Mourik from Melbourne University, have tested these contraceptive bullets on Eastern Grey Kangaroos, Red Kangaroos and Bennett's Wallabies.

The bullets act by immunisation of male and female animals against Luteinizing Hormone Releasing Hormone (LH-RH), the neuro-hormone produced by the brain responsible for sexual development. By creating antibodies against the neuro-hormone, the LH-RH released by the brain is captured in the bloodstream thus inhibiting its action.

This method was found to be as effective but more practical than administration of progestins (a component of the human contraceptive pill that prevents ovulation) into females only, or vasectomy of males.

The bullet itself is a biodegradable implant which, the researchers hope, will result in reduction of fertility over the whole period of a wild kangaroo's or wallaby's reproductive life, enabling effective life-long contraception from just one inoculation. This contraceptive can be shot from an airgun within a range of 0.5 to 16 metres, but to be practical for kangaroo control a system would have to be developed using a .22 calibre rifle or other device with an increased firing range.

This contraceptive method of population control might also be applied to feral animals such as pigs, goats and deer.

Rare as Hen's Teeth

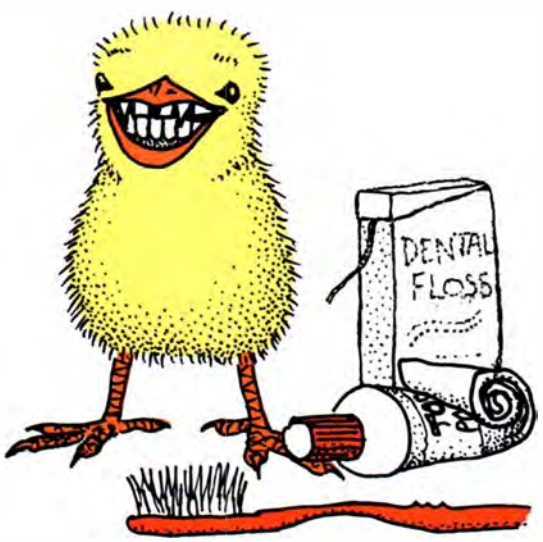
Although toothlessness in birds is proverbial, the first known bird, *Archaeopteryx lithographica,* living about 60 million years ago, and several other fossil birds had simple, conical teeth.

In a truly remarkable series of experiments, however, reported in a 1980 issue of *Science* (Vol. 207, No. 4434), a relic of these ancient teeth has been demonstrated in modern birds. The authors (E.J. Kollar and C. Fisher) showed that certain tissues of chicken embryos have the capacity to take part in tooth development.

They took epithelial (outer) tissue from the gill arches of a five-day-old chicken embryo (the first gill arch in vertebrate embryos develops into jaws) and combined it with mesenchyme (inner tissue) of 16 to 18-day-old mouse embryos from the region where their first molars would form. They then placed this embryological chicken epithelium–mouse mesenchyme combination inside the eye of an adult mouse (a nutrient-rich environment). The result? Teeth—complete with inner dentin and outer enamel.

To explain this amazing phenomenon, we must understand a little about embryology. The outer enamel layer of a tooth develops from epithelial tissue and the inner dentin develops from mesenchyme. However, mesenchyme can only form dentin in the presence of epithelium; in other words, epithelium is a necessary inductor for mesenchyme to produce dentin. The dentin in turn induces the epithelium to produce enamel.

Kollar and Fisher's experiments show that chicken epithelium has the ability to produce enamel and induce mesenchyme to produce dentin (although chicken mesenchyme itself has probably lost the ability to produce dentin). The teeth that developed—although half-expecting them to have complex cusp patterns of a mouse's first molars—were simple structures; perhaps relics of teeth from ancient birds and, in this respect, the first 'bird teeth' to develop in 60 million years! □



Venturing far south towards the south magnetic pole, one of nature's most spectacular phenomena, the aurora australis (southern lights), can often be observed. It forms a fascinating display of unfolding draperies of colour and light as it dances to the music of the spheres. Yet, unlike its northern partner, the aurora borealis (northern lights), which is commonly sighted in

BY MICHAEL MALLIS

AURORA AUSTRALIS

Aurora australis over sea ice in mid-winter (Casey Station, Antarctica). Photo: Gordon McInnes, A.N.T.

northern Europe, Russia and North America, relatively few people have experienced the southern version. The reason for this difference is due simply to the absence of a populated landmass close to the south pole. Both aurorae are known collectively as the aurora polaris (polar lights).

Reference to aurora borealis can be found in the mythologies of various cultures throughout the ages. However, the first reported sighting of aurora australis has been attributed to Captain James Cook on 17 February 1773 on the H.M.S. *Resolution* while sailing in the Southern Indian Ocean. It was Cook who gave this aurora its name. Unfortunately this 'first' sighting is a popular misconception as the aurora had actually already been observed on the *Endeavour* in 1770 during Cook's first voyage of discovery to Australia. Joseph Banks, the expedition botanist, reports in his journal for 16 September 1770 that "about 10 o'clock a phanomenon [*sic*] appeared in the heavens in many things resembling the aurora borealis...". What makes this account fascinating is that it was sighted just off Timor at 10° south of the equator.

There is reason to believe that the aurora (in general) has existed since time immemorial and that prehistoric man must have been an observer of aurora borealis at least. There is subtle evidence in cave paintings to suggest that this was so. For example, the ceiling paintings of the cave of Rouffignac in France show what appear to be folded curtain patterns reminiscent of some of the forms the aurora can take. There are also at least four passages in the Old Testament that seem to make reference to the aurora. The clearest description is in Ezekiel (1:1-26; 593 BC): "...A stormy wind blew from the north, a great cloud with light around it, a fire from which flashes of lightning darted...over the heads of the animals a sort of vault, gleaming like crystal, arched above their heads...".

The ancient Greeks certainly knew of the existence of the aurora. The 6th century Greek philosopher Xenophanes wrote of "...moving accumulations of burning clouds...". This is probably the first account of an aurora in Greek literature. Hesiod's earlier work, *Theogony* (8th century BC), makes mention of "flaming heavens" and "fiery sky dragons" but his story may have been inspired by myth and not an actual sighting. Hippocrates and his student Aeschylus developed a theory to explain the probable cause of an aurora, based on reflected sunlight. This was to persist for the next 25 centuries. Aristotle, in his treatise *Meteorologica*, gave the first scientific description of an aurora, which he termed 'chasmata'. This account is more plausible than Hippocrates' and Aeschylus', although reflected sunlight was still incorporated in the theory.

The Roman scholars Livy and Dionysius also reported the aurora: "...the sky was seen to blaze with numerous fire". And Pliny the Elder (Ist

The Roman goddess of dawn, *Aurora*, from a painting on a Greek vase, dispenses the morning dew from the urns she carries.

century AD) catalogued the aurora as a terrible portent of impending disaster: "...we sometimes see, them which there is no presage of woe more calamitous to the human race, a flame in the sky, which seems to descend to the Earth on showers of blood...". It was also said that the aurora appeared prior to Julius Caesar's assasination.

The North American Indians usually describe the aurora in terms of merry dancers or Gods dancing across the firmament. Norse literature has many references to the aurora and attributes this to reflections from the shields of the Valkyrjes, the Valkyrjes being the souls of dead maidens.

Much later, during the Renaissance Period, the aurora became a source of poetic and artistic inspiration as well as scientific investigation. William Shakespeare has a passage in one of his works which seems to refer to the aurora: "Fierce fiery warriors fought upon the clouds in ranks and squadrons and right form of war that drizzled blood upon the capitol" (*Julius Caesar* II, 2, 19). And Samuel Coleridge was moved to write a few lines in his classic work *The Rime of the Ancient Mariner*:

> "The upper air broke into life
> and a hundred fire-flags sheen
> to and fro they were hurried about
> and to and fro and in and out
> the wan stars dance between."

Lord Byron, John Keats, Walter Scott, Lord Tennyson, Robert Burns and many other poets and philosophers of the day were also inspired to write of the aurora. Similarly, Wagner's opera *The Twilight of the Gods* has a closing scene in which the heavens and Earth turn red to the glow of the aurora.

There are no documented sightings of aurora australis from early South African, South American, Australian or New Zealand cultures, although it is probable that they were observed and regarded fearfully. New Zealand Maori legend, however, tells of the aurora as being a great fire lit by their ancestors to the south.

It is only during the latter half of this century that the processes which produce an aurora have come to be understood. An aurora has its origin at the Sun. The solar wind is a particle stream of protons and electrons which are constantly being 'boiled' off the Sun's surface, escaping its powerful gravitational pull. This solar wind moves outwards in all directions into interplanetary space as a tenuous cloud travelling at high speed. After a few days it encounters the Earth's magnetic field which captures and guides some of these particles along its field lines into the 'auroral ovals'. These ovals are doughnut-shaped, some 23 degrees in radius, encircling the north and south magnetic poles. At places on the auroral ovals, the aurora may be seen on any clear night.

Subject to strong solar activity, such as a solar flare which releases many times more energy and particles than normal, the auroral ovals expand in width, outwards to mid-latitudes and inwards towards the poles. But auroral displays witnessed at mid-latitudes seldom seem as bright, colourful and spectacular as those at polar latitudes.

The solar particles never actually strike the Earth's surface but are accelerated down to heights of 100–200 kilometres above the Earth where they are halted by collisions with the atoms and molecules in the atmosphere. In these collisions the particles transfer energy to the atoms and molecules and, just as in a neon tube, this energy is re-emitted as light; in the atmosphere we call this light the aurora. Its colour is basically dependent on the gas that is present, its height and the proportions in which it occurs. More than 160 different shades of colour have been identified, with oxygen atoms emitting shades of green and red, and nitrogen molecules, red and blue.

The aurora is the only visible manifestation of the vast amounts of energy unleashed by the Sun into the upper atmosphere. Its forms, movement and changes are due to a redistribution of the solar wind that is being funnelled by the Earth's magnetic field.

Visually, the aurora is a light of various intensity, distributed in regular or irregular horizontal bands that stretch across the sky, usually in an east-west direction, and in which may appear striations or rays of light. These rays define the Earth's magnetic field along which the electrons and protons from the solar wind are guided. One auroral form shows a characteristic drapery structure, so called because it looks like a hanging curtain. Another appears to converge to a point, resembling a corona (hence its name 'corona' aurora). And still others appear featureless, that is, void of any apparent motion, structure, varying luminosity or colour variations. These are called 'diffuse'.

Despite its sometimes brilliant display, much of the visible aurora is seen below the colour threshold of the human eye, in which case it is seen as white or almost greenish-white. For this reason moon-lit or twilight-lit cirrus cloud has sometimes been mistaken for an aurora. Of course, we cannot see the auroral glow by day because the Sun outshines it. There are no differences between aurora australis and aurora borealis; in fact, they occur simultaneously in both hemispheres and have similar displays.

The probability of observing the aurora decreases rapidly as one proceeds from the auroral oval towards the equator. Thus, presuming there is no cloud cover, on any one night there is a 97.4 per cent chance of visually observing aurora australis from Mawson (Antarctica), 5.1 per cent chance from Hobart, .75 per cent from Melbourne and only .15 per cent from Sydney.

Photometers are used to study the light emitted by an aurora. These are light monitors that are sensitive to one particular wavelength (or colour). By measuring the wavelength and other parameters of this auroral light, scientists are able to identify and monitor the types of atomic reactions occurring. Auroral research continues in and around the auroral regions through the use of sophisticated rocket-borne instruments, satellites and advanced balloon and ground-based equipment. Research using photometers and magnetometers (instruments sensitive to variations in the Earth's magnetic field strength and direction) has been carried out on Macquarie Island, a rugged windswept island about 1,500 kilometres south of Hobart, by the Australian National Antarctic Research Expeditions (A.N.A.R.E.) since 1948.

A good auroral display, with its play of colours and quick-changing effects, creates a feeling of awe. Indeed, it has often hypnotised me to the point of forgetting to photograph it! A typical display at Macquarie Island lasts between two and 30 minutes, but can last longer, at almost any time of the night. Lengthy observations have been known to cause a sore neck and cold feet but even for someone who has studied and experienced the aurora in detail, it still remains a source of wonder and mystery. □

REEFS

ACCIDENTAL AND ARTIFICIAL

BY LUCY HODGSON

The shifting sands beneath the ocean are almost as barren as those of a terrestrial desert. However, although an empty beer can thrown onto desert sand will lie virtually unchanged for years, in the marine environment it immediately becomes a new habitat.

The can acts as a hard substrate for attachment of algae, sponges, barnacles and other encrusting organisms. It provides shelter for small fish and crustaceans such as gobies and crabs. Larger fish are attracted to the food provided by the attached and sheltering organisms. In short, the beer can becomes a miniature reef environment.

Accidental Reefs

Natural reefs are well known both as good fishing grounds and interesting diving territory, due to the wide variety of sea life associated with them. Any hard substrate, such as rock or coral, acts in the same way as the beer can but on a much larger scale.

An unusual type of reef is formed when a shipwreck settles on the ocean floor. The fate of these 'accidental' reefs depends on the area in which they sink. If the ship is buried, or sinks to great depths where the water is dark and cold (as was the case with the *Titanic*), it may be preserved rela-

The *Yongala*, wrecked near Townsville in Queensland in 1911, shows heavy encrusting invertebrates with a variety of colourful fish nearby. Photo: Neville Coleman, A.M.P.I.

Succession of marine life has begun on this recently-established tyre reef at Glenelg in South Australia. Over a long period of time, the build up of barnacles and other encrusting organisms will probably make these tyres unrecognisable as such. Photo: K. Branden, courtesy S.A. Dept Fisheries.

tively unchanged for hundreds of years. In shallower and warmer water, progressive colonisation by marine organisms may destroy, or in some cases preserve, a wreck, leaving a fascinating puzzle for biologists and archaeologists.

The biological puzzle lies in working out what controls the succession of organisms on a newly formed reef. The study of how plants settle and how animals are recruited to a reef helps biologists predict which animals will colonise a reef under different environmental conditions. It also helps to explain the differences in flora and fauna on established reefs in different areas. It takes approximately five years (depending on water temperature and depth) for a sunken wreck to establish a 'stable' community and act like a 'natural' reef.

The details of plant and animal succession will vary depending on the area. Generally, however, fish, crabs and other mobile creatures are the first to move in from surrounding areas, using the wreck as shelter. Then a thin, slimy film of diatoms and other microscopic algae covers its exposed surfaces. This provides food for gastropods (sea snails) and small shrimps. Hydroids and anemones may settle in sheltered niches, and barnacles, which grow rapidly, usually dominate available space for a time. As the barnacles are removed by predators; tube worms, bryozoans (lace coral) and coralline algae find places for attachment. Ascidians and sponges grow and so too do longer-living organisms such as corals, gorgonians and anemones.

Throughout this succession of fixed organisms, larger mobile animals (fish, crabs, lobsters, octopus) take up residence according to the type of shelter and food provided. Resident fish do not leave the wreck but other transient fish species will visit, feed and then move on.

The puzzle for archaeologists lies in extracting the secrets of a wreck's history from its living shroud. While some parts of a ship are broken down in the marine environment, others are preserved by burial in the sand or mud, or by a covering of encrusting growths. Objects become cemented in place and are less likely to be broken up by wave action. This is why glass and pottery are often found well preserved.

Wood is the most vulnerable material, being broken down by the action of marine borers such as shipworms (which are bivalve molluscs) and boring amphipods and isopods (crustaceans). Wood and other materials also swell when submerged in water so if they are brought to the surface and dried, structural damage can result.

Encrusting organisms provide a coating that protects surfaces from sand abrasion and the corrosive effects of salt water and oxygen. Even without this living coating, metals can be protected as they reach an equilibrium with the surrounding water. In the case of iron, the surface of the metal oxidises (rusts), forming a stable outer layer of iron oxide that actually protects the metal beneath.

Archaeologists find that it is not easy to convert a ship from a living reef back to its original form. One of the best ways to preserve a very old wreck is to leave it where it is.

Artificial Reefs

Ever since ships have been sailing (and sinking), fishermen have recognised that wrecks make good fishing grounds. With this in mind, several countries have investigated the use of artificial reefs to improve otherwise barren fishing areas. The Japanese and Americans have shown that fish catches can be improved two to sixteen times by the placement of artificial reefs.

In Australia, several experimental artificial reefs have been set up with varying success. Earlier attempts resulted in these reefs either breaking up or sinking into the sediment. Many different materials have been used: cement blocks (which are often too expensive and difficult to handle), old cars (these generally rust too quickly to establish a stable reef), derelict boats and car tyres.

John Matthews and Dave Pollard, from the New South Wales Department of Agriculture's Fisheries Division, provided the recipe for one of their more successful reefs: two Manly

Anemones (*Corynactis* sp.) growing on the *Dee Why* ferry, which was sunk off Long Reef in Sydney specifically to create an artificial reef. Photo: M. Spencer, Deacon Publishing Services.

ferries, one Garden Island dock gate, two small barges, two M.S.B. hopper barges and one large bucket dredge, all sunk to a depth of around 50 metres off north Narrabeen. Diving surveys on the reef have shown Jewfish, Teraglin, Snapper, Blue and Red Morwong, and various wrasses living within the wrecks. Yellowtail, Pike, Kingfish and Trevally were observed schooling above the reef. In fact, on any weekend the position of the reef can be determined by the concentration of recreational fishing boats around it.

State Fisheries Departments have also experimented with old car tyres, which they have tied together in the form of pyramids or cylinders and sunk in barren fishing areas. After an initial success with a tyre reef near the mouth of Lake Macquarie, problems were encountered when two other artificial reef projects failed. A reef in the upper reaches of Port Hacking did not attract large quantities of fish, probably because too few fish encountered the reef to establish any communities in this upstream area. A reef built in St Vincent's Gulf broke up during a storm, resulting in tyres littering part of the Gulf and highlighting the need for proper anchorage of artificial reefs.

Provided suitable sites are chosen and tyres are properly attached and anchored, used tyres are considered to be one of the best materials for artificial reefs. They are cheap (some companies even pay for disposal of old tyres) and easy to handle. As there are no other pollution-free methods to dispose of used tyres, the Goodyear Company proposed sponsoring an artificial reef program in South Australia in 1974. This did not eventuate but, in April 1984, South Australian Fisheries obtained a grant from the Commonwealth Employment Program to employ people to build tyre reefs. These reefs are being built at Whyalla and will be transported to sites in Spencer and St Vincent's Gulfs.

Today, 46 people are employed under this scheme in Australia's largest artificial reef project. So far three reefs have been constructed at Grange, Glenelg and Port Noarlunga, using a total of 3,000 tetrahedral tyre structures. Three more reefs are due to be completed for Whyalla, Port Pirie and Port Augusta. A three-year monitoring study is also being conducted to determine how successful each reef is.

Dave Pollard, of the New South Wales Fisheries Division, has estimated that the Japanese Government spent about $A22.5 million between 1962 and 1970 subsidising construction of reefs made from hollow concrete blocks. The $1.3 million spent by

The wreck of the *Yongala*, virtually unrecognisable as a ship, is a haven for schooling fish and the occasional ray, not to mention divers! Photo: K. Deacon, Deacon Publishing Services.

the Australian Government so far on the tyre reef project in South Australia seems insignificant in comparison. However, it is the first step and hopefully the information gathered during the monitoring study will lead to a better understanding of what determines the success (or otherwise) of an artificial reef.

Artificial reefs are often created by foreshore developments such as wharves, retaining walls and breakwalls. The value of these unplanned reefs depends on whether their construction destroys valuable habitats or provides new habitats in otherwise barren areas.

Scientists from the New South Wales Fisheries Division have studied the effect of the revetment wall built into Botany Bay as part of a major port development. Their census of fish populations showed that there was a slight increase (three per cent) in numbers of commercially important fish around this revetment wall, compared to those from a similar-sized area of a natural reef near the mouth of Botany Bay. However, there was an overall greater number and variety of fish species on the natural reef, and construction of the revetment wall and its associated dredging has aggravated the problems already caused by the port development in Botany Bay. These include loss of sea-grass habitat (important nursery areas for many marine animals) and altered wave patterns causing erosion in some areas of the bay.

Since fishermen discovered that old shipwrecks make good fishing grounds, there has been no dispute that fish will usually be attracted by the shelter and food provided by any form of reef. However, as conditions are not always favourable for establishment of a reef community, indiscriminate dumping of large waste items can lead to pollution rather than enhancement of the marine environment.

As scientists investigate the usefulness of artificial reefs to improve recreational and commercial fishing, this information could be used by developers to mitigate the damage caused by foreshore developments. If the positive effects that reefs have on fish populations could be taken into account and utilised, these developments could be constructed so as to create, rather than destroy, habitats for marine life. ☐

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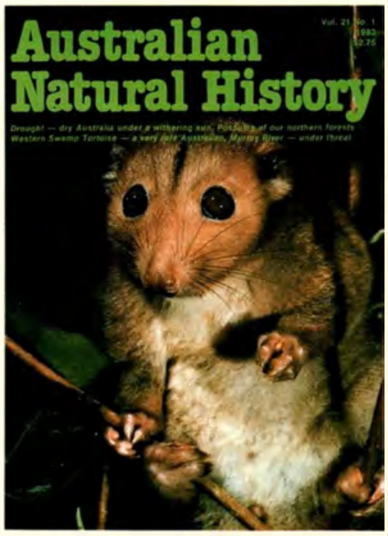

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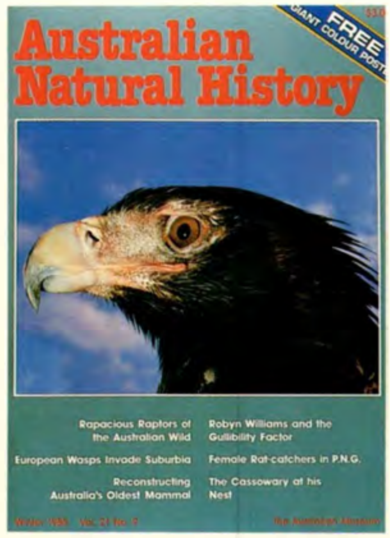

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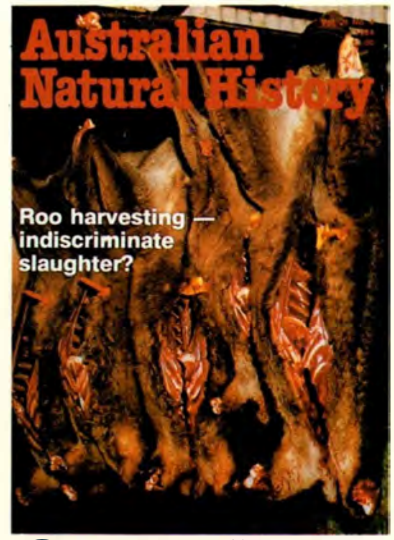

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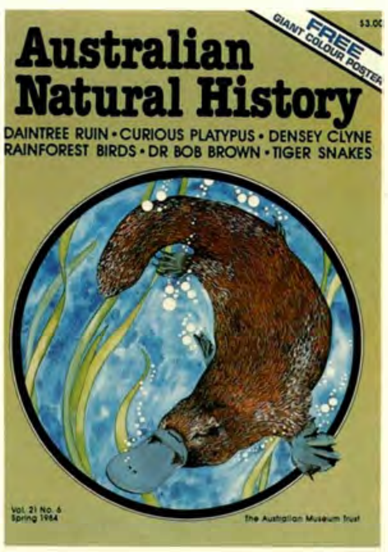

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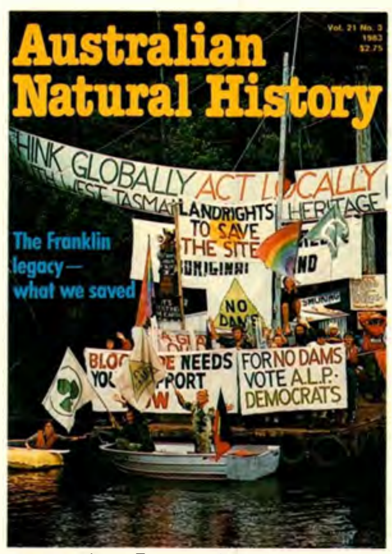

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